UPPER BLEPHAROPLASTY

AESTHETIC AND FUNCTIONAL ASPECTS

MARIJKE HOLLANDER

Upper blepharoplasty

Aesthetic and functional aspects

Marijke Hollander

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CHAPTER 1

General introduction

GENERAL INTRODUCTION

A blepharoplasty (from the Greek blepharon 'eyelid' and plassein/plasty 'to form') is currently defined as the excision of excessive eyelid skin (dermatochalasis), with or without subcutaneous tissue, for either functional or aesthetic reasons.

The first known references to eyelid surgery were described in an Indian document the 'Sushruta Samhita' around 600 B.C.. In the first century, ancient Greeks and Romans made skin excisions to relax the eyelids. This was described by the Roman Aulus Cornelius Celsus (25 B.C.–50 A.D.) in the seventh book of his encyclopaedia, De Medicina octo libri[1,2]. Around 1000 A.D., Ali ibn Isa al-Kahhal, an eye specialist, compiled one of the earliest descriptions of an upper eyelid blepharoplasty; the surname al-Kahhal means 'the oculist'. Further progress stagnated over the next several centuries until Arabian surgeons, namely Avicenna and Ibn Rashid, described the role of excess skin folds in impairing eyesight in the 10th and 11th centuries. Many years later, Karl Ferdinand von Gräfe introduced the term 'blepharoplasty' in 1818 for the technique used to repair deformities of the eyelids and for solely functional indications. In the early 1900s, oculoplastic surgeons started removing upper eyelid skin for aesthetic purposes, with the techniques varying widely[3]. However, early attempts to correct '*the aging eye*' were designed solely to remove excess skin[3]. The incision techniques used those days form the basis for today's cosmetic eyelid surgery. Loeb[4] and Furnas[5] described removing redundant muscle in the late 1970s, but only from some young patients who showed exaggerated individual development of the orbicularis that caused bulkiness[4] or from patients with loose festoons of orbicularis oculi muscle[5].

In the last 20 years, cosmetic upper blepharoplasty has become increasingly popular[6] involving the removal of excess eyelid skin, underlying orbicularis oculi muscle and protruding fat[7]. The practice of marking the incisions before eyelid surgery became popular, making the removal of excessive skin more efficient and thus preventing the removal of too much skin which could result in incomplete eyelid closure. In line with these developments, the taboo associated with cosmetic procedures has slowly decreased over the last few years. Nowadays, blepharoplasty is a very common procedure because it helps to rejuvenate a tired and aging appearance caused by sagging of the eyelid skin.

The aetiology of sagging eyelid skin lies in the weakening of connective tissues, loss of skin elasticity and the effects of gravity over time. They all contribute to the development of dermatochalasis.

Although aging and skin laxity is considered part of the normal aging process, modern western society is seeking, more and more, a smooth and youthful face as it is a symbol of dynamism and good health. When looking at a face, the eyes are the first and most looked at[8,9]. The eye area is considered attractive by many when it shows typical youthful features[10]. A beautiful youthful eye is described as full and convex (figure I)[7, 11-13]. Conversely, an aging eye appears hollow due to volume loss and fat atrophy. A face can be judged as more aged, fatigued and less attractive in the presence of tired-looking eyes and excess skin (Figure II). Aesthetic surgery to the eye region may, therefore, be one of the most effective interventions to enhance facial aesthetics[14].

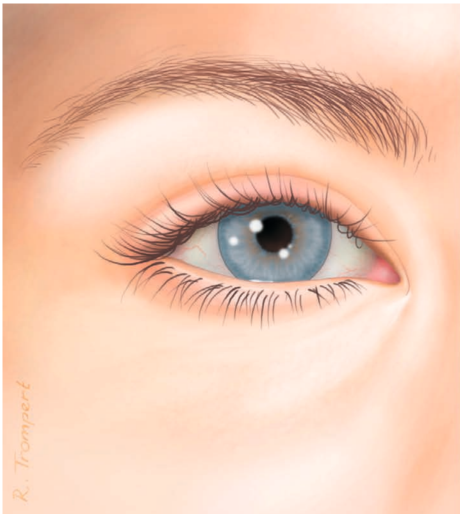

Figure I. Example of a youthful looking eye.

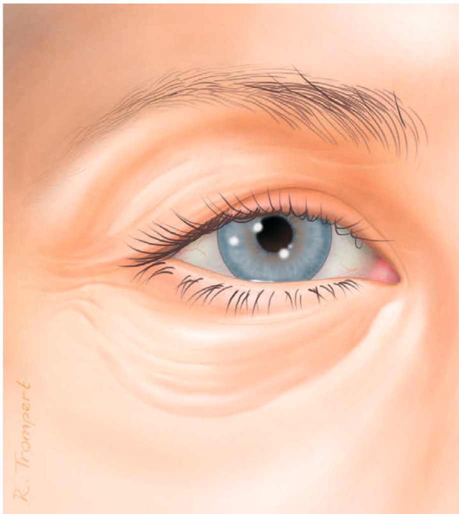

Figure II. Example of an aging eye appearance.

Besides dermatochalasis possibly leading to a less appealing appearance, it may also elicit a variety of functional problems including difficulty with elevating the upper eyelid[15,16], periorbital discomfort and dry eyes[17]. In individuals with dermatochalasis of the upper eyelids, the redundant skin obstructs the superior visual field. The occipitofrontalis muscles tend to compensate by lifting the eyebrows and elevating the redundant upper eyelid skin which may cause tension-type headaches[18-20]. Yet, studies on the functional benefits of an upper blepharoplasty are limited (contrast sensitivity, astigmatism, sensitivity of the eyelid skin, electromyographical data on the frontalis muscle) or sometimes conflicting (eyebrow height, dry eye signs and symptoms). It still remains uncertain which functional effects may be expected after surgery.

Irrespective of whether it is performed for functional or aesthetic reasons, upper eyelid blepharoplasty is one of the most commonly performed surgical procedures in aesthetic surgery. A full description of the eyelid anatomy, including the anatomy of the orbital fat compartments, was provided by Castañares in 1950[21], leading to important improvements in blepharoplasty techniques. Over time, the surgical procedure has changed and several techniques are described in the literature[3,7].

In the past, surgeons were inclined to perform a more invasive blepharoplasty where excess skin was removed together with a strip of orbicularis oculi muscle, sometimes combined with excision or redistribution of fat from the medial and central fat compartments[7]. The rationale for resectioning both muscle and fat along with skin is, however, unclear[22]. Nowadays, surgeons tend to be more conservative and less invasive by sparing the orbicularis oculi muscle and orbital fat because it preserves the fullness of the periorbital region, thus preventing the aged hollow orbit appearance[7,13]. Other aspects of the surgical technique are not set yet, such as the preferred shape of the skin excision, varying from the traditional elliptical shape[23] to the later modified scalpel blade shape[24] and excisions that extend beyond the lateral orbital rim[25]. Surgeons have their own preferences, meaning there is no consensus as to which is the most suitable blepharoplasty procedure and for which patient. In conclusion, there is still a need for a better understanding of the functional and aesthetic outcomes of an upper blepharoplasty and which surgical technique should be used to achieve the best results.

Aims

The general aim of this thesis was to gain an insight into the effects of an upper blepharoplasty. Therefore, a number of studies were performed:

- to evaluate literature regarding functional and aesthetic results of upper blepharoplasty we reviewed the literature to assess the objective and subjective functional effects (chapter 2) and aesthetic results (Chapter 3) of upper blepharoplasties;
- to assess the Patient Reported Aesthetic Results (PRARs) using various FACE-Q modules and the Patient and Observer Scar Assessment Scale following two different surgical upper blepharoplasty techniques, i.e. resectioning only skin or skin with a strip of additional orbicularis oculi muscle (Chapter 4);
- to compare the outcome of traditional elliptical skin excisions with wide lateral skin excisions from pretarsal show measurements, lateral eyebrow heights, patient reported aesthetic results (PRARs) and scarring (Chapter 5);

- to compare the effect of both blepharoplasty techniques on tear film dynamics and dry eye symptoms. The blepharoplasty techniques entailed skin only resections or also removing a strip of orbicularis oculi muscle (Chapter 6);
- to evaluate the effect of an upper blepharoplasty on eyebrow position, electromyographical changes of the frontal muscles and patient reported headache. The outcomes of the two surgical techniques (skin only resections versus removing a strip of additional orbicularis oculi muscle) were compared. Electromyographical changes in the orbicularis oculi muscle were also assessed to evaluate the effect of an additional muscle resection (Chapter 7).
- to develop a method of scanning the periorbital region with 3D technology to enable objective evaluations of surgical periorbital region treatments (Chapter 8). The three-dimensional assessment methodology of the upper eyelids facilitates evaluations of the fullness of the periorbital region after a blepharoplasty and comparisons between techniques.

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CHAPTER 2

Functional outcomes of upper eyelid blepharoplasty: a systematic review

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ABSTRACT

Background

Various functional outcomes after upper blepharoplasty are reported in the literature. We systematically reviewed the literature to assess the objective and subjective functional effects of upper blepharoplasty.

Methods

After a systematic search of four search engines (Pubmed, Embase, Cinahl and Cochraine), any study on objective and subjective (patient reported) functional outcome after upper blepharoplasty was subjected to a quality assessment for possible inclusion in the review. The intervention was defined as a solitary surgical upper blepharoplasty containing the removal of skin, with or without the removal of a strip of orbicularis oculi muscle and/or upper orbital fat. Eligible studies were randomized controlled trials, controlled trials, cohort studies and case series (n≥10).

Results

A total of 3525 studies was assessed, of which 28 studies were included in this systematic review.

Favorable outcomes after an upper blepharoplasty were reported and included enlarged visual field, enhanced quality of life related to fewer headaches and improved vision. Furthermore, sensitivity of the eyelids decreased, with differences in recovery. Outcomes for eyebrow height, astigmatism, contrast sensitivity and eyelid kinematics were not consistent between the studies. No meta-analysis could be performed due to the limited scope of included studies and the great variety in outcomes and blepharoplasty techniques.

Conclusions

Upper blepharoplasty is accompanied by a great variety of beneficial functional outcomes including an increased visual field and improvement in headache- and vision-related quality of life. Further research is needed, especially where results are conflicting (effects on eye dryness and eyebrow height) and/or the data are limited (contrast sensitivity, astigmatism).

INTRODUCTION

Blepharoplasty of the upper eyelids is one of the most commonly performed surgical procedures in aesthetic surgery[1]. This technique is used to correct redundant skin, also known as dermatochalasis, and subcutaneous tissue in the upper eyelid.

Dermatochalasis can lead to an aesthetically poor appearance and a variety of functional symptoms. These functional symptoms include difficulty in elevating the upper eyelids, limited peripheral vision by blocking the field of view[2-5], periorbital discomfort and dry eyes[6,7]. Dermatochalasis may also lead to overuse of the occipitofrontalis muscles, e.g., in patients with ptosis, resulting in tension-type headache[8].

Surgical removal of the redundant skin of the upper eyelid may improve several aspects, such as field of view[2,4,9], eye dryness[6] and quality of life[5,10,11]. In addition, upper blepharoplasty may lead to a decline of the electrical activity of the frontalis muscles, indicating a tension reduction of these muscles, and may subsequently lead to relief of tension headache[8,12].

Unfortunately, few studies have been published that assessed objective functional outcomes of an upper blepharoplasty. Moreover, these studies reported different, and occasionally conflicting, outcomes [7,13-15]. Comparing outcomes between studies is also difficult because some studies involve the combination of blepharoplasty with more extensive procedures such as ptosis surgery[4] and because different blepharoplasty techniques were used in different studies. Finally, the existing randomized controlled studies on blepharoplasty often focused on the aesthetic outcomes and not on functional outcomes. To enhance our understanding of this topic, we performed a systematic review assessing the objectively determined functional outcomes of upper blepharoplasty.

METHODS

A systematic review protocol was established before the beginning of the review process to minimize the potential for bias. The systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search methods for identification of studies

We searched the following electronic databases: PubMed, Embase, Cinahl and Cochrane Central Register of controlled trials. Keywords for the search included “blepharoplasty”, “upper”, “eyelids/surgery”, “eyelid reconstruction”, “eye lid correction”, "blepharochalasis", "dermatochalasis" and "eye lid surgery"(for the full list of keywords, see Appendix). In addition, reference lists of the full-text papers were screened for relevant studies missed in the search.

Eligibility criteria

Studies were eligible if surgical upper blepharoplasty was carried out and outcome variables were assessed before and after surgery. Studies that included adult patients (18 years and older) were included, without further age restrictions. There were no gender or ethnicity restrictions. The intervention in the eligible studies consisted of a solitary surgical upper blepharoplasty containing the removal of skin, with or without the removal of a strip of orbicularis oculi muscle and/or upper orbital fat.

Outcome variables included any functional objective outcome, such as peripheral vision, as well as self-reported functional outcomes such as eye strain, satisfaction and quality of life (QoL). Eligible studies were randomized controlled trials, controlled trials, cohort studies and case series with 10 or more participants. Case series with fewer than 10 participants and case reports were excluded. No language restrictions were applied. Studies were also excluded when a procedure other than the surgical upper blepharoplasty was used or when other surgical procedures were performed as adjunctive to the upper blepharoplasty (e.g., 'double eyelid' operation, 'Asian blepharoplasty', surgical creation of a supratarsal crease, lower blepharoplasty).

Study selection

Duplicates were removed by one observer (MH). Further study selection was performed by two observers (MH & MC) and was conducted in two stages: First, the titles and abstracts were assessed according to the inclusion criteria. The selection process was tested by applying the inclusion criteria to a sample of papers (papers that were excluded) to check whether inclusion criteria could be interpreted reliably. Second, the full text was assessed if studies appeared to meet the inclusion criteria or if a decision on inclusion could not be made based on the title and/or abstract alone. The quality assessment was also piloted by applying the MINORS criteria[16,17] and by filling in the data extraction form on a small sample of papers. Subsequently, two observers independently performed the study selection. Disagreement (in 74 papers) was discussed during a consensus meeting. In case of a persistent disagreement, a third independent expert (JJ) was available to make a binding decision. However, no persistent disagreements were present after the consensus meeting. An overview of the study selection is shown in figure I.

Inter-observer agreement

After the assessment of titles and abstracts, the agreed observations between the two observers (MH & MC) was 97.9% and after the consensus meeting 100%. Cohen's kappa was 1.0 after the consensus meeting.

Quality assessment

The methodological quality of the included studies was assessed by two independent observers (MH & MC) using the methodological index for non-randomized studies (MINORS) criteria[16,17]. The MINORS criteria were used to provide a quality score for the included studies; this was not part of the selection process.

Data extraction

One observer (MH) included studies after full-text quality assessment. Subsequently, the data extraction was carried out on the previously piloted data extraction form. One observer (MH) extracted the data and the second observer (MC) checked the data independently for accuracy and completeness.

Data synthesis

The included studies comprised a range of outcomes, therefore data could not be pooled and no meta-analysis was possible. In the results, we reported only a narrative synthesis of the findings from the included studies.

RESULTS AND DISCUSSION

Study selection

A total of 3525 studies (after removal of duplicates) was screened, of which 86 studies were assessed in full text for eligibility. Finally, 28 studies remained for qualitative synthesis. The first search was performed on the 6th of February 2017, and updated on the 24th of December 2017. This resulted in two additional studies, which were also included. The search of reference lists did not result in additional inclusions (see figure I).

Study characteristics

Studies were categorized based on functional outcome: dry eyes, upper visual field, eyebrow height, shape of cornea, sensitivity of upper eyelid skin, contrast sensitivity, eyelid kinematics and quality of life. The mean (± standard deviation) MINORS score for the included studies in this systematic review was 10±3. Table I provides an overview of the studies selected for review. Below, we describe a synthesis and discuss the included studies.

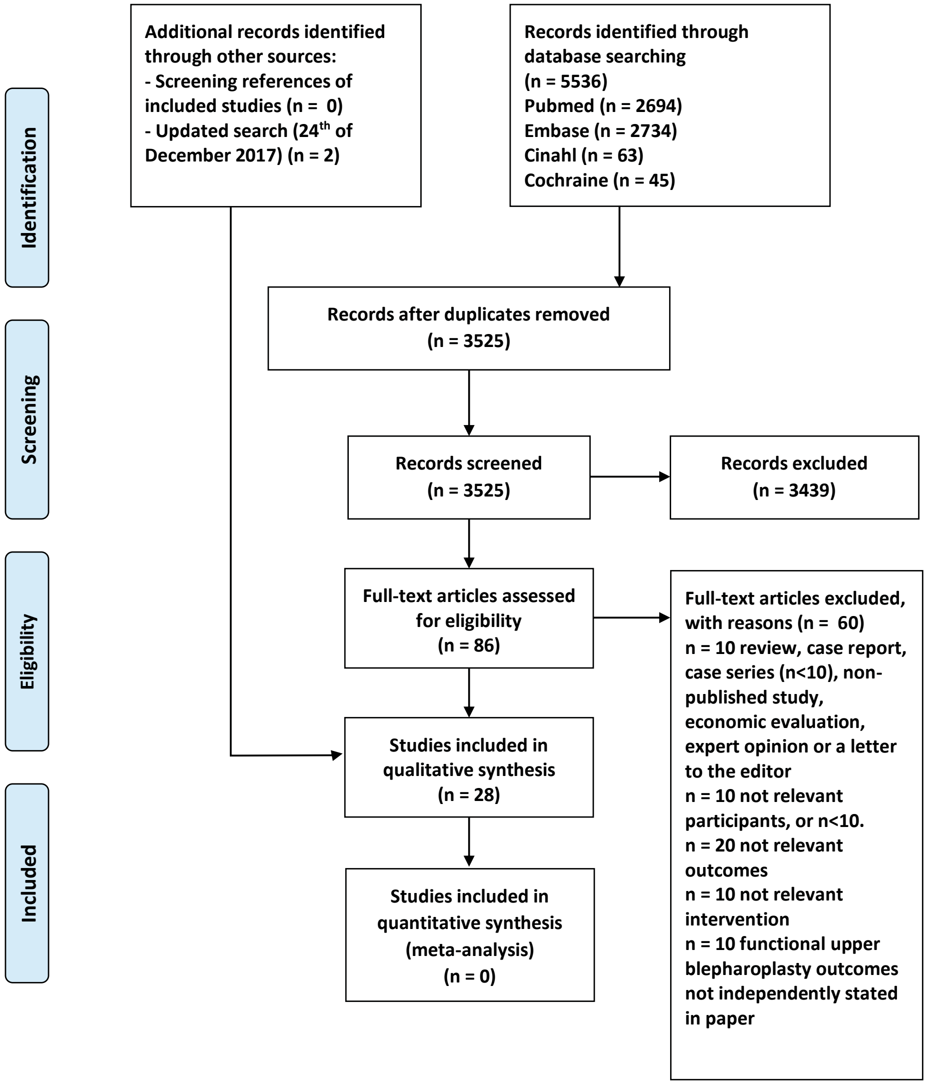

Figure I. Flow diagram

Tabel I. Study characteristics

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Dry eye									
Vold et al (1993)[6]	Assessing if blepharoplasty is effective in alleviating dry eye symptoms.	En bloc resection of skin, subcutaneaous tissue, and orbicularis oculi muscle	Symptoms of dry eyes. Schirmer test, tear break up time and rose bengal staining was measured between groups. Group 1 has dry eye symptoms and the other group has no preoperative symptoms.	69	Group 1 37.8 Group 2 69.6	Group 1 73.7% female Group 2 74.2% female	No significant differences between the groups. Objective clinical findings were compared between groups (and not before-and after blepharoplasty). Of group 1 33 (of 38) patients had subjective improvement of their dry eye symptoms, and almost all values declined significantly.	6	15
Floegel et al (2003)[7]	Evaluating the influence of upper blepharoplasty on dry eye symptoms and objective parameters.	En bloc resection of skin, subcutaneous tissue and orbicularis oculi muscle. Orbital fat was not removed.	Questionnaire, tear film break-up time (FBUT), Schirmer test without anesthesia and impression cytology of the bulbar conjunctiva.	24	58	79% female	Subjective dry eye symptoms were found in 11 patients (46%) preoperatively and in five patients (21%) postoperatively. Mean FBUT pre 6.9s, post 7.2s. Mean Schirmer I pre 11mm and post 17mm. The inflammatory reaction shown by impression cytology decreased postoperatively. All not significant.	3	11

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Rymer et al (2017)[18]	Evaluation of dry eye symptoms in patients undergoing a upper eyelid blepharoplasty and with additional Muller's muscle conjunctival resection.	Skin-only excision. Bipolar electrocautery was used for hemostasis and running nylon skin suture was performed.	Salisbury Eye Evaluation Questionnaire, Schirmer test without anesthesia, tear break up time (TBUT), fluorescein and Rose Bengal corneal staining	28 (which underwent blepharoplasty only)	60.2	96% female	Blepharoplasty-only group: No significant changes in dry eye questionnaire scores (pre- and post-operative). No significant changes in Schirmer, TBUT or rose Bengal scores at any time point. The fluoresceine staining was reduced at 30 days postoperative (compared to baseline and 7 days postoperative) and after 90 days no significant differences remained.	3	18
Perimetry									
Ho et al (2011)[4]	Introducing a modified visual field test to assess the functional disability associated with dermatochalasis (and ptosis) and to demonstrate the effect of a blepharoplasty on visual field.	Not stated	Modified Humphrey visual field test	39	Not stated for blepharoplasty only	Not stated for blepharoplasty only	After blepharoplasty there was a mean change in number of points seen ranging from -4 to +29 (mean 10.83, SD 7.42).	Not stated	8

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Hacker et al (1992)[2]	Assessment of the application of automated perimetry in the evaluation for upper eyelid blepharoplasty	Not stated	Custom Humprey visual field test	17	63.4	65% female	Mean increase of 26.2% of points seen between pre-and postoperative visual fields . Mean preoperative points seen 71.9 and postoperative 97.4 ($p<0.000001$) Preoperative height in degrees 35.7 and 46.6 postoperative.	1.5	8
Klingele et al (1995)[3]	Assessing pre- and postoperative visual fields	Not stated	Automated visual field test (Octopus 500)	20	Not stated	Not stated	After blepharoplasty the upper visual field defect was significantly reduced. The effect was larger on more severe to moderate dermatochalasis ($p<0.01$) compared to mild ($p<0.05$)	2	8
Pemberton et al (2017)[19]	Assessing if preoperative Goldmann Visual Field accurately depicts the postoperative superior visual field.	Skin-only blepharoplasty. Patients requiring reduction of the preoponeurotic fat pad were excluded	Goldmann perimetry	23	67	74% female	Mean area under the curve: Preoperative $478mm^2$ and postoperative $5417mm^2$. Mean difference of $4938mm^2$ (1026%) $P<0.0001$	1	11

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Fuller et al (2017)[9]	Correlation between tangent visual field measurements and clinical exam in dermatochalasis patients.	Not stated	Superior visual field using a Tangent Screen	31	Not stated	Not stated	Vertical meridian: Preopertaive 7.8 degrees Postoperative 20.9 degrees Area under the curve: Preoperative 223 degrees Postoperative 798 degrees * significance level for the blepharoplasty-only group not stated	Not stated	9
Jacobsen et al (2017)[5]*	Investigation of the functional effects of upper blepharoplasty.	Upper blepharoplasty as described by Drolet & Sullivan (2014) and Tyers & Collin	Blepharoptosis test of Octopus 900	45	59.6	76% female	The mean change in visual field for the worst eyes was 35.5% points in females and 30.9% points in the males (p=0.55)	3	10

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Rogers et al (2012)[20]**	To assess the effect of upper eyelid blepharoplasty on contrast sensitivity.	Excision of excess skin	Contrast sensitivity was measured using a Pelli-Robson contrast sensitivity chart and results in log contrast sensitivity. Visual acuity (by Snellen chart or by LogMAR) and visual field (with Humphrey visual field analyzer) were also tested.	14	63.5	Not stated	Contrast sensitivity: Mean increase in log contrast sensitivity 0.14 (p=0.00002). Visual acuity: Mean LogMar visual acuity 0.09 (pre-operative) and 0.15 (post-operative; p=0.13) Perimetry: Visual field data were available on 24 out of 28 lids. The average number of points seen above the horizontal preoperatively was 17.5. After surgery, the average number of points seen increased to 22.4, with an average increase of 4.92 points. Overall 18 out of the 24 visual fields improved following surgery; in 6 lids, there was no change in field.	1.5	10

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Eyebrow height									
Huijing et al (2014)[23]	Evaluation of the direct effect of an upper eyelid blepharoplasty on the position of the eyebrows in a population with complaints of visual impairment.	Excessive skin was excised together with a 2mm strip of orbicularis muscle after which the orbital septum was shrunken by electrocoagulation.	Measuring the position of the eyebrows at three positions for each eye (center of pupil, lateral iris and lateral canthus) by using standardized photographs.	140	55.1	90% female	Mean drop in eyebrow position for all patients at each point ranged from 0.35% to 1.23%. In females no significant drop of the eyebrows after surgery. In males the distance from the center of the pupil to the inferior border of the eyebrow of the left eye displayed a significant decrease of the eyebrow of 7% ($p=0.005$).	2	10
Frankel et al (1997)[27]	Evaluation if upper eyelid blepharoplasty causes eyebrow position to drop in a cosmetic surgery population.	Excision of skin, a strip of orbicularis muscle and fat when indicated.	Change in eyebrow height reflected as a percentage of the pretreatment height. Measurements are based on standardized photographs. The measurements included the distance from the midpupil vertically to the inferiormost eyebrow hairs and from the inferior alarlabial groove to the medial canthus.	40 in the treatment group (subgroup) and 28 in control group)	45.5 in the treatment group	90% female	The mean drop in eyebrow position for the treatment group was 7.69% and for the control group 7.80% ($p=0.08$). No statistically significant difference between the two groups.	9 -40	16

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Fagien (1992)[29]	Determination if significant brow ptosis occurs after removal of excessive upper eyelid skin in patients with brow ptosis.	Excision of skin and orbicularis muscle. Some patients underwent excision and contouring of the sub-brow fat. Herniated orbital fat pads were excised when present.	Measurements of margin to reflex distance (MRD), margin to fold distance (MFD), eyebrow to lid margin distance (BLD) and eyebrow to skinfold distance.	15	62	Not stated	11 (of 15) patients had a change in their eyebrow position (average of 1mm) after surgery. Two patients had a mild descent of the eyebrow (average ≤2mm) two patients were felt to have significant induction of eyebrow ptosis (average ≤3mm).	6 -24	3
Shah et al (2012)[30]	To examine the relation between asymmetric eyebrow elevation and ocular dominance.	Not stated	A caliper was used before and after surgery to measure from the center of the pupil vertically to the inferior eyebrow hairs of each eye and the lateral canthal angle and vertically to the inferior brow hairs. Ocular dominance was determined by using a modified Porta test. Visual acuity was also measured.	47	66	79% female	The mean difference in preoperative brow height was 1.5mm centrally and 2.07mm laterally, and the mean difference in postoperative brow height was 1.7mm centrally and 2.07mm laterally. 66% involuntarily, asymmetrically elevated the right eyebrow and 34% the left. Of the 31 patients with right eyebrow elevation 87% were right-eye dominant and 13% were left-eye dominant. Among patients with left eyebrow elevation, 62,5% were left-eye dominant, and 37,5% were right eye dominant ($p<0.001$)	Not stated	7

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Dar et al (2015)[26]	Evaluating the effect of upper blepharoplasty on eyebrow height, accounting for ocular dominance, fat excision, change in MRD1 and degree of dermatochalasis.	Excision of redundant skin, orbicularis muscle (leaving a small strip of orbicularis inferiorly) and fat when indicated.	Standardized photographs and digitally measuring medial canthus to inferior eyebrow cilia, center of the pupil to the inferior eyebrow cilia, central upper eyelid margin to the corneal light reflex and from the lowest point of dermatochalasis to the corneal light reflex.	19	73.2	53% female	No significant changes in eyebrow height at all positions. Multivariable comparison found insufficient evidence to suggest MRD1, ocular dominance, or dermatochalasis were significantly associated with mean percentage change in brow height at all positions with or without fat excision.	At least 1.5	10
Prado et al (2012)[24]	Assessing the occurrence of secondary brow ptosis after upper lid blepharoplasty.	Preseptal orbicularis skin and muscle were removed using a scalpel The orbital septum was opened and the preaponeurotic fat was removed.	Pre-and postoperative photographs and angular measurements were used (lateral canthal angle of the brow, the most medial point of the brow and the medial canthal angle and the lateral canthal angle of the lid as reference points.	45	60.5	82% female	Significant changes in all angular measurements obtained before and after upper blepharoplasty. Alterations are most apparent in the lateral portion of the eyebrow.	4	10

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Hassanpour and Kermani (2016)[25]	Analyzing the effect of upper blepharoplasty on eyebrow position.	Skin excision (authors of this study also mention that all patients underwent 'traditional blepharoplasty').	Pre-and post-operative digital photographs and measuring the distance between the upper lid margin and the brow were measured.	70	49.7	83% female	The postoperative brow position was unchanged in 46 cases (65.8%) and brow depression was noted in 24 cases (34.2%). The measurements after blepharoplasty showed significant differences from those before surgery. Changes were more significant in the lateral portion of the eyebrow and they occur bilaterally. (p-values not stated)	6	10
Starck et al (1996)[28]	Quantification of changes that occur after blepharoplasty.	Not stated.	Photographs were recorded and expressed as anthropometric ratios. Anthropometric measurements consisted (amongst others) of medial browheight (inferior medial brow to endocanthion) and lateral brow height (inferior lateral brow measured vertically from exocanthion to endocanthion line at iris).	15	54	100% female	Medial and lateral brow heights were not affected by upper lid blepharoplasty surgery.	6	4

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Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Pool and Van der Lei (2015)[22]	Evaluation of dermatochalasis, eyebrow position and (a) symmetry in both sided in patients before and after blepharoplasty.	Bipolar coagulation assisted orbital (BICO) septo-blepharoplasty. This consists of removing redundant skin, a very small rim of the preseptal orbicularis muscle. Subsequently, bipolar coagulation of the septum is performed resulting in shrinkage of the septum and disappearance of the bulging fat compartments without removal of the fat.	Pre-and postoperative photographs were evaluated for (asymmetry in) degree of skin surplus (5-point grading scale), eyebrow height (distance between lower bound of eyebrow and center of the pupil) and eyelid fissure height (distance between upper and low	365	51.5	86.3% female	Eyebrow height: Preoperative mean 15.8mm for the right side and 15.9mm for the left side. Postoperative mean 15.2mm for the right side and 15.1mm for the left side. On both sides the eyebrow height was significantly lower postoperatively than preoperatively ($p=0.000$). This applied to males and females.	2.5	9

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Baker et al (2016)[21]	Evaluation of internal suture browpexy, endoscopic Endotine browplasty and to compare these techniques in patients undergoing simultaneous upper blepharoplasty.	Blepharoplasty consisted of removal of skin and orbicularis muscle.	Standardized photographs were used to measure pre-and postoperative brow position at three positions (central, medial and lateral)	30 (blepharoplasty only group)	67 (blepharoplasty only group)	63% female (blepharoplasty only group)	Significant brow descent at all three brow positions (mean -1.7mm, $p \leq 0.04$)	4.1-5.2	8
Shape of cornea									
Simsek et al (2015)[31]	Changes in corneal astigmatism and subjective visual acuity changes.	Blepharoplasty by removing skin-only.	Measurement of corneal astigmatism with a Pentacam and patient reported visual acuity change.	23	46.3	91% female	Preoperative astigmatism (D) 1.1±0.8D Postop 1month 1.3±0.8D Postop 3 months 1.2±0.8D Increased astigmatism in the first and third month after surgery, compared to the preoperative measurements, showed significant results (p=0.028 and p=0.048)	3	9

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Dogan et al (2015)[33]	Evaluation of corneal parameters.	Excision of skin and subcutaneous tissue with or without orbital fat excision.	Scheimpflug imaging (Pentacam) central corneal thickness, anterior chamber depth, steepest keratometric reading and astigmatic power vectors. Patients are divided in two groups according to preoperative MRD (upper margin reflex distance); group 1 <2.5mm, group 2 ≥2.5mm.	30	56.5	73% female	Significant increase keratometric value of steepest meridian in group 1 (p=0.018). No significant changes in visual acuity, steepest keratometric reading, anterior chamber depth, central corneal thickness or astigmatic power vector	3	9
Zinkernagel et al (2007)[32]	Comparison of upper eyelid procedures on corneal topography.	Skin-only blepharoplasty (SOB), blepharoplasty with the reduction of the medial fat pad (BMFP) and blepharoplasty with reduction of the entire fat pad (BEFP). All procedures were performed using a carbon dioxide laser.	Corneal topography measurements	30	Not independently stated for the blepharoplasty-group	Not independently stated for the blepharoplasty-group	Mean changes in total astigmatism of 0.21D after blepharoplasty (p=0.04), mean change of 0.09D in patients after skin-only blepharoplasty, 0.15D in the BMFP group and 0.21D in the BEFP group.	3	10

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Sensitivity of the upper eyelid skin									
Pool et al (2014)[34]	Assessing the sensitivity of the upper eyelid before and after blepharoplasty	Not stated	perception of touch, temperature, pressure and pain by a cotton ball, a tip-term, Cochet-Bonnet aesthesiometer and a neurological pin.	32	54	91% female	Number of times the touch of a cotton ball was felt was lower in one week to 6-8 weeks after surgery ($p<0.000$) Mean pressure threshold and the number of times that a touch with a glass-headed pin was lower one week after blepharoplasty, persisting after 6-8 weeks($p<0.000$). 6 months postoperative mean pressure thresholds was higher for all places of the upper eyelids as compared to the preoperative ($p<0.000$)	6	10
Kashkouli et al (2008)[35]	Comparison of sensation recovery of upper blepharoplasty eyelid incision performed with radiofrequency or scalpel.	Radiofrequency incision on one side and scalpel on the other side. Supratarsal eyelid crease incision, and skin and subcutaneous tissue excision. The preaponeurotic fat pad was cauterized in 3 rows and the medial fat pad was removed.	Sensitivity measurements using a Cochet-Bonnet filament type aesthesiometer. 3 testpoints were each tested 3 times.	23	52	91% female	Preoperative mean eyelid sensation 4.39 (of 6 times the filament was applied on the eyelid). Mean sensation decreased in both groups at all follow up visits in comparison with preoperative measurement ($p=0.000$) Mean sensation recovery was higher in the radiofrequency group in all groups, but it did not reach significance.	6-7	12

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Contrast sensitivity									
Rogers et al (2012)[20]**	To assess the effect of upper eyelid blepharoplasty on contrast sensitivity.	Excision of excess skin	Contrast sensitivity was measured using a Pelli-Robson contrast sensitivity chart and results in log contrast sensitivity. Visual acuity (by Snellen chart or by LogMAR) and visual field (with Humphrey visual field analyzer) were also tested.	14	63.5	Not stated	Contrast sensitivity: Mean increase in log contrast sensitivity 0.14 (p=0.00002). Visual acuity: Mean LogMar visual acuity 0.09 (pre-operative) and 0.15 (post-operative; p=0.13) Perimetry: Visual field data were available on 24 out of 28 lids. The average number of points seen above the horizontal preoperatively was 17.5. After surgery, the average number of points seen increased to 22.4, with an average increase of 4.92 points. Overall 18 out of the 24 visual fields improved following surgery; in 6 lids, there was no change in field.	1.5	10

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blephroplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Eyelid kinematics									
Abell et al (1999)[36]	Assessing the effects of blepharoplasty on blink dynamics.	Redundant lid skin and subcutaneous tissue were excised bilaterally. The preseptal segment of orbicularis oculi was resected and the pretarsal portion was spared. Prolapsed preaponeurotic fat was removed in some cases.	Blink dynamics by using the modified scleral scarch coil technique.	16	Range between 38 to 59, mean not stated	94% female	No significant change of mean blink down-phase amplitude, peak velocity, duration, and mean sequence relationships.	12	8
Quality of life									
Bahceci Simsek (2017)[10]	Evaluation of changes in headache-related quality of life.	Method of blepharoplasty not stated.	Headache Impact Test 6.	108	49.8	61.1% female	Mean preoperative HIT-6 score 46.4±8.6 and mean postoperative HIT-6 score 42.3±9.3 (p=.03)	3-4	11
Briceño et al (2016)[11]	Assessing vision related quality of life.	Method of blepharoplasty not stated	Abbreviated National Eye Institute Visual Function Questionnaire .	29	Not stated for the blepharoplasty-group	Not stated	Mean preoperative score 74.9, mean postoperative score 86.8 (p=<0.0001)	2-3	10

Tabel I. (Continued)

Author(s) and year of publication	Aim	Intervention	Method of measured outcome(s)	No. of (blepharoplastyonly) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
Jacobsen et al (2017)[5]*	Investigation of the functional effects of upper blepharoplasty.	Upper blepharoplasty as described by Drolet & Sullivan (2014) and Tyres & Collin.	A questionnaire concerning functional and psychosocial impact of their eyelids.	45	59.6	76% female	Descriptive statistics on pre- and postoperative outcomes: Visual field restriction occasionally (pre) to rarely (post). Chin-up backward head tilt occasionally(pre) to never (post). Heavy eyelid feeling from usually (pre) to never (post). Headache due to frown from occasionally (pre) to never (post). Skin irritation from occasionally (pre) to rarely (post) . General nuisance from usually (pre) to never (post).	3	11

* The study of Jacobsen et al (2017) is described in the 'quality of life'-section and the 'Perimetry'-section
** The study of Rogers et al (2012) is described in the 'perimetry' and the 'contrast sensitivity'-section

Dry eyes

Dry eyes were assessed by a variety of diagnostic tests and by scoring subjective complaints. A few studies evaluated whether dry eyes could be alleviated, worsened or provoked by blepharoplasty and whether the method of blepharoplasty makes any difference. One study evaluated subjective dry eye symptoms, such as burning, itching, redness and foreign body sensation of the eyes[6]. In symptomatic patients who underwent a blepharoplasty, the symptoms decreased significantly. Another study evaluated subjective and several objective dry eye parameters, but did not report a significant effect of blepharoplasty based on these parameters[7]. Another study mentioned that a blepharoplasty had no effect on dry eye scores assessed with a questionnaire[18]. The ocular surface scores (fluorescein staining) were reduced 30 days after surgery, while later on (after 90 days), the scores did not significantly differ from baseline. This was also the case for Schirmer test scores, tear break-up time and rose Bengal scores at any point in time.[18] Thus, a blepharoplasty may potentially alleviate subjective complaints of dry eyes, but at least does not induce or worsen dry eye symptoms.

When interpreting the results reported in the previous paragraph, it has to be mentioned that dry eyes are difficult to evaluate. Dry eye symptoms have a complex and multifactorial aetiology as well as that there is no single definitive diagnostic test to identify or classify the severity of dry eye disease. Dysfunction of any component of the lacrimal functional unit, such as decreased tear production, increased evaporative loss and changes in drainage, can result in dry eye symptoms. Subjective dry eye complaints were reported to be alleviated by surgery, but this observation was often not supported by objective tests, such as Schirmer test, Break-up time and Rose Bengal scores[7,18] It was shown, however, that the inflammatory reaction and ocular surface scores reduced after surgery[7,18]. Thus, based on our systematic review, we are unable to draw a clear conclusion about the effect that patients can expect from a blepharoplasty. Some authors suggested that a reduced inflammatory reaction, a changes blink mechanism or more confidence of patients about their appearance might underlie this beneficial effect[7]. Other authors have suggested that by compromising the integrity of the orbicularis muscle, dry eyes even may worsen[13]. The study on eyelid kinematics that was included in this systematic review did not report significant changes in blink dynamics despite resection of orbicularis muscle during upper blepharoplasty.

Upper visual field

Redundant skin and subcutaneous tissue in the upper eyelid may cause limitations in the upper visual field. Three out of seven eligible studies reported a significant reduction of visual field defects after blepharoplasty [2,3,19]. The other four studies reported a tendency for improvement of visual field[4,5,9,20]. Thus, resection of the excess eyelid skin will extend the visual field. The possible lowering of the eyebrow, discussed in the next section, does not seem to affect this increase.

Eyebrow height

In patients with dermatochalasis, obstruction of the superior visual field may result in compensatory frontalis muscle action to lift the eyebrows. When in these cases a blepharoplasty is performed, the frontalis muscles theoretically can loose the neurological feedback from the brain to continue to elevate the eyebrow, which may result in lowering of the brows. Nine studies assessed the occurrence of secondary brow ptosis after upper blepharoplasty.

Five studies reported a significant eyebrow descent after surgery. The descent was found in the whole eyebrow[21,22], the middle portion in males[23] and was most pronounced in the lateral part of the eyebrow[24,25]. Four other studies did not report a significant effect on eyebrow descent after upper blepharoplasty[26-29]. One of these was the study by Dar et al.[26], who evaluated the effect of upper blepharoplasty on eyebrow height while accounting for ocular dominance, fat excision, change in MRD1 (Margin Reflex Distance 1) and degree of dermatochalasis. MRD1 is the distance between the light reflex on the patient's cornea to the upper eyelid margin during primary position of gaze. Multivariable comparison provided insufficient evidence to show that MRD1, ocular dominance or dermatochalasis were significantly associated with the mean percentage of change in eyebrow height at all positions with or without fat excision. Another study addressed ocular dominance specifically[30]. Involuntary unilateral eyebrow elevation may lead to the perception of residual excess skin in the contralateral upper eyelid in a subset of patients who have undergone upper eyelid blepharoplasty. The latter study assessed the relationship between asymmetric eyebrow elevation and ocular dominance and concluded that involuntary asymmetric eyebrow elevation and ocular dominance are significantly associated. Summarizing, data on eyebrow height after blepharoplasty are inconsistent.

The inconsistencies of the studies reported may be the result of various factors including surgical technique, scar formation, frontal muscle activity and ocular dominance. Most of the studies involving surgical technique, i.e. a technique in which surgeons excised herniated fat and/or removed part of the orbicularis muscle, reported a significant decrease of eyebrow height[21-24]. Only the study of Dar et al.[26] did not report that significant changes in eyebrow height occur. Unfortunately, no eligible studies were available in which the effect of a skin-only blepharoplasty on eyebrow height was evaluated.

There might be a relationship between asymmetric eyebrow elevation and ocular dominance. Shah et al.[30] pointed out that asymmetric eyebrow elevation may lead to the perception of residual excess skin in the contralateral upper eyelid in a subset of patients who have undergone upper eyelid blepharoplasty. According to the authors, if unrecognized this asymmetry may result in the surgical overcorrection of the contralateral eyelid[30].

Shape of cornea

Removal of excess upper eyelid skin and raising the eyelid with blepharoplasty may lead to redistribution of the pressure applied by the lids over the cornea and consequently to changes in corneal shape. This change can be documented with corneal topography. Also, the pressure of excess skin and prolapsed fat may cause alterations in corneal curvature. This could change corneal refraction, astigmatism and may cause blurred vision. Two studies reported a significant change in corneal astigmatism after upper blepharoplasty[31,32]: increased astigmatism in the first and third month after surgery[31] and a change in mean astigmatism after blepharoplasty. When fat pads are also reduced, a more pronounced change in astigmatism was observed as compared to skin-only excision (0.21D vs. 0.06D)[32]. The third study measured many ocular variables but the only parameter that was significantly different from the preoperative value was the keratometric value of the steepest meridian in one group of patients[33].

The extent to which patient notice the above mentioned changes remains unclear. Visual changes of 0.50D or less are noticed only by patients whose normal activities of daily living require a high standard of visual performance. It is worth noting that astigmatic changes may also occur after ptosis surgery[34-36] and tend to regress after 6 -12 months[34,36].

Sensitivity of the upper eyelid skin

During blepharoplasty, the sensory innervation of the upper eyelid skin can be damaged, resulting in paraesthesia or anaesthesia of the pretarsal skin. Only two studies on this aspect met our inclusion criteria; both reported significantly decreased sensitivity after upper blepharoplasty, but different findings about recovery over time. One study reported full recovery of sensitivity after 6 months (perception of touch, temperature, pressure and pain)[37], whereas the other study reported only partial recovery after 6-7 months (pressure)[38]. Thus, decreased sensitivity of the upper eyelid skin may follow after an upper blepharoplasty. However, the included studies did not agree about the recovery after upper blepharoplasty. Since the follow-up in the included studies was only six to seven months, it would be interesting to prolong the follow-up in future studies to see the outcome after a longer time period.

Contrast sensitivity

Patients may note brighter vision after upper blepharoplasty, which may be caused by the removal of redundant skin. Rogers et al.[20] evaluated whether this surgery also has an effect on contrast sensitivity. Contrast sensitivity is defined as the ability to detect luminance contrast. A reduction can have a considerable effect on functions such as night driving and reading. Postoperative contrast sensitivity indeed increased significantly in this study(p=0.00002). Another excluded study evaluated the cause of increased contrast sensitivity and improved visual acuity after upper eyelid surgery[39]. The hypothesis in this study was that increases in contrast sensitivity are the result of changes in corneal topography, high-order aberrations (subtle and complex refractive errors) or lash ptosis. However, no changes in corneal topography after upper eyelid surgery were observed. Kim et al.[39] concluded that reduction of high-order aberrations increase contrast sensitivity and allow more accurate vision. The authors explained that overhanging skin and lash ptosis block light entering the eye and cause diffraction. The study concluded that the changes in contrast sensitivity are caused by changes in ocular high-order aberrations and by the degree of lash ptosis after surgery. The actual practical visual benefit of this increase in contrast sensitivity is difficult to qualify. The authors stated that the effect of upper eyelid blepharoplasty is approximately equivalent to half the effect of cataract surgery on contrast sensitivity[20].

Eyelid kinematics

Abell et al.[40] evaluated the effect of upper blepharoplasty on blink dynamics. This was done to test the hypothesis that partial orbicularis oculi removal causes alterations in blinking. Also, altered blinking is a possible cause of dry eye symptoms after blepharoplasty. The blink dynamics were evaluated by a modified scleral search coil technique. Despite muscle resection, no significant changes in blink dynamics were found.

Quality of life aspects

Bahceci-Simsek[10] conducted a prospective study among 108 patients who underwent upper eyelid blepharoplasty. They evaluated changes in headache-related quality of life (QoL) after blepharoplasty and used the Headache Impact Test 6 (HIT-6). The results indicated that blepharoplasty can improve headache-related QoL. Another study used the Abbreviated National Eye Institute Visual Function Questionnaire (NEIVFQ9) as a tool for assessing vision-related QoL in patients with dermatochalasis[11]. This study found a significant increase in visual function in dermatochalasis patients after surgery. Finally, Jacobsen et al.[5] described the functional and psychological impact of upper blepharoplasty on patients. They also reported improvement. Thus, all self-reported outcomes, including headache and heavy eyelid feeling, improved after blepharoplasty.

As mentioned before, upper blepharoplasty may lead to a decline in the electrical activity of the frontalis muscles, which in turn may lead to a relief of tension headache[12]. An excluded study in our review (only 9 patients evaluated) supported this presumption. In that study every HIT-6 question improved significantly[8]. Future research should study this relationship between blepharoplasty, frontal muscle activity and headache more in detail.

Limitations of the literature and further research

One limitation is that most included studies in this systematic review were dominated by female participants. Therefore, the conclusions in those studies cannot be automatically generalized to male participants.

Another limitation in comparing the outcomes of the included studies is the use of a variety of surgical techniques of upper blepharoplasty. In some articles the exact method of blepharoplasty was not even described in detail. In many procedures, excess skin is removed together with a strip of orbicularis oculi muscle, sometimes combined with excision or redistribution of fat from the medial and central fat compartments. The rationale for both muscle and fat resection along with skin is unclear. It is also, unclear whether the septum should be coagulated during surgery. One theory supports the importance of saving the orbicularis oculi muscle and orbital fat because this preserves the fullness of the periorbital region, thus preventing the hollow orbit of the aged [13, 41-44]. Another theory is that dry eye complaints are prevented by preserving the orbicularis oculi muscle[45]. Although blepharoplasty is performed very frequently in aesthetic surgery, there is no consensus about which procedure is most suited for a blepharoplasty and for which patient. In the review of Hoorntje et al[46] a lack of consensus about what is to be done with the orbicularis oculi muscle in upper eyelid blepharoplasty is demonstrated.

In theory, left-right comparative studies may result in more evidence-based outcomes. The study of Kiang et al[45] conducted a left-right comparative study where patients were treated with skin-only blepharoplasty on one side and a combined skin-muscle removal on the other side. They concluded that muscle-sparing blepharoplasty may induce less sluggish eyelid closure, less lagopthalmos and less dry eye disease. In this systematic review their study was excluded due to the performance (on a part of the participants) of a tarsal fixation to improve the supratarsal crease definition or to create one, which was one of the exclusion criteria. Another split-face pilot study was performed to evaluate the aesthetic differences between skin-only blepharoplasty and blepharoplasty with stripping of the orbicularis oculi muscle. A trend favouring the skin-only side was present, but no difference between the techniques was significant[47].

CONCLUSIONS

Several positive functional effects may be expected after upper blepharoplasty, such as an increased visual field and improvement in headache- and vision-related QoL. Further research is needed, especially where results are conflicting (eye dryness, eye brow height) and/or in cases of limited scientific data (contrast sensitivity, astigmatism, frontalis muscle activity).

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None.

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2

APPENDIX: SEARCH STRATEGY.

Pubmed search

(((“blepharoplasty”[Mesh]) OR “eyelids/surgery”[Mesh]) OR (eyelid*[tiab] AND (reconstruction*[tiab] OR surger*[tiab] OR correction*[tiab]) OR dermatochalasis[tiab] OR blepharochalasis[tiab] OR blepharoplasty*[tiab])) AND upper[tiab]

Embase search

‘eyelid reconstruction’/exp

OR

(eyelid*:ab,ti AND (reconstruction*:ab,ti OR surger*:ab,ti) OR dermatochalasis:ab,ti OR blepharochalasis:ab,ti OR blepharoplasty*:ab,ti)

AND

Upper:ab,ti

Cinahl search

(MH “blepharoplasty”)

OR

Eyelid* AND (reconstruction* OR correction* OR surger*)

OR

dermatochalasis OR blepharochalasis OR blepharoplast*

AND

Upper

Cochrane Central register of controlled trials search

blepharoplasty OR eyelid* AND (reconstruction* OR correction* OR surger*) OR (dermatochalasis OR blepharochalasis OR blepharoplast*) AND upper

CHAPTER 3

Aesthetic outcomes of upper eyelid blepharoplasty: a systematic review

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ABSTRACT

Background

Although upper blepharoplasty is a common cosmetic surgical intervention, there is still a need for a better scientific understanding of the aesthetic results and which surgical technique is preferable to achieve the best aesthetic results.

Methods

After a systematic search using four search engines (Pubmed, Embase, Cinahl and Cochrane), any study on aesthetic outcome after a solitary upper blepharoplasty was subjected to a quality assessment for possible inclusion. Eligible studies were randomized controlled trials, controlled trials, cohort studies and case series (n≥10).

Results

A total of 4043 studies were assessed, of which 26 studies were included. Aesthetic outcomes included patient reported outcome measures, scarring, eyebrow height, tarsal platform show and panel or expert evaluation. Meta-analysis was not possible. Patients were generally satisfied with the aesthetic result and scar formation after an upper blepharoplasty. The amount of tarsal platform show increased which positively affected the aesthetics. The eyebrow seems to move down slightly. The used surgical technique (skin only or skin/muscle removal) did not influence patient satisfaction, nor the physician's assessed aesthetic outcomes.

Conclusion

Patients are generally satisfied after an upper blepharoplasty. The optimal design of skin excision is still a matter of debate, especially when addressing lateral hooding. Further objective research is advised.

INTRODUCTION

When looking at a face, the eyes are the first and most looked at[1]. Eye-tracking studies confirm this; age judgments are made upon preferential attention towards the eye region[2]. A face can be judged as more aged, fatigued and less attractive in the presence of tired-looking eyes and excess skin[2,3]. Aesthetic surgery to the eye region may therefore be one of the most effective interventions to enhance facial aesthetics[4].

Blepharoplasty of the upper eyelids is one of the most commonly performed surgical procedures in aesthetic surgery[5]. In the past, surgeons were more inclined to perform a more invasive blepharoplasty where excess skin is removed together with a strip of orbicularis oculi muscle, sometimes combined with excision or redistribution of fat from the medial and central fat compartments. The rationale for both muscle and fat resection along with skin is, however, unclear[6].

Nowadays, surgeons tend to be more conservative and less invasive by sparing the orbicularis oculi muscle and orbital fat, because this preserves the fullness of the periorbital region, thus preventing the aged hollow orbit appearance[7–10]. The preferred shape of the skin excision is also not clear, varying from elliptical[11], lenticular[12,13], S-shape[8,14], and trapezoid[15] to excisions that extend beyond the lateral orbital rim[16]. Each surgeon has their own preference, but there is no consensus as to which is the most suitable blepharoplasty procedure and for which patient[6]. Therefore, the literature was systematically reviewed to assess which technique gives the best aesthetic results.

METHODS

A systematic review protocol was established before beginning the review process by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Prospero registration number: CRD42018117291.

Search methods for identification of studies

We searched the following electronic databases: PubMed, Embase, Cinahl and Cochrane Central Register of controlled trials. The search Keywords included “blepharoplasty”, “upper”, “eyelids/surgery”, “eyelid reconstruction”, “eye lid correction”, “blepharochalasis”, “dermatochalasis” and “eye lid surgery” (for the full list of keywords, see appendix). Reference lists of the full-text papers were screened for relevant studies missed in the search.

Eligibility criteria

Studies were eligible if a solitary surgical upper blepharoplasty had been carried out on adult Caucasian patients (≥18 years, no gender restriction) and aesthetic outcome variables (e.g. visibility of scars) were assessed after surgery. Evaluations by an panel as well as patient reported outcome measures were considered. Direct postoperative variables such as oedema, bruising and bleeding were not included, since this review concentrates on the final more long-term aesthetic results.

Eligible studies were randomized controlled trials, controlled trials, cohort studies and case series (≥10 participants), without language restrictions. Studies were also excluded when additional cosmetic or surgical procedures were done simultaneously or during follow-up (e.g., peeling, 'double eyelid' operation, 'Asian blepharoplasty', surgical creation of a supratarsal crease, lower blepharoplasty; ptosis correction, browpexy).

Study selection (see flowchart)

Duplicates were removed by one observer (MH). Further study selection was performed by two observers (MH & JS) and was conducted in two steps. On assessing the titles and abstracts according to the inclusion criteria, the selection process was tested by applying the inclusion criteria to a sample of 10 excluded papers to check whether they could be interpreted reliably. The full text was only assessed if the study appeared to meet the inclusion criteria or when a decision on inclusion could not be made based on the title and/or abstract alone. The quality of the assessment was piloted by applying the MINORS criteria[17,18] and by completing the data extraction form on a small sample of papers. Subsequently, two observers independently performed the study selection. Disagreement was discussed during a consensus meeting. When necessary, a third independent expert (RS) was available to make a binding decision.

Inter-observer agreement

After assessing the titles and abstracts, the agreed observations between the two observers (MH & JS) was 97.5% and 100% after the consensus meeting. The Cohen's kappa was 1.0 after the consensus meeting.

Quality assessment

The methodological quality of the included studies was assessed by two independent observers (MH & JS) using the methodological index for non-randomized studies (MINORS) criteria[17,18].

Data extraction

After a full-text assessment, both observers (MH & JS) extracted the data from the included studies using the data extraction form and checked the data independently for accuracy and completeness.

Data synthesis

The included studies comprised a range of outcomes, therefore the data could not be pooled and no meta-analysis was possible. We therefore only report a narrative synthesis.

RESULTS

Study selection

A total of 4043 studies (after removal of duplicates) was screened, of which 127 full texts were assessed for eligibility. 26 studies were suitable for systematic review. The first search was performed on October 10, 2018. This search was updated on February 22, 2019, but did not result in any additional studies. Also, the search of the reference lists did not result in additional inclusions (see figure I).

Study characteristics (Table I)

The aesthetic outcomes after an upper blepharoplasty consisted of patient reported outcome measures (PROMs), panel or expert evaluation, the amount of scarring, eyebrow height and tarsal platform show. The MINORS assessment of study quality revealed a mean (± standard deviation) score of 13.5±6. Below, we describe a synthesis of the included studies.

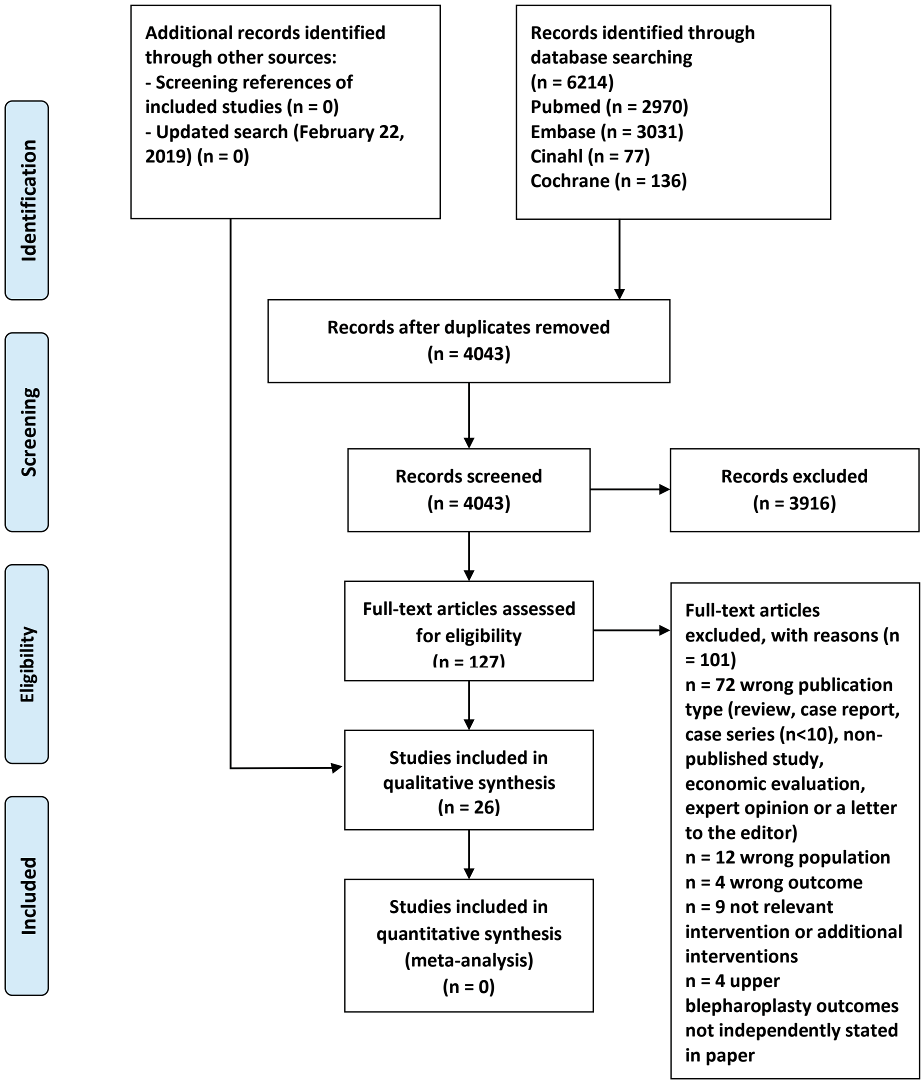

Figure I. Flow diagram

Table I.

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X						Joshi et al (2007)[19]	Evaluation of established suture materials and techniques for blepharoplasty closure and evaluate for any differences in rates of complications between these groups.	(1) Prospective study. (2) Removal of a strip of skin. Redundant muscle was also resected. The septum was cauterized Upper eyelid fat removal on indication. (3) Markings not stated.	Erythema, suture marks, wound infections, milia, standing cone deformity, unacceptable scarring, dehiscence and satisfaction.	866	52	86%	There were significant differences between the groups with respect to formation of milia, scarring and persistent erythema ($p<0.008$). Fast absorbing gut suture with two interrupted prolene sutures yielded the best results and lowest rates of complications. Satisfaction (568 patients): 74% highly satisfied, 21% satisfied, 5% unsatisfied.	3	16
X						Van der Lei et al (2007)[20]	Report on experience with bipolar coagulation-assisted orbital septoblepharoplasty.	(1) Retrospective study (2) Skin/muscle (3) Crease demarcation (7-9mm above upper eyelid margin centrally), medially from the level of lacrimal punctum and laterally the extension depends The crease on the presence of lateral hooding.	Complication scoring (satisfaction and scarring)	296	53.7 (females) 56.0 (males)	84	Satisfied / very satisfied (data not shown)	9 weeks (72%), 24 months (28%)	8

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X		X	X			Jaggi et al (2009)[21]	Patient satisfaction, pain and wound quality of absorbable suture closure versus non absorbable suture closure in upper blepharoplasty.	(1) Prospective, split face study (Closure of the incision using absorbable sutures and non-absorbable sutures). (2) Removal of skin, muscle and fat (3) Supratarsal crease bilaterally, and a temporal flare was placed in a suitable crow's foot.	Validated questionnaire (BOE-questionnaire) on patient satisfaction, scar visibility, pain.	28	ns	ns	No significant differences.	>12	19
X		X				Thomas & Perez-Guisado (2012)[22]	Explanation of a new approach for anatomical reconstruction of the upper-eyelid crease and the results obtained when an independent resection of the orbicularis oculi muscle, and subsequent suture are performed.	(1) Retrospective study. (2) Removal of skin and independent resection of orbicularis oculi muscle, similar in size to the resected skin. The orbital septum is opened and middle pocket is trimmed using dissection, excision and cautery. The excess medial fat pocket is removed in a similar fashion. Subsequent suturing of the muscle and then the skin was sutured. (3) Markings showed as figure.	Patients were asked if they were completely satisfied of dissatisfied with the outcome of their operation.	50	53.6	84%	98% satisfied 2% unsatisfied and re-intervention needed	2	8

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X		X				Van Exsel (2016)[23]	To investigate the efficacy of arnica ointment after upper blepharoplasty.	(1) Prospective study. (2) Removal of skin and 2- to 3 –mm strip of orbicularis oculi muscle without opening the orbital septum. The septum was then cauterized. (3) Marking not stated.	Study participants were randomized for topical arnica ointment or placebo ointment. Primary outcome: Subjective overall outcome of the appearance of the periorbital areas as based on light photography.	116	53.6 in the Arnica group 56.5 in the placebo group.	76%	Patient satisfaction: Satisfaction with postoperative recovery was 9.1 (range 4.9-10 in the arnica study-arm and 9.5 (range 7.1-10) in the placebo arm. Satisfaction with the postoperative cosmetic outcome was high, scoring 9.3 (range 5.5-10) in the arnica arm and 9.3 in the placebo arm (p=0.872).	1.5	24

3

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X	X	X				Jacobsen et al (2017)[13]	Investigation of the functional benefits and patient satisfaction with upper blepharoplasty.	(1) Prospective study. (2) Upper blepharoplasty as described by Drolet & Sullivan (2014). The skin is removed, no or little removal of orbicularis, removal of fat if necessary in case of asymmetry. (3) Lenticular marking.	Before and after blepharoplasty standardized photographs were taken and quantitative measurements were performed: Skin fold/MRD-visual axis (right and left eye) Skin fold/MRD-visual axis(worst eye) A questionnaire concerning functional, psychosocial impact of their eyelids and (postoperative) their satisfaction with the result. The surgeon who performed the operation evaluated the surgical outcome using a five-step-scale.	45	59.6	76%	The mean change in skin fold/MRD-axis for the worst eyes was 1.43 mm in females and 2.09mm in males ($p=0.16$). Satisfaction with result: All subjects were satisfied with the postoperative result. Surgeon evaluation: Two patients had a fair result and 34 had a good result.	3	11

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X		X	X			Saalabian et al (2017)[24]	Comparison of satisfaction levels of patients in categories of tissue resection: skin, skin/muscle, skin/muscle/fat, skin/fat. Evaluated by questionnaires. Also number of medical preconditions were scored.	(1) Retrospective study. (2) Removal of skin and muscle (when laxity was observed). (3) Along the supratarsal fold to outline inferior resection borders. Distance between superior incision lines and lower border of the brow >12mm. Lenticular medial margins, lateral triangular margin markings.	Medical records review, questionnaire, telephone inquiry.	387	63.5	83.5	Aesthetic and scar related aspects, recovery period, complication rates: no differences between tissue resection groups. With more risk factors: longer recovery period, more complications, worse scar ratings.	ns	11
X						Raschke et al (2011)[25]	Description of an objective photo-assisted evaluation for pre- and postoperative evaluation of blepharoplasties.	(1) Prospective study. (2) Excessive skin excision with redundant fat from medial and central fat compartment. (3) Marking the lax skin above the supratarsal fold.	Patient satisfaction questionnaires.	31	57	100% female	Most patients highly satisfied (11 patients; 78.6%).	3	12

3

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X			X			Bellinvia et al (2013)[16]	To describe a technique for upper blepharoplasty reducing the need for browpexy or browlifting. Indications and surgical outcomes are also presented.	(1) Retrospective study. (2) Removal of skin and medial fat pads when indicated. The strip of orbicular muscle was not excised. (3) Cutaneous excision extended beyond he eyelid to include the lower lateral portion of the eyebrow area.	Telephone interview including overall satisfaction (very satisfied, satisfied, dissatisfied) and the degree of visibility of scars (insignificant, modest, marked).	100	ns	ns	Overall satisfaction: 83% very satisfied 16% satisfied 1 dissatisfied Visibility of scar: 92% insignificant 8% modest 0% marked	>36	8

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X	X	X				LoPiccolo et al (2013)[15]	To conduct a single-blind, randomized, controlled, split-face study to evaluate the effects of orbicularis oculi muscle stripping on upper eyelid blepharoplasty.	(1) Prospective, randomized, single-blind, split-face-study. (2) Each patient was randomized to receive upper lid blepharoplasty with orbicularis oculi muscle stripping on one eyelid (treatment) and without muscle stripping on the other (control) (3) The bilateral upper lids were first marked along the supratarsal fold to delineate the inferior boarder of the excision, approximately 8–9 mm above the ciliary margin. The superior portion was marked at least 10 mm from the inferior brow edge. Lines connecting these margins were then inked to define the lateral borders of the excision, with the medial portion being lenticular and the lateral more trapezoidal in shape.	Subjects performed cosmetic evaluation (scar thickness, width, color, texture, and overall lid appearance). A composite score was calculated as the sum of these five scores. In addition, two blinded physicians assessed the overall cosmetic outcome using photographs. Scoring for each parameter was performed on a scale of 1 (excellent eyelid aesthetics, scar matches surrounding skin) to 5 (poor eyelid aesthetics, scar does not match surrounding skin) for patient and blinded physician evaluations.	10	56.9	70% female	Blinded physician evaluation failed to show a difference in the overall cosmetic appearance of the eyelids between the control and treatment sides at any time point. Analysis of the composite of all patient scores showed a trend favoring the control side at 3 months ($p = .28$) and the treatment side at 17 months ($p = .50$), but neither difference was significant.	17	20

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X						Paixao et al (2006)[26]	To evaluate the impact on quality of life of patients submitted to upper blepharoplasty.	(1) Prospective study. (2) not stated (3) not stated	Standardized questionnaire on quality of life and complications.	41	Median 53±±9.3	100%	Quality of life with greater impact on the first postoperative week was related to physical appearance perception. Satisfaction levels with the surgery were significantly related with absence of undesirable effects ($p<0.01$)	3	11
	X					Baker et al (2002)[27]	Comparison of free beam CO_2 laser versus Diamond laser scalpel.	(1) Prospective, split face study, blinded evaluation. (2) Skin/Muscle 241 Fat removal. (3) Markings not stated.	Intraoperative: time of surgery, bleeding Postoperative: erythema, bleeding, edema, pain, wound/scar appearance	10	Range 46-61	80% female	No significant differences between groups	4	20
	X		X			Ritland et al (2004)[28]	Comparison of hemorrhage and wound healing after radiosurgery or conventional surgery for dermatochalasis.	(1) Prospective, split face study. (2) scalpel incisions on one side, radiosurgery on the other side. Orbicularis tissue was removed. No fat removal. (3) Markings not stated.	One masked colleague scored hemorrhage/ edema/discoloration and wound healing (Hollander score) 1 hour, 1, week, 3 months after surgery.	13	65	69% female	Tendency of higher Hollander score at 1 week after radiosurgery. Both good results at 3 months.	3 months	19

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
	X					Damasceno et al (2011)[29]	Comparison of the aesthetic outcomes of upper blepharoplasty with or without resection of the preseptal orbicularis oculi muscle.	(1) Prospective, randomized, double-blind, split-face study. (2) One side (Group 1): Resection of only skin. Other side (Group 2): Resection of skin and the same amount of preseptal orbicularis oculi muscle. Orbital fat was preserved in all cases. (3) The mark was extended from a point above the lacrimal punctum to the lateral canthus. Then, the mark was extended laterally and superiorly as far as the orbital rim.	Three masked ophthalmic plastic specialists analyzed aesthetic outcomes by the visual analogical scale 7, 30 and 90 days after upper blepharoplasty.	15	56.7	100% female	1 week postoperative:: Mean VAS-score 4.6 group 1; 6.5 group 2 (p=0.01) 1 month postoperative: Mean VAS-score 6.7 group 1; 6.8 group 2 (p=0.09) 3 months postoperative: Mean VAS score 7.9 group 1; 8.2 group 2 (p=0.20)	3 months	22

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X	X		X			Scaccia et al (1994)[11]	Comparison of two closure techniques; running subcuticular 5-0 polypropylene and running skin suture 6-0 fast absorbing catgut	(1) Prospective, double-blind study. (2) Skin, muscle and fat excision (3) Elliptical.	Clinical evaluation: infection, erythema, suture marks, milia, uneven scar, hypertrophic scar, dehiscence, final aesthetic result. Postoperative discomfort scale 0-10. Photographic evaluation by surgeon and patient: which side best result on scale 0-10	20	ns	ns	Tendency that absorbable running suture has slightly superior aesthetic result, somewhat faster in wound closure, improvement in patient comfort. Physician assessment showed a preference for the results obtained with the fast-absorbing suture: subjective ratings averaged 9.5, compared with 8.6 for the polypropylene suture. Self-assessment by patients paralleled this result.	Mean 3.5 (range 1-8)	19

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
X	X		X			Kouba et al (2010)[14]	To assess upper eyelid blepharoplasty scars in participants whose incision had been closed with 6-0 polypropylene sutures, 6-0 fast-absorbing gut sutures, or ECA.	(1) Prospective, split-eyelid, single-blinded randomized study. (2) Surgical technique not stated. (3) Modified elliptical incision.	Split-eyelid study of the short (1-month) and intermediate term (3 months) efficacy of polypropylene, fast-absorbing gut and ECA. Participant preference closure technique and cosmetic evaluation (thickness, width, texture, color change, overall cosmetic outcome). Blinded physician assessed cosmetic outcome by using photographs. Scoring was performed on a 5-point scale (excellent wound healing, scar matches surrounding skin) to 5 (poor scar wound healing, does not match surrounding skin).	36	55.8±5.4	97% female	At 1 month, ECA was superior to fast-absorbing gut (2.33 vs 2.83; p= 0.03) and had a marginally better outcome than polypropylene (2.33 vs 2.67; p= 0.25), and polypropylene had an equivalent outcome to fastabsorbing gut (p= 0.46). At 3-month follow-up, ECA remained superior to fast-absorbing gut (p= 0.03).	3	20

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
				X		Prado et al (2012)[32]	Assessing the occurrence of secondary brow ptosis after upper lid blepharoplasty.	(1) Prospective study. (2) Preseptal orbicularis skin and muscle were removed using a scalpel. The orbital septum was opened and the preaponeurotic fat was removed. (3) Markings not stated.	Pre-and postoperative photographs and angular measurements were used (lateral canthal angle of the brow, the most medial point of the brow and the medial canthal angle and the lateral canthal angle of the lid as reference points.	45	60.5±	82% female	Significant changes in all angular measurements obtained before and after upper blepharoplasty (in accordance with tendency of the brow to move down). Alterations are most apparent in the lateral portion of the eyebrow.	2-4	8
				X		Huijing et al (2014)[33]	Evaluation of the direct effect of an upper eyelid blepharoplasty on the position of the eyebrows in a population with complaints of visual impairment.	(1) Study design not stated (Retrospective/prospective). (2) Excessive skin was excised together with a 2mm strip of orbicularis muscle after which the orbital septum was shrunken by electrocoagulation. (3) Crease demarcation (7-9mm above upper eyelid margin centrally), medially from the level of lacrimal punctum and laterally the extension depends The crease on the presence of lateral hooding.	Measuring the position of the eyebrows at three positions for each eye (center of pupil, lateral iris and lateral canthus) by using standardized photographs.	140	55.1	90% female	Mean drop in eyebrow position for all patients at each point ranged from 0.35% to 1.23%. In females no significant drop of the eyebrows after surgery. In males the distance from the center of the pupil to the inferior border of the eyebrow of the left eye displayed a significant decrease of the eyebrow of 7% (p=0.005).	2	10

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured out-come(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
				X		Pool and Van der Lei (2015)[34]	Evaluation of dermatochalasis, eyebrow position and (a)symmetry in both sides in patients before and after blepharoplasty.	(1) Retrospective study. (2) Bipolar coagulation assisted orbital (BICO) septo-blepharoplasty. This consists of removing redundant skin, a very small rim of the preseptal orbicularis muscle. Subsequently, bipolar coagulation of the septum is performed resulting in shrinkage of the septum and disappearance of the bulging fat compartments without removal of the fat. (3) Crease demarcation (7-9mm above upper eyelid margin centrally), medially from the level of lacrimal punctum and laterally the extension depends on the presence of lateral hooding.	Pre-and postoperative photographs were evaluated for (asymmetry in) degree of skin surplus (5-point grading scale), eyebrow height (distance between lower bound of eyebrow and center of the pupil) and eyelid fissure height (distance between upper and low	365	51.5	86.3% female	Eyebrow height: Preoperative mean 15.8mm for the right side and 15.9mm for the left side. Postoperative mean 15.2mm for the right side and 15.1mm for the left side. On both sides the eyebrow height was significantly lower postoperatively than preoperatively (p=0.000). This applied to males and females. Degree of skin surplus: Skin surplus was significantly lower postoperatively vs preoperatively (p=.000). Asymmetry in degree of skin surplus was present in 107 patient preoperatively vs 52 postoperatively (p=.000)	2.5	8

3

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
				X		Baker et al (2016)[35]	Evaluation of internal suture browpexy, endoscopic Endotine browplasty and to compare these techniques in patients undergoing simultaneous upper blepharoplasty.	(1) Retrospective study. (2) Removal of skin and orbicularis muscle. (3) Markings not stated.	Standardized photographs were used to measure pre-and postoperative brow position at three positions (central, medial and lateral)	30 (blepharoplasty only group)	67 (blepharoplasty only group)	63% female (blepharoplasty only group)	Significant brow descent at all three brow positions (mean -1.7mm, p≤0.04)	4.1-5.2	12
				X		Hassanpour and Kermani (2016)[36]	Analyzing the effect of upper blepharoplasty on eyebrow position.	(1) Retrospective study. (2) Skin excision (authors of this study also mention that all patients underwent 'traditional blepharoplasty'). (3) Markings not stated.	Pre-and postoperative digital photographs and measuring the distance between the upper lid margin and the brow were measured.	70	49.7	83% female	The postoperative brow position was unchanged in 46 cases (65.8%) and brow depression was noted in 24 cases (34.2%). The measurements after blepharoplasty showed significant differences from those before surgery. Changes were more significant in the lateral portion of the eyebrow and they occur bilaterally. (p-values not stated)	6	8

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
				X	X	Starck et al (1996)[37]	Description of a method for quantification of changes that occur after blepharoplasty.	(1) Not stated. (2) Not stated. (3) Not stated.	Photographs were recorded and expressed as anthropometric ratios. Anthropometric measurements consisted (amongst others) of medial browheight (inferior medial brow to endocanthion) and lateral brow height (inferior lateral brow measured vertically from exocanthion to endocanthion line at iris).	15	54	100% female	Medial and lateral brow heights were not significantly affected by upper blepharoplasty surgery.	6	9

3

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
				X		Frankel et al (1997)[38]	Evaluation if upper eyelid blepharoplasty causes eyebrow position to drop in a cosmetic surgery population.	(1) Retrospective study. (2) Excision of skin, a strip of orbicularis muscle and fat when indicated. (3) Not stated.	Change in eyebrow height reflected as a percentage of the pretreatment height. Measurements are based on standardized photographs. The measurements included the distance from the midpupil vertically to the inferiormost eyebrow hairs and from the inferior alar-labial groove to the medial canthus.	40 in the treatment group (subgroup) and 28 in control group)	45.5 in the treatment group	90% female	The mean drop in eyebrow position for the treatment group was 7.69% and for the control group 7.80% (p=0.08). No statistically significant difference between the two groups.	9 -40 months	16
				X		Dar et al (2015)[39]	Evaluating the effect of upper blepharoplasty on eyebrow height, accounting for ocular dominance, fat excision, change in MRD1 and degree of dermatochalasis.	(1) Retrospective study. (2) Excision of redundant skin, orbicularis muscle (leaving a small strip of orbicularis inferiorly) and fat when indicated. (3) Markings not stated.	Standardized photographs and digitally measuring medial canthus to inferior eyebrow cilia, center of the pupil to the inferior eyebrow cilia, central upper eyelid margin to the corneal light reflex and from the lowest point of dermatochalasis to the corneal light reflex.	19	73.2	53% female	No significant changes in eyebrow height at all positions. Multivariable comparison found insufficient evidence to suggest MRD1, ocular dominance, or dermatochalasis were significantly associated with mean percentage change in brow height at all positions with or without fat excision.	>1.5	7

Table I. (Continued)

PROM	Panel/Expert	Satisfaction	Scarring	Eyebrow height	Tarsal Platform Show	Author (year)	Aim	(1) Study design (2) surgical technique (3) preoperative markings	Method of measured outcome(s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender (% female)	Outcomes	Length of follow up (months)	MINORS score
				X		Fagien (1992)[40]	Determination if significant brow ptosis occurs after removal of excessive upper eyelid skin in patients with brow ptosis.	(!) Study design not stated. (2) Excision of skin and orbicularis muscle. Some patients underwent excision and contouring of the sub-brow fat. Herniated orbital fat pads were excised when present. (3) Horizontal elliptical markings.	Measurements of margin to reflex distance (MRD), margin to fold distance (MFD), eyebrow to lid margin distance (BLD) and eyebrow to skinfold distance.	15	62	Not stated	11 (of 15) patients had a change in their eyebrow position (average of 1mm) after surgery. Two patients had a mild descent of the eyebrow (average ≤2mm) two patients were felt to have significant induction of eyebrow ptosis (average ≤3mm).	6 -24	5
					X	Novaes de Figueirdo et al (2016)[41]	Evaluation of the efficacy of upper blepharoplasty with or without a technique (brassiere sutures) to increase tarsal platform show (TPS) and decrease brow fat span (BFS).	(1) Prospective, randomized study. (2) Traditional upper blepharoplasty (removal of preseptal orbicularis muscle and skin; group A) versus orbicularis oculi muscle fixation to the periosteum (Group B). (3) Marking not stated.	Tarsal platform show (TPS) and brow fat span (BFS) measured at three anatomic landmarks. Asymmetry calculated as the smaller subtracted from the larger value of TPS and BFS.	50 (28 group A, 22 group B)	Group A: 60.7 Group B: 55.0	100% female	Preoperative and postoperative evaluation: Significant increase in TPS and decrease in BFS in both groups ($p<0.05$). No significant differences between the groups in TPS, BFS and TPS/BFS ratio ($p>0.05$). No significant asymmetries ($p>0.05$).	8.9 months	21

3

PROMs

Satisfaction with appearance and improved quality of life are important outcomes for patients undergoing facial aesthetic procedures. Twelve studies evaluated an aesthetic aspect using a PROM. Most of these studies used a blepharoplasty technique whereby skin, orbicularis muscle, and fat (on indication) were removed[11,13,19–24.] Patient satisfaction after blepharoplasty was generally high[13,19,23]. Van Exsel et al.[23] removed skin and a small strip of orbicularis muscle (2–3 mm) and patient satisfaction was 9.5 and postoperative cosmetic satisfaction was 9.3 (assessed using a questionnaire with a visual analogue scale). Jaggi et al.[21] used elliptical incisions with a temporal flare in a crow's foot and the patients were satisfied regardless of the suture material used (running fast-absorbing or non-absorbable sutures). Also, 98% of the patients were satisfied when skin and orbicularis muscle were removed and independently sutured[22]. Joshi et al.[19] and van der Lei et al.[20] both cauterized the septum during blepharoplasty, and the patients were satisfied according to their satisfaction scoring method[19,20.] Saalabian et al.[24] compared the satisfaction levels of patients according to tissue resection categories (skin, skin/muscle, skin/muscle/fat, skin/fat). There were no differences in relation to scar aspects, recovery period, or complication rates. However, patients with more risk factors (i.e., hypertension, smoking, and anticoagulation or platelet antiaggregation therapy) showed worse scar ratings, a longer recovery period, and more complications. Scar aspects were also evaluated by Kouba et al.[14] and concluded that tissue adhesive appears to provide greater cosmesis than absorbable suture material. There were only two skin-only studies in which resection of fat was performed when indicated[16,25]. Patients were highly satisfied in most cases, with high satisfaction ranging from 78.6%[25] to 83%[16]. One study used a split-face design whereby one side had only skin removed and the other had skin and orbicularis muscle removed, but there was no significant difference in cosmetic appearance of the eyelids between the two techniques[15]. Paixao et al.[26] did not specify their surgical marking or techniques used. However, they concluded that satisfaction levels with the surgery were significantly related to the absence of undesirable effects (i.e., hypertrophic scar, small changes in vision, chemosis, pruritus, milia, and the feeling of tightness). In summary, patients are generally satisfied after an upper blepharoplasty. It appears that the technique used, suture material used, and whether or not the septum is coagulated do not influence patient satisfaction. However, only a few split-face or randomized controlled trials compared these techniques using patient reported aesthetic outcomes. Also, the shape of the surgical markings was not always described, so the influence of this rather important variable on aesthetics could not be assessed.

Expert panel or expert evaluation

Surgeons may have a different interpretation of the result than the patient. All studies with an expert evaluation had removed skin and orbicularis muscle[11,15,27–29], or no or little removal of orbicularis muscle[13], or did not state their technique[14].Two studies had a split-face design to compare the aesthetic outcomes of upper blepharoplasty with or without resection of the preseptal orbicularis oculi muscle. Blinded physician evaluations of the overall cosmetic appearance did not differentiate significantly between the eyelids on the two sides[15]. Damasceno et al.[29] concluded that the aesthetic outcome was worse on the skin-only side compared to the skin–muscle side at 1 week postoperative, but not at 1 month or 3 months postoperative. Baker et al.[27] compared upper blepharoplasty performed with a free beam CO2 laser or with a diamond laser scalpel to make surgical incisions and found no significant difference between the groups regarding wound or scar appearance. Skin, orbicularis muscle, and fat were removed in their patients. Also, Ritland et al.[28] compared the use of a scalpel and an electrosurgical instrument when removing skin and orbicularis muscle (fat was preserved). At 3 months, there was no significant difference in the Hollander wound score, which assesses step-off borders, contour irregularities, margin separation, edge inversion, excessive distortion, and overall scar appearance[30]. Thus, expert evaluation found no apparent influence on the aesthetic outcome for the depth of the resected tissue (skin/muscle/fat) or the use of different surgical instruments to make the skin incision.

Scarring

The amount of visible scarring is vital for the aesthetic outcome after upper blepharoplasty. The optimal scar is invisible. There are various ways of assessing scar aspects such as pigmentation, vascularity, irregularities, and length and width, either self-reported or as assessed by experts or a panel. Six studies evaluated scarring after blepharoplasty, three of which considered different suture materials. Scaccia et al.[11] removed the skin after elliptical surgical markings, orbicularis muscle, and fat. On a scale from 1 to 10 (10 being excellent results), the physician's subjective ratings after 3 months averaged 9.5 for the running 6–0 fast absorbing catgut suture, compared to 8.6 for the running 5–0 polypropylene suture[11]. The patients' self-assessments paralleled this result[11]. In contrast to this, Jaggi et al.[21] reported no differences in patient-reported scar visibility when using absorbable or non-absorbable sutures. In another study[14], participants and a blinded physician rated scars and the overall cosmetic outcome on a five-point scale (0 being excellent wound healing, scar matches surrounding skin) after using different suture materials. It was mentioned that only a modified elliptical marking was used. Tissue adhesive (ethyl cyanoacrylate, ECA) had a superior cosmetic outcome after 1 month compared to 6–0 fast absorbing gut (P= 0.03), but there were no significant differences when comparisons were made with 6–0 polypropylene. The mean score decreased at 3 months postoperative as the scars became less visible. Participant and physician ratings for the overall cosmetic outcome were the same for the different suture materials used. The participants were also asked to evaluate the scar outcome according to five categories: thickness, width, texture, colour change, and overall cosmetic outcome. The most significant differences here were that ECA was preferred over fast-absorbing gut suture in each of the following categories: scar thickness at 1 month ($P = 0.04$) and 3 months ($P = 0.03$), erythema at 1 month ($P = 0.03$), and composite score (sum of scores for thickness, width, texture, colour change) at 1 month ($P = 0.03$) and 3 months ($P < 0.001$). Scar texture did not differ between the groups[14]. Saalabian et al.[24] compared aesthetic and scar-related aspects between the tissue resection categories (skin and/or muscle and/or fat) and found no differences. Ritland et al.[28] used the Hollander wound score and found good results after 3 months (skin and muscle removal). Furthermore, the visibility of the scar in the study by Bellinvia et al.[16] was classed as insignificant by 92% of the respondents after 8 months of follow-up, despite the extension of the excision beyond the lateral orbital rim (removal of skin with or without fat). In summary, the amount of scarring after upper blepharoplasty appears to be acceptable. However, data were conflicting or missing regarding suture material, suture technique (e.g., running, intradermal, or solitary), the shape of the surgical markings, whether the surgical marking was beyond the lateral orbital rim or not, and as to which blepharoplasty technique should be used to achieve the least amount of visible scarring. Interestingly, no study mentioned whether any measures should be taken to minimize wound tension and/ or enhance wound healing. Also, scar maturation can take more than 1 year[31], so it would be advisable to have at least 1 year of follow-up when assessing scar aesthetics.

Eyebrow height

Decreased eyebrow height and dermatochalasis are the two main causes of lateral hooding, i.e. the excess skin lateral to the eyelid. Consequently, pre- and postblepharoplasty aesthetics are affected by both the amount of excess skin and the possible change in position of the eyebrow. Therefore, the peri-orbital region with eye and eyebrow is considered as one aesthetic unit. Nine studies assessed the occurrence of secondary brow ptosis after upper blepharoplasty. They all reported some lowering of the eyebrow after blepharoplasty, which was significant in five studies (a total of 650 participants)[32–36]. Four studies (a total of 89 participants) either mentioned insignificant results for eyebrow height[37–39] or did not mention any significance levels[40]. No study reported elevation of the eyebrow after upper blepharoplasty. The duration of follow-up varied widely between the included studies (from 1.5 to 40 months). Most of the studies performed an upper blepharoplasty that consisted of skin excision and at least removal of the orbicularis muscle. Only Starck et al.[37] did not mention their surgical technique. All studies used standardized pre- and postoperative photographs to evaluate eyebrow height, except for Fagien et al.[40], who did not specify their method. However, most of these studies failed to provide a detailed description of how the standardized photographs were taken. Only Prado et al.[32] and Dar et al.[39] described their standardization, which were "primary, maximally relaxed, standard fashion" and "primary position of the eye", respectively. When an eyebrow descent was measured, this was observed for the whole eyebrow[34,35], for the middle portion in males[33], and as most pronounced in the lateral part of the eyebrow[32,36]. The four other studies did not report a significant effect on eyebrow descent after upper blepharoplasty[37–40]. In summary, the eyebrows tend to move down after blepharoplasty, although the extent and the influence on the aesthetic outcome require further elucidation.

Tarsal platform show (TPS)

Masking of the tarsal platform, also known as the 'eyeshadow space', may be considered an undesirable trait. The tarsal platform can be masked by dermatochalasis and/or brow ptosis. Therefore, the distance between the upper eyelid and the crease (TPS or upper lid sulcus height) and the area between the sulcus and eyebrow (brow fat span, BFS) affect the aesthetic outcome after upper blepharoplasty. Novaes de Figuerdo et al.[41] showed an increase in TPS and a decrease in BFS, after the traditional blepharoplasty technique (removal of preseptal orbicularis muscle and skin), without asymmetry. This was similar across the three measured regions: the centre of the pupil region, lateral corneal limbus region, and at the eyelid lateral canthus. Starck et al.[37] evaluated the anthropometric measurements and found that the TPS was doubled postoperatively ($P < 0.05$), and that upper iris coverage had decreased slightly postoperatively (-6%; $P < 0.05$). The blepharoplasty technique was not stated. In summary, the amount of visible eyelid skin/tarsal show increases after blepharoplasty.

DISCUSSION

The purpose of this systematic review was to gain a better understanding of the aesthetic results after upper blepharoplasty and to determine which surgical technique is preferable. It appears that patients are generally satisfied with the overall aesthetic results after any surgical upper blepharoplasty technique. However, these results should be interpreted with care because of the possible presence of publication bias and also because of the poor quality of some of the studies. Since blepharoplasties are performed to give a pleasing aesthetic result, it is possible that only positive results are published and negative results may not be. Also, not all studies mentioned whether all consecutive patients were included and several studies were retrospective. Another potential bias is the fact that not all studies were executed in a double-blind, or even single-blind manner, which is especially important when evaluating aesthetic results. It is difficult to measure aesthetic results objectively. Beauty is in the eye of the beholder and therefore the definition of a beautiful eye varies, but it is generally agreed that youthfulness correlates with attractiveness. In other words, an eye is considered to be 'attractive' when it has typical youthful features instead of aging ones[3]. A beautiful, youthful eye is described as full and convex[7,8,42–50.] Conversely, an aging eye appears hollower, due to volume loss and fat atrophy. Therefore, a trend is noted in blepharoplasty surgery towards a more conservative treatment of only removing excess skin[7], presumably preventing the hollowing of the eye with aging. Histological studies have revealed that changes in the aging upper eyelid occur primarily in the skin and subcutaneous layers, with characteristic loss of collagen elastic fibres, while the whole muscle layer remains histologically intact, with no signs of aging[51]. Therefore, preserving the orbicularis muscle during upper blepharoplasty, to supposedly maintain a fuller and more youthful upper eyelid, is postulated to be a wise approach[16]. Based on the results of the present systematic review, the technique used (skin only or additional muscle resection) does not influence aesthetic outcomes. Therefore, it seems rational to perform the least invasive method (skin only). The eyebrows are also an important part of the periorbital aesthetic unit. Although it is not entirely clear what happens with the eyebrows during aging, it seems that they tend to descend as the years pass[3,52]. The lateral end of the eyebrow drops in older people due to progressive loss of collagen fibre elasticity, changes in the orbital rim contour, and lipoatrophy[3,52], creating lateral hooding and limiting tarsal show. The temporal part of the eyebrows descends more and earlier than the more central parts[52]. Ko et al.[52] state that the lack of deep tissue support and lack of suspension from the frontalis muscle are more pronounced in the lateral part of the eyebrow, but this may not apply to men[53]. Regarding attractiveness, the more homogeneous and even the tarsal show, the more attractive the eye[3]. This often means addressing the lateral hooding. Some authors state that skin resection should not extend beyond the lateral orbital rim, because the scar will not be hidden within a natural skin fold[12]. The lateral hooding may then be corrected by an eyebrow or forehead lift, but this is not always necessary or wanted. Friedland et al.[54] and Bellinvia et al.[16] proposed a technique that includes extending the upper incision further laterally and upwards, towards the tail of the eyebrow. However, Beraka et al.[55] wrote a response commenting on this method. The studies included in this systematic review reported a variety of excision shapes, if mentioned at all. Therefore, it remains uncertain as to which shape of skin excision should be used for which indications.

CONCLUSIONS

In conclusion, patients are generally satisfied with the overall aesthetic result and scar formation after upper blepharoplasty. It results in an increase in the tarsal platform show which positively affects aesthetics. The eyebrow seems to move downwards after upper blepharoplasty which may or may not affect the aesthetics negatively. The used technique (skin or additional muscle resection) does not influence patient satisfaction, nor aesthetic outcomes. The optimal design of skin excision continues to be a matter of debate, especially when addressing lateral hooding.

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APPENDIX. SEARCH STRATEGY

Pubmed search

(((“blepharoplasty”[Mesh]) OR “eyelids/surgery”[Mesh]) OR (eyelid*[tiab] AND (reconstruction*[tiab] OR surger*[tiab] OR correction*[tiab]) OR dermatochalasis[tiab] OR blepharochalasis[tiab] OR blepharoplasty*[tiab])) AND upper[tiab]

Embase search

‘eyelid reconstruction’/exp
OR
(eyelid*:ab,ti AND (reconstruction*:ab,ti OR surger*:ab,ti) OR dermatochalasis:ab,ti OR blepharochalasis:ab,ti OR blepharoplasty*:ab,ti)
AND
Upper:ab,ti

Cinahl search

(MH “blepharoplasty”)
OR
Eyelid* AND (reconstruction* OR correction* OR surger*)
OR
dermatochalasis OR blepharochalasis OR blepharoplast*
AND
Upper

Cochrane Central register of controlled trials search

blepharoplasty OR eyelid* AND (reconstruction* OR correction* OR surger*) OR (dermatochalasis OR blepharochalasis OR blepharoplast*) AND upper

CHAPTER 4

Patient reported aesthetic outcomes of upper blepharoplasty: a randomized controlled trial comparing two surgical techniques

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ABSTRACT

Background

Although an upper blepharoplasty is a common cosmetic surgical intervention, there is still a need for a better understanding of which surgical technique is preferable, from a patient perspective, regarding the best aesthetic results. It is not yet set whether additional orbicularis oculi muscle excision leads to better patient reported aesthetic results (PRARs) compared to a skin-only resection blepharoplasty.

Methods

A double blind randomized controlled trial of an upper blepharoplasty, with or without muscle excision, was performed on 54 healthy Caucasian patients who assessed the procedure via PRARs. Validated FACE-Q questionnaires (self-evaluation of the eyes in general, upper eyelids, forehead and eyebrows, overall face, age appearance appraisal, age appraisal, social functioning, satisfaction with outcome, adverse effects) were completed preoperatively, and 6 and 12 months after upper blepharoplasty. The Patient and Observer Scar Assessment Scale was used to assess scarring. All scores were compared between groups.

Results

The FACE-Q scores for skin only and skin/muscle upper blepharoplasty were not only similar regarding the upper eyelids, forehead and eyebrows, overall face, patient perceived aging and age, social functioning and satisfaction with results, but also increased for both procedures with time. The FACE-Q score regarding the eyes in general was higher (+17.5%) in the skin-only group at 12 months follow-up. Scarring and adverse effects did not differ between groups.

Conclusions

Additional muscle resection does not seem to influence patient satisfaction. Thus, when performing an upper blepharoplasty, there is no need for additional muscle resection as a routine procedure to improve patient satisfaction.

INTRODUCTION

Dermatochalasis is a major cause of aesthetic dissatisfaction with the periorbital area and an important reason for patients to undergo an upper blepharoplasty. In the past, surgeons were inclined to perform a more invasive blepharoplasty with removal of excess skin together with a strip of orbicularis oculi muscle, sometimes combined with excision or redistribution of fat from the medial and central fat compartments. Nowadays, surgeons tend to be more conservative by sparing the orbicularis oculi muscle and orbital fat because this might preserve the fullness of the upper eyelid region, thus preventing an aged hollow orbit appearance[1-4]. Whether the latter effect is also noticed by patients and regarded as a less appealing aesthetic outcome after blepharoplasty, is currently unknown.

Many upper blepharoplasty studies based their aesthetic outcome conclusions mainly on expert evaluations and technical aspects[5,6]. Infrequently, the treatment outcomes were based on patient reported outcomes with validated questionnaires[3,7,8.] Also, the details of the surgical technique used are often not reported[6,9]. Therefore, it is still not set whether variations in surgical technique result in different patient reported aesthetic results (PRARs).

Although an upper blepharoplasty is a common cosmetic surgical intervention, it is still unknown which surgical technique is preferred by patients for the best aesthetic results. The aim of this randomized controlled trial was to assess the PRARs of two different surgical upper blepharoplasty techniques.

METHODS

Study population

All consecutive healthy Caucasian patients between the age of 30 and 70, that consulted the department of Oral and Maxillofacial Surgery at the University Medical Center Groningen for an upper blepharoplasty between February 2018 and October 2019, were asked to participate (participant enrolment flowchart, see supplemental figure I). Patients were included if they showed dermatochalasis of both upper eyelids and an upper eyelid blepharoplasty was indicated. Consultations were performed by two maxillofacial surgeons (J.J., R.H.S.) with extensive experience in upper blepharoplasties. Patients had to be fluent in Dutch in order to understand the Dutch questionnaires fully. Patients were excluded if they suffered from severe hollowing of the upper eyelid area (including A-frame deformity), had a history of ocular- or orbital trauma, a history of eyelid or eyebrow region surgery, had been subjected to other cosmetic surgical or non-surgical procedures, had ophthalmic disease, or suffered from blepharoptosis.

Study design

A prospective, single-centre, randomized, double-blind, controlled trial investigating PRARs of upper blepharoplasties. The study protocol was approved by the institutional review board (METc2017/451) and registered in the Netherlands Trial Register (ID NL7886). Written informed consent was obtained from all study participants.

Blinding and randomization (figure I)

Eligible participants were randomly assigned to treatment group 'A' (resection of skin only) or 'B' (resection of skin and a strip of underlying orbicularis oculi muscle). Block randomisation (blocks of four) was used by an independent investigator (M.H.J.H.) according to the list created prior to the start of the study by a randomisation computer tool (Sealed Envelope Ltd. 2017). Participants received an unique code in consecutive order, i.e., the first included participant received the first code on the list. Investigators and participants were blinded. Only the surgeons knew which was treatment 'A' or 'B' until the completion of the trial. Participants were informed about both surgical procedures, but did not know which treatment they had undergone, and received identical information about the postoperative course of events.

Outcomes

Demographic data were recorded including age, gender, medical history and use of medication. Severity of dermatochalasis was assessed before upper blepharoplasty and categorized according to a 4-level photonumerical severity scale using anatomical cut-off points: normal if the upper eyelid skin was not touching the eyelashes, mild if the upper eyelid skin was touching the eyelashes, moderate if the upper eyelid skin was hanging over the eyelashes, and severe if the upper eyelid skin was hanging over the eye[10]. The removed tissue was weighed per eye and recorded in grams.

a. FACE-Q

PRARs were obtained at baseline and 6 and 12 months after the surgical upper blepharoplasty by means of validated FACE-Q questionnaires[11-14]. Questions refer to eyes in general, but also to upper eyelids, forehead and eyebrows, overall face, age appearance appraisal, age appraisal, social functioning, and satisfaction with outcome. Scale scores range from 0 (worst) to 100 (best), except for the age appraisal scale. The latter scale score ranges from -15 (best) to +15 (worst). Additionally, a checklist measuring post-blepharoplasty adverse effects was completed.

b. POSAS

Scarring was assessed 12 months after surgery with the Patient and Observer Scar Assessment Scale (POSAS, version 2.0/NL)[15]. POSAS was developed and validated to capture the patients' perceptions of a discrete scar site and consists of two separate domains: a patient and observer domain[14]. The patient scale consists of seven questions, six of which patients have to rate specific characteristics of their scar (pain, itch, colour, stiffness, thickness, regularity). The seventh question rates their overall opinion regarding the scar site. The observer also rates six scar aspects (vascularity, pigmentation, pliability, thickness, relief and surface area (i.e., contraction/expansion)) and calculates a total score. Additionally, the seventh question rates the observer's overall opinion regarding the scar site. All questions are answered on a Likert Scale from 1 to 10, with 1 being no difference between the scar and non-injured skin, and 10 representing the most difference. The total score of both scales is the sum of the scores of each of the six POSAS items (range: 6 (normal skin) to 60 (worst scar imaginable)).

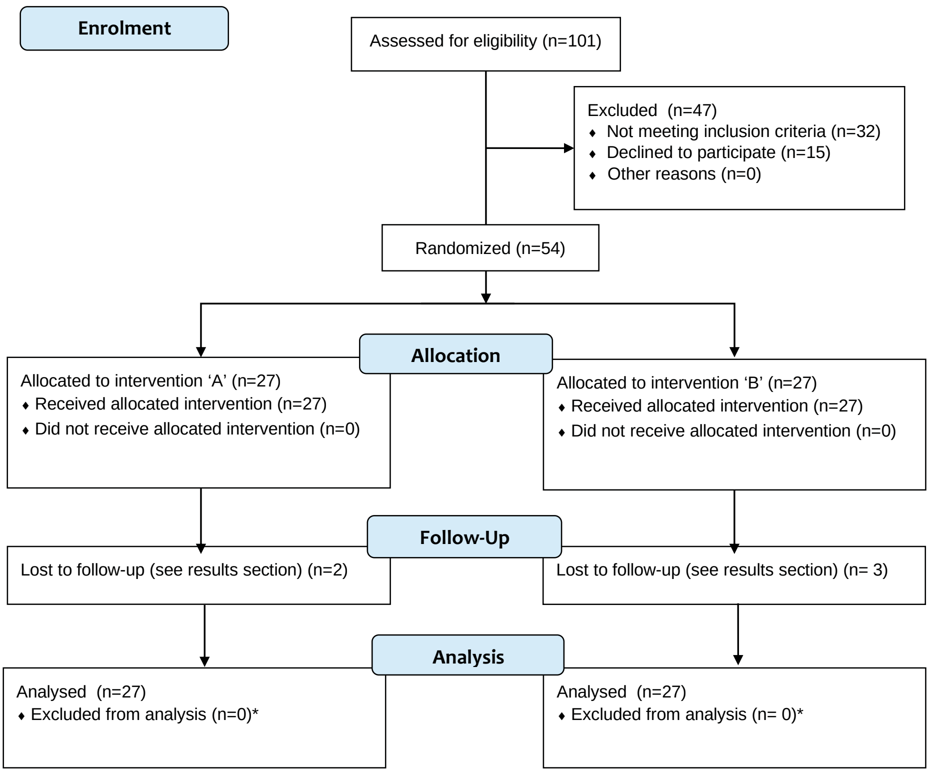

Figure I. Flow diagram participant enrolment

* Only the lost to follow up values were excluded from the analysis.

Surgical procedure

The upper blepharoplasties were performed by two surgeons (J.J., R.H.S.). The surgical procedure was standardized prior to the study, and took place in an outpatient environment, and ad random (i.e. patients were randomized). The performance of the upper blepharoplasties were divided equally between both surgeons. Both groups' procedures were as follows:

Preoperatively, with the patient in an upright position, the surgeon used a marking pen to draw the incision lines on the skin of the eyelids. The lid crease incision was marked first, by generally following the eyelid crease of the upper eyelid. A pinch technique was used to assess the maximum amount of skin to be removed. The patients were asked to close their eyelids gently. A pair of smooth forceps was used to grasp the excess skin above the eyelid crease incision until the eyelashes began to rotate upwards. This was considered to be the maximum amount of skin that could be removed safely. The surgical markings were made within these boundaries (Figure IIa). Approximately 1.7 ml of Ultracaine DS Forte (40 mg Articain, 10 µg Epinephrine per ml) local anaesthetic was injected subcutaneously per eye.

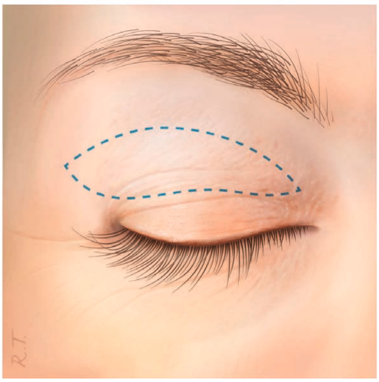

Figure IIa. Shape of surgical markings and skin excision.

After incising the skin with a scalpel, the excess skin was removed (figure IIb). Cauterization was used to achieve haemostasis. The group B participants underwent subsequent removal of an additional strip of the underlying orbicularis oculi muscle (figures IIc and IId). The removed tissue was weighed per eye. The orbital septum was coagulated in order to create scarring and thereby to accentuate the eyelid crease better[3] (figure IIe). The muscle edges were approximated with two to three small bipolar coagulation spots (figure IIf). The skin was sutured with Ethilon 6-0 (Ethicon, Cornelia, Georgia, USA) intracutaneously in a running fashion (figure IIg) and adhesive suture strips were placed. Photographs of the surgical technique are shown in figure IIIa, IIIb, IIIc and IIId.

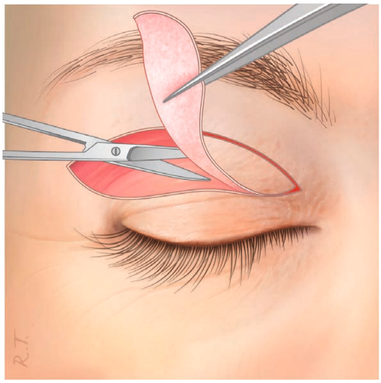

Figure IIb. Removal of excess skin.

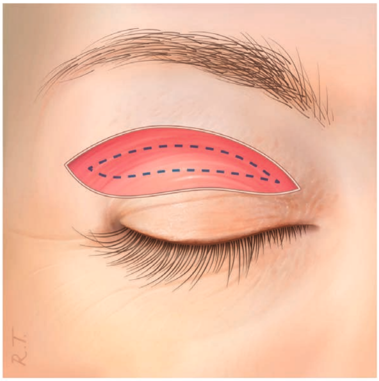

Figure IIc. Shape and amount of orbicularis oculi muscle removed (only in treatment group B).

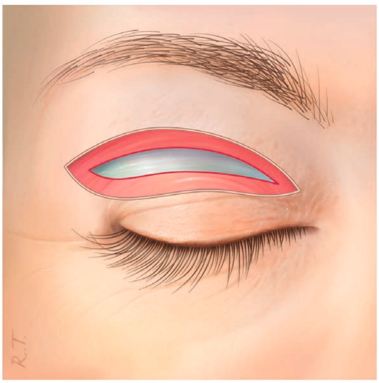

Figure IId. A strip of 2-3mm of orbicularis oculi muscle is removed (only in treatment group B). It is smaller than the initial strip of removed skin.

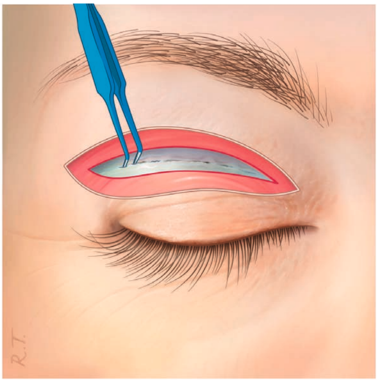

Figure IIe. Coagulation of the orbital septum (only in treatment group B)

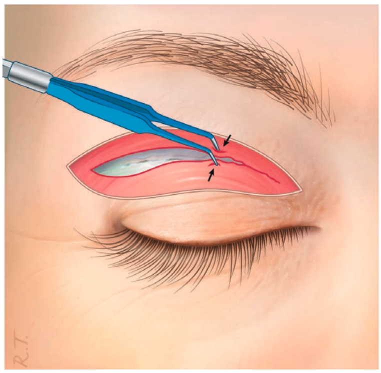

Figure IIf. Approximation of muscle edges with bipolar coagulation on 2 to 3 small spots (only in treatment group B).

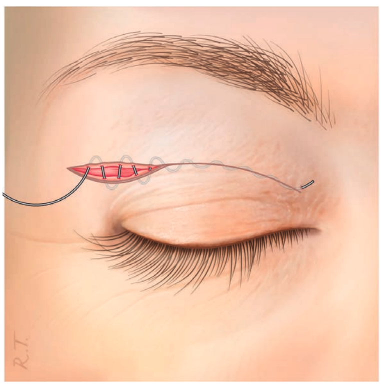

Figure IIg. Intracutaneous sutures running from the medial to lateral side.

Figure IIIa. Shape of surgical markings and skin excision.

Figure IIIb. Removal of excess skin.

Figure IIIc. Placement of intracutaneous sutures running from the medial to lateral side.

Figure IIId. Skin approximation after intracutaneous suturing.

The participants were asked to avoid heavy lifting, sudden bending, and strenuous sporting activities for 7 days following the procedure. The patients were seen 7 days postoperatively to remove the suture strips and sutures, and after 2, 6 and 12 months to be examined and evaluated for potential complications.

When indicated, i.e. when a significant amount of protruding medial fat was present, the patients underwent removal of the protruding medial fat whereby the orbital septum was only opened medially to expose the fat. Pressing the globe gently made the fat protrude through the open septum. The capsules were opened and the pads were trimmed with bipolar coagulation to create the desired contour of the eyelid. All the other treatment procedure steps were identical in groups A and B.

Statistical analysis

Twenty-seven patients were needed per treatment group to detect a difference of 7.0 in FACE-Q score (based on minimally important differences derived from results in literature[16] (G*Power version 3.1.9.6, University of Kiel, Germany) between group A and group B at 6 and 12 months, with a two-sided 5% significance level and a power of 90%, allowing for a 10% attrition rate and 10% for possible non-parametric testing. Data were analysed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test, Kolmogorov–Smirnov test, and graphical interpretation of normal Q–Q plots were used to determine the distribution of the data.

Independent samples t-test was used to assess differences in age and amount of removed tissue between the groups at baseline. Similarly, the Chi Square test of homogeneity was used to evaluate differences in gender, dermatochalasis severity score and medial fat removal between the groups at baseline.

FACE-Q score differences between group A and B were evaluated using generalised estimating equations (GEE). The GEE model included FACE-Q scores, baseline FACE-Q scores, gender, age, dermatochalasis severity score and removed tissue during surgery. P-values <0.05 were considered statistically significant. Missing data were not imputed. Baseline FACE-Q 'Satisfaction with result' scores were not part of the GEE model because there is no baseline 'Satisfaction with result' present before surgery. All residuals showed a Gaussian distribution. Different correlation structures (exchangeable, M-dependent, unstructured) were tested and the model with the lowest information criterion was used, which was the exchangeable correlation structure for all variables.

Pre-and post-blepharoplasty differences were analysed using Friedman test and pairwise comparisons were performed. There were no outliers in the data, as assessed by inspection of boxplots. However, FACE-Q scores were not normally distributed. The Wilcoxon signed rank test was used to evaluate possible differences between the 6 and 12 month postoperative FACE-Q 'Satisfaction with results' questionnaires.

POSAS-scores showed no normal distribution and differences between groups A and B were analysed using the Mann Whitney U test.

Fisher's exact test was used (>20% of the expected cell counts being less than five) to evaluate the differences in the adverse effects (FACE-Q) scores between groups A and B.

RESULTS

The characteristics of the patients included in groups A and B, depicted in Table I, were comparable at baseline. A total of 5 female patients was excluded: two patients (group B) were lost to the 2 month and 12 month follow-ups, two patients (group A) were excluded after the 6-month follow-up visit due to burn-out and to multiple health problems related to a dysregulated diabetes mellitus, and one patient (group B) was excluded from the 12-month analysis because of her wish to correct the scarred tissue of one eyelid after the initial procedure. In the latter patient, the sutures came loose which resulted in a widened scar that was corrected after the 6-month follow-up visit. The procedures were equally divided and the outcomes did not differ between the surgeons. Figure IV and V show results for both procedures.

Table I. Patient characteristics after randomization.

	Treatment A n=27		**Treatment B n=27**		**P value**	**Total n=54**	
Gender (number and % female)	21 (78%)		23 (85%)		*0.484*	44 (82%)	
Age (years; mean ± SD [range])	58 ± 8.6 [43-70]		55 ± 9.1 [39-70]		*0.241*	57 ± 8.9 [39-70]	
Dermatochalasis severity score (number of patients)	*Right eye* Normal: 0 Mild: 11 Moderate: 15 Severe: 1	*Left eye* Normal: 0 Mild: 10 Moderate: 16 Severe: 1	*Right eye* Normal: 0 Mild: 12 Moderate: 13 Severe: 2	*Left eye* Normal: 0 Mild: 13 Moderate: 12 Severe: 2	*Right eye* *p=0.771* *Left eye* *p=0.523*	*Right eye* Normal: 0 Mild: 23 Moderate: 28 Severe: 3	*Left eye* Normal: 0 Mild: 23 Moderate: 28 Severe: 3
Removed skin (g; mean ± SD [range])	*Right eye* 0.30 ± 0.08 [0.18-0.42]	*Left eye* 0.32 ± 0.08 [0.21-0.51]	*Right eye* 0.32 ± 0.11 [0.18-0.61]	*Left eye* 0.34 ± 0.12 [0.14-0.65]	*Right eye* *p=0.563* *Left eye* *p=0.703*	*Right eye* 0.31 ± 0.09 [0.18-0.61]	*Left eye* 0.33 ± 0.10 [0.14-0.65)
Removed muscle (g; mean±SD [range])	-	-	*Right eye* 0.11±0.07 [0.05-0.40)	*Left eye* 0.11±0.07 [0.05-0.40]	-	-	-
Medial fat removal (no. of patients)	2*		0		*p=0.552*	2	

* Removal of medial fat from both eyes.

Figure IVa. Preoperative photograph of a participant from group A (skin only).

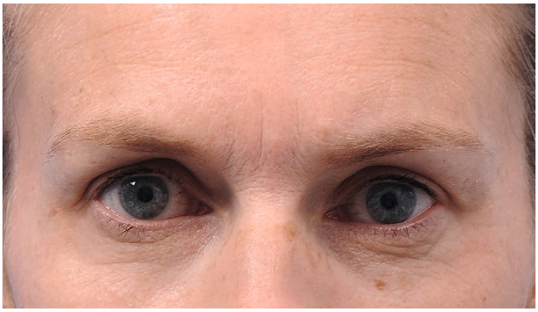

Figure IVb. Photograph 12 months after upper eyelid blepharoplasty (group A; skin-only)

Figure Va. Preoperative photograph of a participant from group B (skin/muscle).

Figure Vb. Photograph 12 months after upper eyelid blepharoplasty (group B; skin/muscle)

Pre- and postoperative FACE-Q scores (figure VI)

In both groups, postoperative FACE-Q scores improved compared to baseline values and the majority of patients showed significant improvement (table II). There were no significant differences between the 6-month and 12-month follow-up scores.

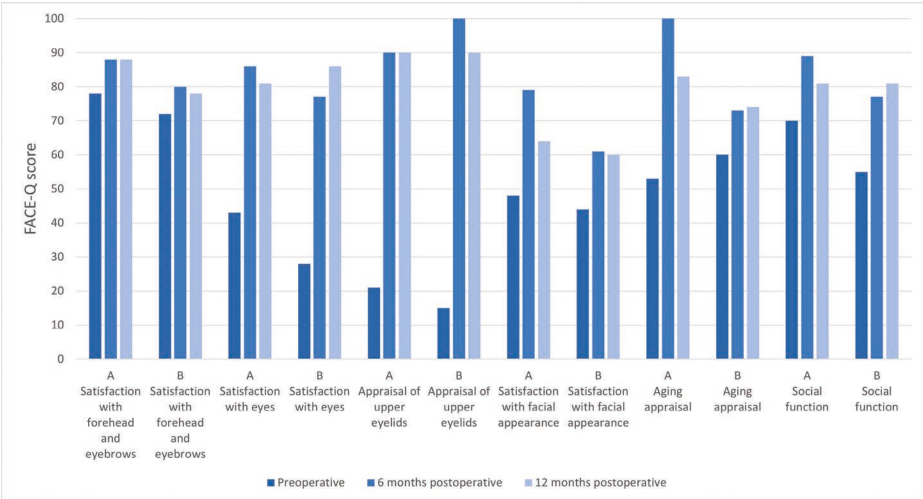

Figure VI. Median FACE-Q scores.

Table II. Comparison between median [Q1;Q3] pre-and postoperative FACE-Q scores.

	Satisfaction with forehead and eyebrows	***Satisfaction with eyes***	***Appraisal of upper eyelids***	***Satisfaction with facial appearance***	***Aging appraisal***	***Patient- perceived age (VAS)***	***Social functioning***
Group A							
Preoperative	78[64;85]	43[24;63]	21[8;38]	48[42;58]	53[42;83]	0[-5;5]	70[55;86]
6 months postoperative	88[72;100] (p=0.247)	86[75;100]* (p<0.001)	90[81;100]* (p<0.001)	79[60;94]* (p<0.001)	100[72;100]* (p<0.001)	-3[-7;0] (p=0.083)	89[70;100]* (p=0.003)
12 months postoperative	88[68;100] (p=0.247)	81[66;96]* (p < 0.001)	90[70;100]* (p<0.001)	64[53;78]* (p=0.001)	83[66;100]* (p=0.001)	-2[-5;0]* (p=0.017)	81[70;100]* (p=0.013)
Group B							
Preoperative	72[55;84]	28[20;43]	15[0;46]	44[38;53]	60[42;-73]	0[0;3]	55[46;81]
6 months postoperative	80[70;94]* (p=0.018)	77[63;100]* (p<0.001)	100[81;100]* (p<0.001)	61[51;92]* (p<0.001)	73[58;100]* (p=0.001)	0[-5;3] (p=0.132)	77[59;98]* (p=0.003)
12 months postoperative	78[72;93]* (p=0.006)	86[67;98]* (p<0.001)	90[75;100]* (p<0.001)	60[51;81]* (p<0.001)	74[60;100]* (p=0.002)	0[-4;0] (p=0.060)	81[72;92]* (p=0.007)

*Statistically significant improvement in FACE-Q score compared to baseline FACE-Q score.

Comparison of both groups' FACE-Q outcomes

Although there were no significant differences in the 6 month postoperative scores for 'Satisfaction with the eyes', the GEE showed a significant difference between group A's and B's final 'Satisfaction with the eyes' FACE-Q score: Group A's (skin only) score was 17.5 points higher 12 months postoperatively (regression coefficient β 17.5, p=0.012) than group B's. However, the GEE showed no significant differences between groups A and B regarding the other FACE-Q scores after upper blepharoplasty (table III). Possible confounding variables were included in the model (gender, age, dermatochalasis severity score and removed tissue during surgery) as well as the fact that we corrected for the baseline FACE-Q scores.

Satisfaction with results

In both groups, there were no significant differences between the patients' 'Satisfaction with the results' scores from the 6 month (median [Q1;Q3]: 73[59;79] (A) and 71[51;100] (B); p=0.433) and the 12 month (73[59;100] (A) and 73 [51;87] (B); p=0.602) follow-ups.

POSAS

Median[Q1;Q3] patient POSAS scores were not statistically significantly different between groups A and B (6[6;9] (A) and 7[6;10] (B); p=0.152). The overall patient opinion of the scar site was 1[1;1] (A) and 1[1;2] (B); p=0.468). Median observer reported POSAS-scores were 7[7;8] (A) and 7[6;9] (B); p=0.345). The overall observer (physician) opinion of the scar site was 1[1;2] (A) and 1[1;2] (B); p=0.897).

FACE-Q adverse effects

Table IV shows the number of patients who reported experiencing some adverse effects 6 and 12 months postoperatively. Also, the scoring of any pre-existing eyelid related problems at baseline was based on the FACE-Q adverse effect questionnaire. According to table IV, the patients reported a variety of, usually minor, adverse effects. One participant complained strongly about excessive tearing, but she had also reported this in the preoperative questionnaire and this was therefore considered unchanged. The participants were less bothered by each item postoperatively compared to baseline. There were no significant differences in adverse effects between groups A and B.

Table III. Differences in FACE-Q scores between group A and group B.

	Baseline		6 months postoperatively		12 months postoperatively	
FACE-Q	Group A Median [Q1;Q3]	Group B Median [Q1;Q3]	Adjusted difference* (95% CI)	p-value	Adjusted difference* (95% CI)	p-value
Satisfaction with forehead and eyebrows	78[64;85]	72[55;84]	0.8 (-12.1 – 13.8)	0.895	0.7 (-13.2-14.7)	0.918
Satisfaction with eyes	43[24;63]	28[20;43]	6.4 (-9.2 – 22.0)	0.100	17.5 (3.8-31.1)	0.012
Appraisal of upper eyelids	21[8;38]	15[0;46]	2.2 (-11.5 – 15.9)	0.755	8.4 (-7.3-24.0)	0.294
Satisfaction with facial appearance	48[42;58]	44[38;53]	1.7 (-8.8 – 12.3)	0.745	7.5 (-3.5-18.6)	0.179
Aging appraisal	53[42;83]	60[42;-73]	-10.0 (-20.7–0.7)	0.068	-2.0 (-11.8-7.8)	0.689
Patient- perceived age (VAS)	0[-5;5]	0[0;3]	-0.8 (-1.3-3.0)	0.440	0.3 (-1.8-2.4)	0.799
Social functioning	70[55;86]	55[46;81]	-4.5 (-12.5 – 3.5)	0.272	3.7 (-5.6-13.0)	0.437
Satisfaction with results	N.A.	N.A.	-7.3 (-5.6-20.3)	0.269	-0.4 (-13.5-12.7)	0.945

*Adjusted difference is the regression coefficient from the generalised estimating equations models, which represents the difference between the treatment groups (group A–group B), adjusted for the baseline values, gender, age, dermatochalasis severity score and amount of tissue removed.
N.A.: not applicable

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Table IV. Descriptive statistics of the FACE-Q questionnaire regarding adverse effects after upper blepharoplasty compared to baseline. The numbers indicate the number of subjects reporting a particular problem.

Preoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		**p-value***
Difficulty closing eyes	26	-	1	-	-	Group A	*1.000*
	26	1	-	-	-	Group B	
Eye dryness	14	6	7	-	-	Group A	*0.063*
	11	13	2	1	-	Group B	
Tearing excessively	12	6	7	2	-	Group A	*0.356*
	14	8	2	3	-	Group B	
Irritation of the eye	7	15	4	1	-	Group A	*0.278*
	9	10	3	5	-	Group B	
Hollowing	16	8	3	-	-	Group A	*1.000*
	17	7	2	1	-	Group B	
6 months postoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		
Difficulty closing eyes	25	1	-	-	1	Group A	*0.610*
	23	3	-	-	1	Group B	
Eye dryness	19	5	2	-	1	Group A	*0.414*
	19	7	-	-	1	Group B	
Tearing excessively	14	8	4	-	1	Group A	*0.063*
	20	5	-	1	1	Group B	
Irritation of the eye	16	9	1	-	1	Group A	*0.499*
	19	5	2	-	1	Group B	

Table IV. (Continued)

6 months postoperatively	Not at all	A little	Moderately	Extremely	Missing		p-value*
Hollowing	23	2	1	-	1	Group A	*0.668*
	22	4	-	-	1	Group B	
Eyelid scars	21	4	1	-	1	Group A	*0.502*
	23	1	2	-	1	Group B	
12 months postoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		
Difficulty closing eyes	25	-	-	-	2	Group A	*0.490*
	23	1	-	-	3	Group B	
Eye dryness	19	5	1	-	2	Group A	*0.428*
	16	8	-	-	3	Group B	
Tearing excessively	15	10	-	-	2	Group A	*0.401*
	16	6	1	1	3	Group B	
Irritation of the eye	16	9	-	-	2	Group A	*1.000*
	16	8	-	-	3	Group B	
Hollowing	21	4	-	-	2	Group A	*0.110*
	24	-	-	-	3	Group B	
Eyelid scars	21	2	2	-	2	Group A	*0.546*
	22	-	2	-	3	Group B	

*P-value of difference between group A and group B.

DISCUSSION

Satisfaction with appearance and improved quality of life are important outcomes for patients undergoing facial aesthetic procedures. Although patient-satisfaction is generally high after an upper blepharoplasty, the possible differences in PRARs between surgical techniques have scarcely been studied[6]. Nowadays, surgeons tend to be more conservative regarding removal of orbicularis oculi muscle and orbital fat to preserve the volume of the peri-orbital region, which might result in a more youthful appearance.

We did not observe significant differences when comparing the skin-only excision technique with the skin-muscle excision, except in the 'satisfaction with the eyes' questionnaire which favoured the skin-only group. This entailed questions about shape, attractiveness, alert (not tired), open, bright-eyed, nice and youthful eyes, and the skin only group's score was, markedly, 17.5 points higher which indicates that, for those aspects, skin only is preferable to skin-muscle resections.

'Appraisal of the upper eyelids' was not significantly different between the groups. This FACE-Q item asks about more negative aspects of the upper eyelid (bothered by skin on the eyelashes, saggy upper eyelids, droopy upper eyelids, appearance of eyelid folds, heavy upper eyelids, how tired your upper eyelids make you look, how old your upper eyelids make you look). Therefore, it seems that both surgical techniques provide relief from the negative sequelae (appraisal of upper eyelids), but the skin only technique results in higher satisfaction with the eyes.

When the patients were asked if they thought the eyes appeared more 'hollowed', the answers following both techniques were comparable. Apparently, the potential volume reduction of the eyelids by removing additional orbicularis oculi muscle was not really noticed by the patients and was not regarded as less appealing within 12 months after the blepharoplasty. Also, the surgeons and the blinded researchers did not notice any apparent differences in hollowing between the participants and surgical techniques. These findings are in line with former studies. LoPiccolo et al.[17] described a split face study (n=10) whereby only skin was removed from one side and skin and orbicularis muscle was removed from the other side, with no significant difference in cosmetic appearance of the eyelids.

We found no significant differences in scarring between the surgical techniques, as assessed by both the patients and observers. This is in line with Saalabian et al.[18] who compared the satisfaction levels of patients according to tissue resection categories (skin, skin/muscle, skin/muscle/fat) and concluded that there were no differences in relation to scar aspects, recovery period and complication rates.

We conclude from our study that upper blepharoplasty patients (both groups) report significant improvements postoperatively regarding the eyes and eyelids, and in the satisfaction with their facial appearance and aging appraisal. Also, the patient-perceived age had decreased, which infers that patients perceive themselves as looking more youthful than before surgery. The patients also considered themselves to be more social and confident after the upper blepharoplasty. This is in line with the literature[19].

A remarkable result in our study is the more positive appraisal of the forehead and eyebrows after an upper blepharoplasty by both groups. The eyebrows tend to move down after a blepharoplasty which can have an impact on the aesthetic unit of the eye[6]. However, the extent and influence is not clear in the literature[6]. Satisfaction with the forehead and eyebrows increased with a median of 6 to 10 points, which indicates a 6-10% improvement. However, whether patients are more satisfied with their eyebrows or their forehead remains unclear. We hypothesize that a downward movement of the eyebrows tends to smoothen-out the wrinkles on the forehead . This theory is in part supported by the Huijing et al.[20] study which showed that forehead lines diminish significantly after an upper blepharoplasty, but they did not show a significant lowering of the eyebrows. Also, no significant relationship was observed between eyebrow height and horizontal forehead lines pre- and postoperatively. Another explanation might be that patients regard themselves as more appealing after an upper blepharoplasty and therefore appraise their general appearance (including eyebrows and forehead) as more positive. Nevertheless, the use of a questionnaire that did not discriminate between eyebrows and forehead lines is a limitation of our study. More research has to be done to elucidate this issue further.

Overall, an upper blepharoplasty results in increased satisfaction with appearance, regardless of the conservation of the orbicularis oculi muscle. In our opinion, since the results are comparable, the least invasive method should be used. Additionally, when considering the eyes in general, the skin only technique is preferable. The surgical technique should be tailored to the needs of the individual patient. In our opinion, removal of a strip orbicularis oculi muscle should not be standard procedure but only be performed on indication. Also, there is still a need for more knowledge about other aspects of the surgical technique, such as the desired shape of the skin excision and whether the techniques have different objective functional outcomes.

CONCLUSION

A skin only or skin/muscle upper blepharoplasty resulted in similar FACE-Q scores regarding upper eyelids, forehead and eyebrows, overall face, patient perceived aging and age, social functioning, and satisfaction with the postoperative results, while the FACE-Q score regarding eyes in general was more positive in the skin-only group at the 12 month follow-up. Scarring and other adverse effects did not differ between the two techniques. Post-operatively, independent of the technique used, there was a significant increase in FACE-Q scores in the abovementioned domains. Following the above mentioned outcomes, the less invasive skin-only upper blepharoplasty should be advocated as the routine procedure.

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Conflict of interest
None.

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CHAPTER 5

Traditional versus laterally extended upper blepharoplasty skin excisions: objective and patient reported outcomes

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ABSTRACT

Background

Different skin excision shapes may result in different aesthetic outcomes when performing an upper blepharoplasty.

Methods

Two skin-only excision shapes were objectively and subjectively evaluated in 28 matched patients: the laterally extended skin excision (A) and traditional elliptical skin excision (B). The pretarsal show, lateral eyebrow height, amount of scarring (Patient and Observer Scar Assessment Scale), and patient reported aesthetic results (FACE-Q questionnaires) were scored and compared at 6 and 12 months postoperatively.

Results

In both groups, the pretarsal show improved significantly after the blepharoplasty. The homogeneity of the pretarsal show improved significantly in the lateral extension group (A), together with a slightly more pretarsal show (0.5-0.8 mm at central pupil region) at 6 and 12 months follow up compared to group B ($p=0.004$). A trend was observed in the Exocanthion45°(EX-EX45) measurement where group A showed 0.6mm more pretarsal show at 6 months postoperative. The homogeneity of the pretarsal show had significantly improved in group A 12 months after the blepharoplasty, but not in group B. No other significant differences were observed between the groups regarding the pretarsal show measurements or FACE-Q scores. Both groups showed descent of the lateral eyebrow, but this was only significant in group B. Group B showed 1.4 to 2.0mm more descent compared to group A. Both groups' scarring and adverse effects scores were low and did not differ.

Conclusion

Both excision shapes result in positive aesthetic results, but the laterally extended skin excision technique is accompanied by a slightly more favourable outcome.

INTRODUCTION

The eye area is considered attractive when it shows typical youthful features. Prantl et al.[1] found that an even pretarsal show or tarsal platform show is generally perceived as youthful and attractive[1]. When the pretarsal show is less or uneven, as in lateral hooding, a person is perceived as looking more tired[2].

Making an eye more attractive can be achieved by removing redundant upper eyelid skin and/or by elevating the eyebrow. However, elevating the eyebrows cannot always be advocated. Elevating the whole eyebrow can result in a tired and sad expression whereas only elevating the lateral part of the eyebrow can result in a 'surprised' appearance[2]. Special attention has to be paid to the shape of the skin excision of the upper eyelid in patients with dermatochalasis which have a normal position of the eyebrows in order to achieve a homogenous distribution of the pretarsal show.

Traditionally, the skin excision has an elliptical shape[3] but it was later modified to a scalpel blade shape[4]. The latter results in widening of the lateral excision in order to address the lateral hooding better, but even this modification might not address the lateral hooding sufficiently. Therefore, Bellinvia et al.[5] modified the excision into a wide lateral excision, and in a higher position, to eliminate the lateral hooding without any need for eyebrow manipulation. As to which skin excision design is the most preferable, remains uncertain. To the best of our knowledge, no study has compared various excision shapes to assess the aesthetic result. The aim of this study was to compare the outcome of traditional elliptical skin excisions with wide lateral skin excisions from pretarsal show and eyebrow height measurements, patient reported aesthetic results (PRARs) and scarring.

METHODS

Study design

A multi-centre prospective trial was undertaken at the Department of Oral and Maxillofacial Surgery of the University Medical Centre Groningen (UMCG) and at the Treant Scheper Hospital, Emmen, the Netherlands. Two blepharoplasty techniques were compared. The traditional elliptical skin excision was performed at the UMCG. The laterally extended skin excision was performed at the Scheper Hospital. The study protocol was approved by the institutional review board of the UMCG (METc 2019/557) and registered in the Netherlands Trial Register (ID NL7886). Written informed consent was obtained from all study participants.

Study population

All consecutive healthy male and female Caucasian patients, between the age of 30 and 70, who attended a consultation about dermatochalasis of both upper eyelids, and in whom an upper blepharoplasty was indicated at the Scheper Hospital between November 2018 and June 2019, were asked to participate (group A). The consultation and procedure was performed by one maxillofacial surgeon (J.S.). Patients were excluded if they had a history of ocular trauma or had experienced trauma of the orbital region, a history of eyelid or eyebrow region surgery, other facial cosmetic surgical or non-surgical procedures, any current ophthalmic disease, or suffered from blepharoptosis or significant eyebrow ptosis.

These participants were matched to participants from another larger trial (group B) that was performed by the same research group at the UMCG between February 2018 and October 2019. The in- and exclusion criteria were the same.

Matching was done on basis of baseline dermatochalasis severity score (per eye), gender and age (in that order of priority) by one researcher (M.C.) using a case-control matching tool (MedCalc, version 19.4, MedCalc Software, Ostend, Belgium). This matching tool generated a list of best matches between participants from group A to participants from the larger trial. The first 14 participants that were best matches regarding baseline dermatochalasis severity score (per eye), gender and age were included in this study (group B). At this stage, the researcher (M.C.) was blinded regarding all other participant data. The patients could not be blinded regarding the shape of the excision but received a unique code to anonymize the data.

Surgical procedure

Three experienced surgeons (J.J., R.H.S., J.S.) performed the upper blepharoplasties. The surgical procedure was standardized prior to the study and took place in an outpatient environment. J.S. only performed the laterally extended excision shape (see figure Ia; group A), while the surgeons J.J. and R.H.S. only performed the traditional elliptical excision shape (see figure Ib; group B). Preoperatively, surgical landmarks and planned skin excisions were marked on both groups' upright positioned patients in a neutral gaze with a relaxed frontalis muscle. The lid crease incision is marked first, generally following the eyelid crease of the upper eyelid.

In the wide laterally extended skin excisions the technique described by Bellinvia et al.[5] was used (figure Ia). A line was drawn at the top margin of the area to be excised. The first markings were made medially, 5-6 mm above the medial canthus. The marking was curved superiorly, leaving the thin lid skin to reach the thick skin over the super orbital rim, never going downward. The line ended laterally, over and beyond the area of lateral hooding, at the height of the medial margin of the eyebrow. The markings did not cross the eyebrow.

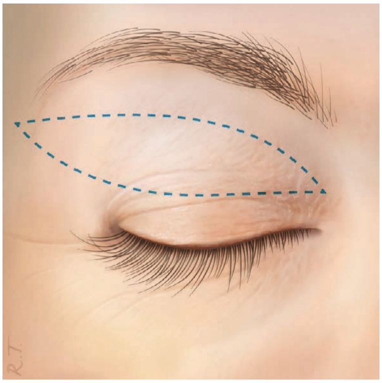

Figure Ia. Skin marking on upper eyelid with lateral extension of the excision (group A).

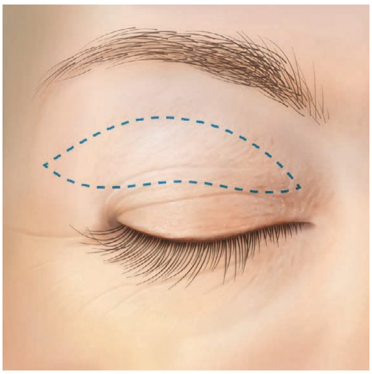

Figure Ib. Skin marking on upper eyelid without lateral extension of the excision (group B).

For the traditional elliptical excision shape, the lid crease incision was marked first, generally following the eyelid crease of the upper eyelid and extending upwards in the area of lateral hooding within the boundary of the lateral orbital rim. The upper marking was always in the thin eyelid skin, following the lower contour of the eyebrow and at least 10mm below it[6]. The markings of this technique resulted in an elliptical shape (figure Ib). For both techniques, markings did not extend beyond the medial canthus.

After marking, the patient is asked to gently close the eyelids. A smooth pair of forceps is used to grasp the excess skin above the eyelid crease incision, just until the eyelashes begin to rotate upwards (pinch technique). This was considered the maximum amount of skin that could be removed safely. The surgical markings were made within these boundaries. The amount of skin to be resected was tailored to the individual patient to resect the optimal amount of skin.

Then, approximately 1.7 ml of local anaesthetic (40 mg articaine and 10 mcg epinephrine per ml) was injected subcutaneously per eye. Subsequently, skin incisions were made with a surgical blade following the markings and the excess skin was removed. If needed, cauterization was used to achieve haemostasis. No orbicularis oculi muscle or fat was removed or excised. The skin was closed with a 6-0 monofilament suture intracutaneously in a running fashion combined with adhesive suture strips. In group A, an additional suture was placed on the lateral part of the eyelids to minimize wound tension.

The participants were asked to avoid strenuous activities and their sutures were removed after 7 days.

Outcomes

The study outcomes were evaluated preoperatively, and 6- and 12-months post-blepharoplasty.

The primary outcome was the change in the visible pretarsal skin assessed from standardized photos taken after the two skin excision techniques and between the two techniques. In addition, the pretarsal show homogeneity, the PRARs (FACE-Q questionnaires)[7-9] and the amount of scarring (Patient and Observer Scar Assessment Scale)[10] were assessed.

Demographic data were recorded including age, gender and medical history. Preoperatively, the severity of dermatochalasis was assessed and categorized according to a 4-level photonumerical severity scale using anatomical cut-off points: normal (upper eyelid skin is not touching the eyelashes), mild (upper eyelid skin is touching the eyelashes), moderate (upper eyelid skin is hanging over the eyelashes), and severe (upper eyelid skin is hanging over the eye)[11]. During surgery, the amount of removed tissue was weighed per eye and was recorded in grams.

Pretarsal show and eyebrow height

Standardized digital photographs were taken prior to surgery of the primary gaze, with the head in a natural position, to assess pretarsal show. Each photograph was taken by the same researcher (M.H.J.H.), under the same lighting conditions, at a fixed distance between the patient and with the same camera (Nikon D5600 AF-S DX NIKKOR VR, Minato, Tokio, Japan). To account for size discrepancy between pre-and postoperative photographs, a horizontal visible iris diameter, in millimetres (HVID; 11.77mm in male, 11.64mm in female participants)[12], was used for calibration purposes[13-15]. The photographs were measured digitally by the NIH ImageJ software (Version 1.53a, National Institutes of Health, USA). The following distances were measured for each eye (figure II):

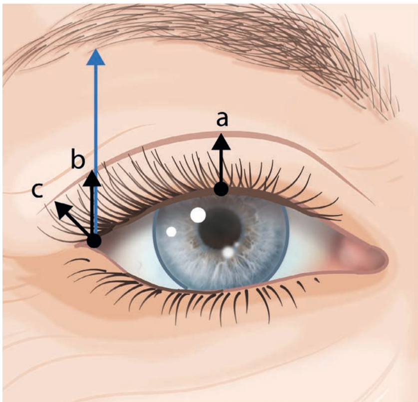

Figure II. Pretarsal show and lateral eyebrow measurements. The blue line represents the lateral eyebrow measurement. The measurements on the left eye were identical to the right eye.

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a. Upper palpebral sulcus at center of pupil (USP) – Upper limbus at center of pupil (ULP)
b. Upper palpebral sulcus at exocanthion (USEX) – exocanthion (EX)
c. Exocanthion (EX) – Upper palpebral sulcus in a 45° angle from USEX-EX (EX45)

To assess the homogeneity of the pretarsal show, USP-ULP and EX-EX45 subtractions were undertaken to provide a difference score.

To assess lateral eyebrow height, the distance between the exocanthion and the lower margin of the eyebrow was measured (figure II). This was done for both eyes.

FACE-Q questionnaires
FACE-Q questionnaires were filled in preoperatively, at 6 and at 12 months[7-9]. The FACE-Q modules refer to the eyes in general, upper eyelids, forehead and eyebrows, overall face, age appearance appraisal, age appraisal, social functioning, and satisfaction with outcome. The scale scores range from 0 (worst) to 100 (best), except for the age appraisal scale that ranges from -15 (best) to +15 (worst). Included is a module with a checklist measuring adverse effects.

Patient and Observer Scar Assessment Scale

The validated Patient and Observer Scar Assessment Scale questionnaire (POSAS, version 2.0/NL) was used 12 months postoperatively. There are two separate domains: a patient domain and an observer domain. The patient scale consists of seven questions, six asking about specific scar-characteristics, i.e., pain, itch, colour, stiffness, thickness and regularity, while the seventh question rates the overall opinion of the scar site. The observer scale consists of questions to rate scar vascularity, pigmentation, pliability, thickness, relief and surface area. This provides the total score. The seventh observer question is on the overall opinion of the scar. All questions are answered on a Likert Scale from 1 to 10, with 1 equal to no difference between the scar and non-injured skin and 10 representing the most difference. The total score of both scales entails adding the scores of each of the six items (range, 6 to 60). The lowest score, 6, reflects normal skin, whereas the highest score, 60, reflects the worst scar imaginable.

Sample size and statistical analysis

The sample size calculation of our primary outcome was based on pretarsal show measurements. In the Prantl et al.[1] study, the mean measurement between the upper palpebral sulcus and the upper limbus was 26.1 (% of iris width) for the 15% most attractive eyes and 38.8 (% of iris width) for the 15% most unattractive eyes, with a SD of 15.6 (% of iris width). We used, for the sample size calculation, a HVID of 10mm[13] for millimetre conversion purposes. We considered a difference of 1.3mm (difference between the most attractive and the most unattractive eyes) as a clinically relevant difference. All measurements were carried out per eye and not by averaging both eyes of each participant. A sample size of 14 patients (28 eyes) was needed per treatment group to detect a difference of 1.3 mm in pretarsal show between the groups at 6 and 12 months, with a 0.05 level of significance and a power of 80%, allowing for a 10% attrition rate and 10% for possible non-parametric testing (G*Power version 3.1.9.6, University of Kiel, Germany).

Data was analysed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test, Kolmogorov–Smirnov test, and graphical interpretation of normal Q–Q plots were used to determine the distribution of the data. Baseline characteristics and the amount of removed skin during surgery were summarized descriptively and differences were assessed. Independent samples t-test was used to assess differences in age and the amount of tissue removed between groups A and B at baseline. Similarly, Fisher’s exact test was used to evaluate differences in gender and dermatochalasis severity scores between groups A and B at baseline.

GEE (Generalized Estimating Equations, a statistical model that measures adjusted differences by taking possible confounding factors into account) was used to assess the differences in pretarsal show and pretarsal show homogeneity between groups A and B. The GEE model included the pretarsal show measurements, baseline pretarsal show, gender, age, dermatochalasis severity score and the amount of skin removed during surgery. Before GEE model fitting, the following variable selection procedure was applied. First, we determined which variables were of clinical relevance to the outcome variable. We achieved consensus amongst experts, i.e. A.V., R.H.S., J.J., J.S., about the following possible confounding variables: baseline values of the outcome variable, age, gender, dermatochalasis severity score and amount of tissue removed during surgery. Then, different correlation structures (exchangeable, M-dependent, unstructured) were tested. The working correlation structure was chosen on the basis of the goodness of fit (Corrected Quasi Likelihood under Independence Model Criterion; QICC). The model with the lowest information criterion was used for further analysis, which was the exchangeable correlation structure for all variables. Residuals were plotted in a histogram to assess assumptions for using GEE, and all residuals showed a Gaussian distribution.

We considered p-values less than 0.05 to be statistically significant. Missing data were not imputed. For the lateral eyebrow height, the GEE model included the lateral eyebrow height, baseline lateral eyebrow height, gender, age, dermatochalasis severity score and the amount of skin removed during surgery. All residuals showed a Gaussian distribution and the M-dependent correlation structure was used (model with the lowest information criterion).

Similarly, the difference between the groups' (A&B) FACE-Q scores from the different time points was evaluated using GEE. The GEE model included FACE-Q scores, baseline FACE-Q scores, gender, age, dermatochalasis severity scores and amount of removed skin during surgery. Only the baseline FACE-Q scores for 'Satisfaction with outcome' were not part of the GEE model because no baseline 'Satisfaction with outcome' i.e., before surgery, exists. All residuals showed a Gaussian distribution. Different correlation structures (exchangeable, M-dependent, unstructured) were tested and the model with the lowest information criterion was used, which was the exchangeable correlation structure in all cases.

The differences in the pre-and post-blepharoplasty FACE-Q scores, the pretarsal show measurements and eyebrow height, were analysed using the Friedman test and pairwise comparisons were performed. All postoperative FACE-Q scores were compared with each group's baseline FACE-Q scores. There were no outliers in the data, as assessed by inspecting the boxplots, and the data did not show a normal distribution.

Descriptive statistics regarding POSAS-scores were summarized and differences between groups A and B were analysed using the Mann Whitney U test because the data did not show a normal distribution. Descriptive statistics are provided as medians [Q1;Q3].

Fisher's exact test was used to evaluate the differences in adverse effects (FACE-Q) between groups A and B.

RESULTS

The baseline characteristics are shown in table I. There were no significant differences at baseline regarding age, gender, dermatochalasis severity score and amount of removed skin during surgery. One participant (group A) was excluded from the 12-month analysis due to a malignancy. For both procedures, a representative pre-and postoperative photograph are shown in figure III and IV.

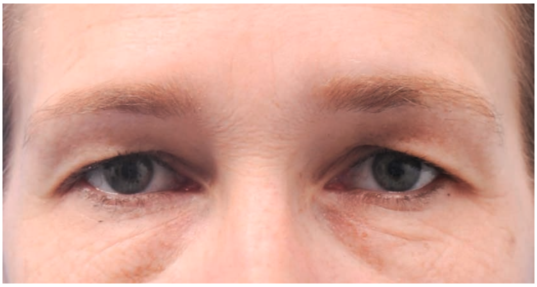

Figure IIIa. Preoperative photograph of a participant (group A)

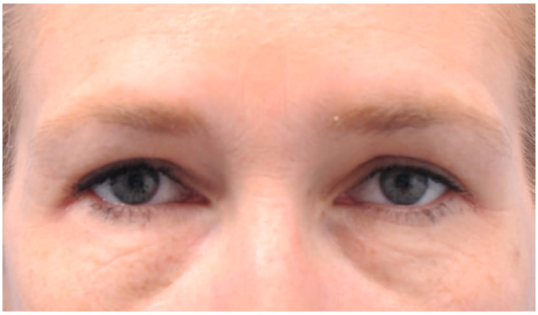

Figure IIIb. Photograph 12 months after upper eyelid blepharoplasty with lateral extension of the excision (group A)

Figure IVa. Preoperative photograph of a participant (group B)

Figure IVb. Photograph 12 months after upper eyelid blepharoplasty without the lateral extension of the excision (group B)

Table I. Patient characteristics.

	Group A n=14			Group B n=14			p-value		
Gender (number and %)	4 male (29%), 10 female (71%)			3 male (21%), 11 female (79%)			1.000		
Age (years; mean ± SD)	49 ± 9			55 ± 8			0.111		
Dermatochalasis severity score (number of patients)	*Right eye* Normal: 0 Mild: 4 Moderate: 7 Severe: 3	*Left eye* Normal: 0 Mild: 6 Moderate: 5 Severe: 3	*Mean* Normal: 0 Mild: 5 Moderate: 6 Severe: 3	*Right eye* Normal: 0 Mild: 4 Moderate: 9 Severe: 1	*Left eye* Normal: 0 Mild: 4 Moderate: 9 Severe: 1	*Mean* Normal: 0 Mild: 4 Moderate: 9 Severe: 1	*Right eye* 0.674	*Left eye* 0.387	*Mean* 0.253
Removed skin (g; mean ± SD [range])	*Right eye* 0.28 ± 0.08 [0.16-0.39]	*Left eye* 0.27 ± 0.07 [0.19-0.40]	*Mean* 0.27 ± 0.06	*Right eye* 0.29 ± 0.07 [0.18-0.41]	*Left eye* 0.31 ± 0.08 [0.18-0.50]	*Mean* 0.30 ± 0.07	*Right eye* 0.595	*Left eye* 0.154	*Mean* 0.299

Pretarsal show (table II)

Postoperatively, all the pretarsal show measurements had improved, with the majority having improved significantly. In group B, no significant increase in Exocanthion 45°(EX-EX45) was observed compared to baseline. The homogeneity of the pretarsal show had improved significantly in group A by the 12 month follow up, while this was not observed in group B. There were no other significant differences between the 6-month and 12-month follow-ups.

The GEE showed significant outcome differences between groups A and B regarding the central pupil (USP-ULP) pretarsal show measurement. On average, patients in group A had 0.5mm more pretarsal show (regression coefficient β 0.5, p=0.032) than group B patients 6 months postoperatively, and 0.8mm more at the 12 month follow up (regression coefficient β 0.8, p=0.004). The other pretarsal show measurements were not significantly different between groups A and B. A trend was observed in the Exocanthion 45°(EX-EX45) measurement (p=0.068). Here, group A showed 0.6mm more pretarsal show compared to group B, 6 months postoperatively.

Eyebrow height (table II)

The lateral eyebrow showed a descent in both groups, but this was only significant for group B at both 6 months (p=0.001) and 12 months (p<0.001) follow up. The differences between the 6-month and 12-month follow-up were not significant.

The GEE showed significant differences between groups A and B in lateral eyebrow height. The median postoperative lateral eyebrow height of patients in group B was 1.4 (6 months follow up; p=0.029) to 2.0 mm (12 months follow up; p=0.007) lower compared to the patients in group A (i.a. corrected for preoperative lateral eyebrow height).

FACE-Q (table III)

Table III shows both groups' median [Q1;Q3] FACE-Q scores. All the postoperative FACE-Q scores improved significantly compared to the baseline values, except for in both groups' 'satisfaction with forehead and eyebrows' questionnaire and group B's 'Patient-perceived age' 6 and 12 months postoperatively. The differences between the 6-month and 12-month follow-ups were not significant. The GEE for each FACE-Q domain did not show any significant differences between groups A and B during the 6- and 12-month follow-ups.

Table II. Pre-and post-operative pretarsal show and eyebrow height in millimetres (median[Q1;Q3] and differences between groups).

	Preoperatively		**6 months postoperatively**			**12 months postoperatively**		
	Group A *median [Q1;Q3]* *n=14*	***Group B*** *median [Q1;Q3]* *n=14*	***Group A*** *median [Q1;Q3] (p-value*)* *n=14*	***Group B*** *median [Q1;Q3] (p-value*)* *n=14*	***Adjusted difference** between groups A and B (95% CI) and p-value***	***Group A*** *median [Q1;Q3] (p-value*)* *n=13*	***Group B*** *median [Q1;Q3] (p-value*)* *n=14*	***Adjusted difference** between groups A and B (95% CI) and p-value***
Pretarsal show								
Central pupil (USP-ULP)	1.1 [0;2.5]	1.3 [0.2;2.5]	3.1 [1.9;4.3] (p<0.001)	3.0 [2.3;3.4] (p<0.001)	0.5 (0.7-0.9) p=0.032	3.3 [2.1;3.9] (p<0.001)	2.7 [1.4;3.6] (p<0.001)	0.8 (0.3-1.4) p=0.004
Exocanthion (USEX-EX)	3.1 [0.6;3.8]	3.2 [0;4.3]	4.7 [4.0 ;5.5] (p<0.001)	5.0 [3.6;5.6] (p=0.002)	0.5 (-0.3-1.3) p=0.242	4.7 [3.8;5.2] (p<0.001)	4.4 [2.5;5.5] (p=0.009)	0.6 (-0.3-1.4) p=0.178
Exocanthion 45° (EX-EX45)	2.5 [0.4;3.3]	2.5 [0;3.5]	3.5 [3.1;4.1] (p<0.001)	3.1 [2.6;3.9] (p=0.322)	0.6 (0-1.3) p=0.068	3.3 [2.8;3.9] (p=0.002)	3.4 [1.8;3.9] (p=0.322)	0.3 (-0.4-1.0) p=0.387
Homogeneity of pretarsal show (USP-ULP) – (EX-EX45)	-0.7 [-1.5;0]	-0.5 [-1.2-0.1]	-0.7 [-1.4;0.3] (p=0.332)	-0.4 [-0.7;0.2] (p=0.242)	-0.2 (-0.7-0.4) p=0.529	-0.3 [-1.0;0.5] (p=0.001)	-0.6 [-1.1;0.1] (p=0.242)	0.5 (-0.1-1.2) p=0.124
Eyebrow height								
Lateral eyebrow height	14.0 [11.2;15.6]	15.8 [12.5;18.0]	13.2 [10.1;15.9] (p=0.872)	13.0 [10.8;16.5] (p=0.001)	1.4 (-0.2-2.7) p=0.029	13.2 [11.2;14.8] (p=0.872)	12.8 [11.2;16.1] (p<0.001)	2.0 (-0.5-3.4) p=0.007

The sample sizes represent the amount of included patients. Please note that both eyes of the patients were analysed separately. Therefore when 14 participants were included, 28 eyes were analysed.

* p-value of the comparison between preoperative and postoperative outcomes within a group.

**The adjusted difference is the regression coefficient from the generalized estimating equation models (GEE), which represents the difference in pretarsal show (in millimeters) between the treatment groups (group A–group B), adjusted for baseline values, gender, age, dermatochalasis severity score and amount of tissue removed. For the eyebrow height, the adjusted difference represents the difference in eyebrow height (in millimeters) between the treatment group (Group A-group B), adjusted for baseline values, gender, age, dermatochalasis severity score and amount of tissue removed.

Table III. Pre-and postoperative FACE-Q scores (median[Q1;Q3] and differences between groups).

	Preoperatively		6 months postoperatively			12 months postoperatively		
	Group A *median [Q1;Q3]* *n=14*	***Group B*** *median [Q1;Q3]* *n=14*	***Group A*** *median [Q1;Q3] (p-value*)* *n=14*	***Group B median*** *[Q1;Q3] (p-value*)* *n=14*	***Adjusted difference** between groups A and B (95% CI) and p-value***	***Group A*** *median [Q1;Q3] (p-value*)* *n=13*	***Group B*** *median [Q1;Q3] (p-value*)* *n=14*	***Adjusted difference** between groups A and B (95% CI) and p-value***
Satisfaction with forehead and eyebrows	74 [67;81]	80 [59;89]	80 [71;89] (p=0.338)	76 [72;94] (p=0.139)	0 (-8.2-8) p=0.977	78 [69;92] (p=0.338)	91 [75;100] (p=0.139)	-6 (-15-4) p=0.258
Satisfaction with eyes	41 32;55]	47 [32;63]	79 [66;100] (p=0.001)	86 [68;93] (p=0.001)	7 (-9-23) p=0.411	77 [64;98] (p<0.001)	86 [70;100] (p=0.001)	10 (-7-26) p=0.270
Appraisal of upper eyelids	34 [25;48]	28 [15;57]	100 [90;100] (p<0.001)	100 [87;100] (p<0.001)	-2 (-21-17) p=0.837	100 [85;100] (p=0.002)	90 [69;100] (p=0.001)	6 (-14-26) p=0.561
Satisfaction with facial appearance	48 [40;54]	56 [44;62]	64 [60;90] (p=0.001)	72 [60;87] (p=0.002)	7 (-5-20) p=0.243	68 [57;89] (p=0.004)	68 [61;90] (p=0.001)	2 (-11-15) p=0.774
Aging appraisal	74 [51;83	60 [46;93]	100 [87;100] (p=0.014)	90 [72;100] (p=0.001)	7 (-8-23) p=0.360	83 [66;100] (p=0.006)	83 [69;100] (p=0.039)	3 (-11-17) p=0.690
Patient- perceived age	0 [-1;4]	0 [-5;4]	-3 [-5;0] (p=0.019)	0 [-6;0] (p=0.135)	-1.4 (-3.8-0.9) p=0.222	-1 [-5;0] (p=0.002)	0 [-6;0] (p=0.135)	-1.2 (-3.0-0.6) p=0.189
Social functioning	66 [51;86]	66 [55;74]	82 [62;100] (p=0.014)	84 [70;100] (p=0.019)	-3.5 (-17-10) p=0.610	77 [62;100] (p=0.014)	87 [67;100] (p=0.025)	-3 (-15-9) p=0.657
Satisfaction with outcome	N.A.	N.A.	76 [59;100]	68 [59;79]	9 (-5-22) p=0.219	90 [59;100]	73 [58;100]	5 (-9-19) p=0.478

* p-value of the comparison between preoperative and postoperative outcomes within a group.
** The adjusted difference is the regression coefficient from the generalized estimating equation models (GEE), and represents the difference in FACE-Q scores between the treatment groups (group A–group B), adjusted for baseline values, gender, age, dermatochalasis severity score and amount of tissue removed.
N.A. Not applicable.

Scarring

The differences in the median POSAS scores were not significant between groups A and B. The median [Q1;Q3] patient scar assessment score for group A was 8.0 [6.0;14.0] and 6.0 [6.0;6.5] for group B (p=0.054), and overall impression was 1.0 [1.0;2.0] for group A and 1.0 [1.0;1.0] for group B (p=0.155).

The median [Q1;Q3] observer scar assessment score was 7.0 [6.5;7.5] for group A and 7.0 [6.0;7.0] for group B (p=0.720), and the overall impression was 1.0 [1.0;1.5] for group A and 1.0 [1.0;1.0] for group B (p=0.720).

Adverse effects (table IV)

Table IV shows the number of patients who reported being bothered by an item at baseline, at 6 and 12 months postoperatively. Based on this table, the patients reported a variety of postoperative adverse effects, from a mild to moderate degree but, on the whole, both groups' participants were bothered by fewer items after the upper blepharoplasty. The differences between groups A and B regarding adverse effects, including noticeability of scars, were not significant.

Table IV. Descriptive statistics from the FACE-Q questionnaire regarding adverse effects after upper blepharoplasty compared to baseline. The numbers indicate the number of subjects reporting a particular problem.

Preoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		***p-value****
Difficulty closing eyes	14	-	-	-	-	Group A	*1.000*
	14	-	-	-	-	Group B	
Eye dryness	7	4	3	-	-	Group A	*0.872*
	9	2	3	-	-	Group B	
Tearing excessively	10	3	1	-	-	Group A	*0.424*
	6	4	3	1	-	Group B	
Eye irritation	9	2	2	1	-	Group A	*0.194*
	6	7	1	-	-	Group B	
Hollowing	7	2	3	2	-	Group A	*0.454*
	7	5	2	-	-	Group B	
6 months postoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		
Difficulty closing eyes	14	-	-	-	-	Group A	*1.000*
	14	-	-	-	-	Group B	
Eye dryness	12	1	1	-	-	Group A	*1.000*
	11	2	1	-	-	Group B	
Tearing excessively	10	3	1	-	-	Group A	*0.745*
	8	4	2	-	-	Group B	
Eye irritation	11	2	1	-	-	Group A	*0.209*
	8	6	-	-	-	Group B	

Table IV. (Continued)

6 months postoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		***p-value****
Hollowing	13	1	-	-	-	Group A	*0.596*
	11	3	-	-	-	Group B	
Eyelid scars (obvious, noticeable, uneven)?	10	4	-	-	-	Group A	*0.326*
	13	1	-	-	-	Group B	
12 months postoperatively	**Not at all**	**A little**	**Moderately**	**Extremely**	**Missing**		
Difficulty closing eyes	12	-	-	-	2	Group A	*1.000*
	14	-	-	-	-	Group B	
Eye dryness	10	2	-	-	2	Group A	*0.652*
	10	4	-	-	-	Group B	
Tearing excessively	9	2	1	-	2	Group A	*0.652*
	10	4	-	-	-	Group B	
Eye irritation	9	2	1	-	2	Group A	*0.809*
	11	3	-	-	-	Group B	
Hollowing	12	-	-	-	2	Group A	*0.140*
	11	3	-	-	-	Group B	
Eyelid scars (obvious, noticeable, uneven)?	9	2	1	-	2	Group A	*0.379*
	13	1	-	-	-	Group B	

*p-value of difference between groups A and group B.

DISCUSSION

Patient satisfaction generally increases after an upper blepharoplasty[16]. However, since specific periorbital features correlate with attractiveness and perceived age, this aspect requires specific attention. To the best of our knowledge, only a few studies have explored the distinct physical landmarks that define eye attractiveness before and after upper blepharoplasty. Tarsal platform masking, also known as the 'eyeshadow space', is considered an undesirable trait, especially when the tarsal platform is not distributed evenly, e.g. with lateral hooding.

In our study, pretarsal show and patient satisfaction increased after an upper blepharoplasty, regardless of the type of skin excision. Theoretically, the laterally extended excision shape could provide more relief from lateral hooding than the more conventional skin excision approach. We found that the 'Exocanthion 45°' (lateral area of the pretarsal platform) only increased significantly in the laterally extended skin excision group (A), and not in the group without lateral extension (group B). This suggests that a laterally extended skin excision may address the lateral hooding more suitably. Also, the homogeneity of the pretarsal show had improved significantly in group A 12 months after the blepharoplasty, while no such effect was observed in group B. The literature does not have any papers on the homogeneity of pretarsal show distribution after a blepharoplasty. However, the increased pretarsal show as a result of a blepharoplasty was in line with the literature[17-19], although the shape of the excisions were not mentioned.

Furthermore, the laterally extended excision group showed less lateral eyebrow descent compared to the traditional group. We did not expect these results, since we expected the lateral extended scar to pull the eyebrow downwards. However, the heavy skin that is resected in the lateral extension technique may have had a positive effect on the gravitational forces that otherwise would have pulled the lateral eyebrow downwards.

Our study also found that the pretarsal show in the centre of the pupil area was significantly larger after performing the laterally extended skin excision. The mechanism of this effect is not clear. It might be that this excision location, which is higher in the infra-brow area and consists of thicker skin than in the thin upper eyelid skin, provides a firmer base to pull up the thin eyelid skin.

Despite there being some significant differences in the lateral area of the eyelid following the two excision techniques, these results have to be interpreted with care. Although the groups were comparable at baseline, the procedures took place in different hospitals and were performed by different surgeons. In theory, this could have influenced the patients' experiences and satisfaction, although all measurements were performed by an independent researcher not involved in the treatments. Also, although the surgeons participating in this study were well trained in and had abundant experience with both procedures, their surgical skills could still vary. The amount of upper eyelid skin that had to be removed in the individual patients is subjected to the insights of the surgeon. More research should investigate the observed effects of the various excision shapes further, preferably in a randomized controlled trial. Furthermore, not all patients might be good candidates for the laterally extended excision technique. Brow elevation surgery might be more suitable for patients who display a significant lateral brow ptosis to create optimal eyebrow aesthetics. Also, in patients who solely show dermatochalasis in the central area of the eyelid (and not lateral hooding), a lateral extension of the incision may not be needed.

Despite the indications in the objective (pretarsal show and lateral eyebrow height) and subjective (patient's perceived age) measurements that favoured the lateral extension group, no major differences were found between the other results between the two upper blepharoplasty excision shapes. In theory, the scarring would be more noticeable in the laterally extended group, but no significant differences between groups were reported by patients.

In conclusion, both excision shapes result in positive aesthetic results, although the laterally extended skin excision had a slightly more favourable outcome.

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Conflicts of interest
None.

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CHAPTER 6

Impact of upper blepharoplasty, with or without orbicularis oculi muscle removal, on tear film dynamics and dry eye symptoms: a randomized controlled trial

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ABSTRACT

Background

Upper blepharoplasty has been postulated to affect dry eye symptoms since the function of the orbicularis oculi muscle is closely related to the tear fluid passage system. We aimed to assess the effect of blepharoplasty with or without the removal of a strip of orbicularis oculi muscle on tear film dynamics and dry eye symptoms.

Methods

A double blind randomized controlled trial comparing upper blepharoplasty without (group A) or with (group B) orbicularis oculi muscle excision was performed on 54 healthy Caucasian patients. Tear film dynamics and dry eye symptoms were evaluated using multiple dry eye parameters, i.e. tear osmolarity, Schirmer test I, corneal/conjunctival staining, tear break-up time (TBUT), Oxford Scheme, Sicca Ocular Staining Score, and Ocular Surface Disease Index questionnaire. All the parameters were assessed preoperatively, and 6 and 12 months after upper blepharoplasty. All the groups' outcomes were compared.

Results

The differences were not significant between the two upper blepharoplasty techniques regarding most of the above mentioned outcomes. Subjective symptoms of ocular irritation, consistent with dry eye disease and vision-related impairment, were reduced after upper blepharoplasty independent of the type of the technique applied, while the pre- and postoperative outcomes of the objective tear dynamics did not differ 12 months after surgery. However, group B demonstrated a significant increase in tear osmolarity and TBUT at the 6-month follow-up visit.

Conclusion

An upper blepharoplasty alleviates subjective dry eye complaints in the long term, while not changing the tear dynamics. The improvement was independent of the blepharoplasty technique used.

INTRODUCTION

Dry eye disease is a common multifactorial disease of the ocular surface. Dysfunction of any component of the lacrimal functional unit, such as decreased tear production, increased evaporative loss and changes in drainage, can result in dry eye symptoms. Dry eyes can be divided into two primary categories: aqueous tear-deficient and evaporative. The first type involves a failure of lacrimal secretion and a failure of water secretion. The second type involves excessive water loss due to tear film instability. Dysfunction can be caused by a variety of iatrogenic interventions, such as ophthalmic surgical procedures including upper blepharoplasty[1].

A traditional upper blepharoplasty entails the removal of excess skin together with a strip of orbicularis oculi muscle, sometimes combined with excision or redistribution of fat from the medial and central fat compartments. Nowadays, the preservation of youthful fullness of the upper eyelids is gaining more attention with surgeons tending to be more conservative during upper blepharoplasties by sparing the orbicularis oculi muscle and orbital fat[2-5].

About 13% of the patients experience dry eye symptoms after an upper blepharoplasty[6]. There is still a lot of uncertainty regarding the relationship between dry eye disease and upper blepharoplasty, in general but various mechanisms have been proposed to explain the association. Specifically, it has been suggested that an upper blepharoplasty may change the relative position of the eyelid, thereby mechanically altering the corneoscleral and conjunctival interface[7]. Another explanation attributes dry eye symptoms to the close interaction between the eyelids, lacrimal pump and tear film[7]. The lacrimal pump mechanism is intimately associated with the orbicularis muscle function. The tear fluid passage support mechanism is the tear pump, stimulated by orbicularis oculi muscle contraction, namely when the pretarsal and preseptal muscles close the eyelids. When the pretarsal muscle contracts and shortens, the canaliculi squeeze tears into the lacrimal sac while the muscle pulls the lacrimal sac laterally and forward, creating a vacuum to draw the tears into the sac. Upon relaxation, tears are driven into the nasolacrimal duct[8,9].

In theory, violating the orbicularis oculi muscle during an upper blepharoplasty may lead to blink alterations, which might account for decreased mechanical tear film distribution, reduced outflow of lipid secretion from the meibomian glands, and reduced tear drainage with impaired debris removal from the ocular surface[1,7]. This, in turn, may cause irritation and/or dry eye symptoms. On the contrary, the correction of abundant tissue of the upper eyelid may also improve mechanical eyelid function and alleviate dry eye complaints.

However, it is still not set in the literature whether resecting additional orbicularis oculi muscle during an upper blepharoplasty affects the tear film or dry eye symptoms[10].

To the best of our knowledge, no study has been published so far comparing the tear film dynamics and dry eye symptoms in patients undergoing a skin only upper blepharoplasty and patients with additional removal of orbicularis oculi muscle. Therefore, we aimed to compare the effect of the two blepharoplasty techniques on tear film dynamics and dry eye symptoms in patients.

METHODS

Study population

All consecutive healthy Caucasian patients, between 30 and 70 years of age, who consulted the department of Oral and Maxillofacial Surgery at the University Medical Center Groningen for an upper blepharoplasty between February 2018 and October 2019, and spoke Dutch fluently, were asked to participate (Fig. I). The consultations were performed by two maxillofacial surgeons (J.J., R.H.S.) with extensive experience in upper blepharoplasties. Patients were included if they showed dermatochalasis of both upper eyelids and an upper eyelid blepharoplasty was indicated. Indications for upper eyelid blepharoplasty included excess upper eyelid skin that resulted in functional symptoms or cosmetic concerns in patients. The indication for blepharoplasty in this study were predominantly cosmetic, while patients often reported a heavy feeling of the eyelids. Only one patient complained about visual symptoms (limited upper peripheral vision).

Patients were excluded if they had a history of ocular- or orbital trauma, had a history of eyelid surgery or surgery in the region of the eyebrows, had been subjected to other cosmetic surgical or non-surgical procedures, had a current or history of ophthalmic disease, or suffered from blepharoptosis or any (systemic) disease or condition that could interfere with the ophthalmic tests.

Study design

A prospective, single-centre, randomized, double-blind, controlled trial investigating dry eye parameters before and after upper blepharoplasty. The study protocol was approved by the institutional review board (METc2017/451) and registered in the Netherlands Trial Register (ID NL7886). Written informed consent was obtained from all the study participants.

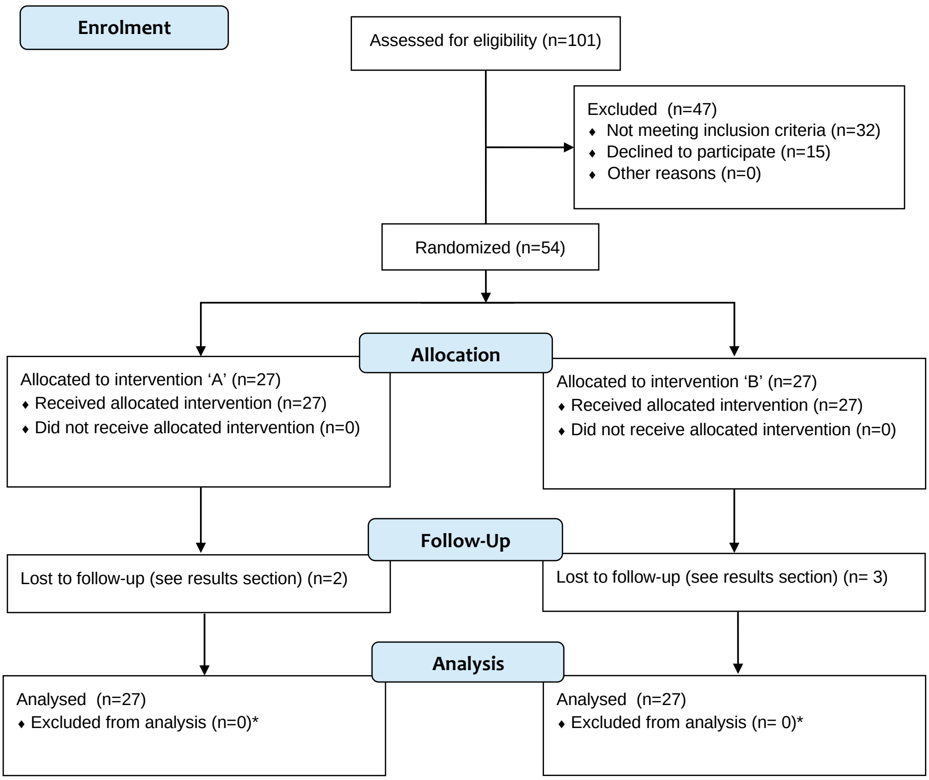

Figure I. Flow diagram participant enrolment
* Only lost to follow up missing values were excluded from analysis.

Blinding and randomization

Eligible participants were randomly assigned to treatment group 'A' (resection of skin only) or 'B' (resection of skin and a strip of underlying orbicularis oculi muscle). Randomisation was performed by creating a blocked randomisation list prior to the start of the study with a web-based randomization system (www.sealedenvelope.com). The participants received a unique code in consecutive order, i.e. the first included participant received the first code on the list. The investigators and participants were blinded. Only the surgeons knew which treatment was given to the participants until completion of the trial. The participants were informed about both surgical procedures, but did not know which treatment they underwent. All the patients received identical information about the procedure and postoperative course.

Outcomes

Demographic data were recorded including age, gender, medical history, use of medication and use of contact lenses. The severity of the upper eyelid dermatochalasis was assessed before the upper blepharoplasty and categorized according to a 4-level photonumerical severity scale using anatomical cut-off points, i.e. normal if the upper eyelid skin was not touching the eyelashes, mild if the upper eyelid skin was touching the eyelashes, moderate if the upper eyelid skin was hanging over the eyelashes, and severe if the upper eyelid skin was hanging over the eye[11]. The removed tissue was weighed per eye and recorded in grams.

The study outcomes were evaluated preoperatively, and 6- and 12-months post-blepharoplasty. All the tests were performed on both eyes by the same researcher (M.H.J.H), who was blinded for the procedure, and are listed below in order of execution. The patients also underwent a detailed ophthalmic examination, including best corrected visual acuity and the presence of blepharitis, meibomian gland dysfunction, ocular mucin, ectropion/entropion and other eyelid abnormalities (except dermatochalasis).

a. Tear osmolarity

Tear osmolarity was evaluated using the Tearlab osmolarity system (OcuSense, Inc, San Diego, CA). This test utilizes a temperature-corrected impedance measurement to provide an indirect assessment of osmolarity. A 50nL tear sample was collected from the lateral meniscus of each eye at least 15 minutes after using the slit lamp (ophthalmic examination). Tear hyperosmolarity is considered a biomarker for dry eye disease[12]. In healthy people, the mean tear osmolarity is 298 mOsms/L[13] and 308 mOsms/L or more in dry eye disease cases[14].

b. Schirmer test I

The Schirmer test I measures total tear secretion, including reflex and basal tears. A folded test strip of sterile filter paper, supplied in a standard kit, was placed over the margin of each lower eyelid at the junction of the middle and lateral thirds, without prior application of anaesthetic eye drops. The extent of wetting was measured by leaving the paper on the lower eyelid for five minutes, held in place by the patients gently closing their eyes. The paper was then removed and the amount of paper wetting in millimetres was recorded per eye. It is generally agreed that a Schirmer I test of ≤5mm in 5 minutes is abnormal[15].

c. Cornea staining

Fluorescein dye was used to stain areas of discontinuity in the epithelial surface of the cornea. Corneal and conjunctival surfaces are stained whenever there is a disruption of cell-to-cell junctions[16]. A sterile strip of fluorescein was moistened with sterile NaCl. The NaCl was allowed to just saturate the impregnated tip, at which point the excess was immediately shaken free into a waste bin. The moistened strip was then applied to the conjunctival fornix of the eye. The cornea was observed under a cobalt blue filtered light from a slit lamp microscope. Punctate epithelial erosions (PEE) on the cornea that stain with fluorescein were counted and scored with the SICCA ocular staining score and the Oxford Scheme. This was repeated for the contralateral eye.

d. Tear break-up time (TBUT)

TBUT was also measured with the fluorescein to determine tear film stability. A TBUT of ≤10 seconds is abnormal and indicative of a deficiency or abnormal quality of the outermost mucus layer of the tear film[17]. The subjects were asked to blink three times and then to look straight ahead without blinking. The tear film was observed under the cobalt blue filtered light of the slit lamp microscope and the time that elapsed between the last blink and appearance of the first break in the tear film was recorded in seconds. This was measured three times and the mean value was used for further analysis.

e. Conjunctival staining

A sterile strip of lissamine green was moistened in the same way as the fluorescein strip and placed in the conjunctival fornix of the eye. The subjects were asked to blink a few times after which the eyes were examined and graded directly. The staining was evaluated with the help of the slit lamp (x16 magnification) using a neutral density filter over the light source to avoid blanching of the conjunctiva. The temporal area of the conjunctiva was observed while the subject looked nasally along the horizontal plane, and the nasal conjunctiva was observed while the subject looked temporally. Conjunctival staining with lissamine green was evaluated by the amount of visible punctate staining on the conjunctiva and by using the Oxford Scheme[18] and the SICCA Ocular Staining Score[19].

f. The Oxford scheme

The Oxford Scheme, which has been specifically developed to quantify epithelial surface damage in case of dry eyes, involves a chart with a series of panels labelled A–E (grade 0 to V) in order of severity (absent, minimal, mild, moderate, severe)[18]. The whole exposed ocular surface was considered, without separating the cornea and the conjunctiva, and the number of dots representing the staining increased logarithmically.

g. Ocular staining score

A quantitative dry eye grading scheme was developed as part of SICCA (Sjögren's International Collaborative Clinical Alliance): the Ocular Staining Score (OSS)[19]. It uses lissamine green to grade the conjunctiva and fluorescein to grade the cornea.

Regarding the cornea, the score is 0 if there is no PEE. Counts of 1-5 PEE are scored as 1; 6-30 PEE are scored as 2; and >30 PEE are scored as 3. An additional point was added if: 1) PEE occurred in the central 4mm diameter portion of the cornea; 2) one or more filaments were seen anywhere on the cornea; or 3) one or more patches of confluent staining, including linear stains, were found anywhere on the cornea. The total fluorescein score for the cornea (the PEE grade plus any extra points for modifiers) was noted in the central square of the SICCA ocular staining score form. The maximum possible score for each cornea was 6.

Regarding the conjunctiva, grade 0 was defined as 0 to 9 dots of Lissamine green staining; grade 1 was defined by the presence of 10 to 32 dots; grade 2 by 33 to 100 dots; and grade 3 >100 dots. The total OSS for each eye was the summation of the fluorescein score for the cornea and the lissamine green scores for the nasal and temporal conjunctiva. Therefore, the maximum possible score for each eye was 12. The eyes were graded separately and the scores recorded on the SICCA ocular staining score form.

h. Ocular surface disease index (OSDI) questionnaire

The OSDI is a validated 12-item questionnaire designed to provide an assessment of the symptoms of ocular irritation consistent with dry eye disease and their impact on vision-related functioning[20]. The questionnaire has 3 subscales: ocular symptoms, vision-related function, and environmental triggers. Our patients rated their responses on the 0 to 4 scale with 0 corresponding to "none of the time" and 4 corresponding to "all of the time." A final score was calculated with a formula, which could range from 0 to 100, with scores 0 to 12 representing normal, 13 to 22 representing mild dry eye disease, 23 to 32 representing moderate dry eye disease, and greater than 33 representing severe dry eye disease.

Surgical procedure

The upper blepharoplasties were performed by two surgeons (J.J., R.H.S.) and took place in an outpatient environment. The surgical procedure was standardized prior to the study. The patients either underwent the removal of upper eyelid skin only procedure (group A) or the additional removal of a strip of orbicularis oculi muscle (group B). The surgical landmarks and planned skin excisions were marked on the upright positioned patient's eyes. Approximately 1.7 ml of Ultracaine DS Forte (40 mg Articain, 10 µg Epinephrine per ml) local anaesthetic was injected subcutaneously per eye. After the skin incision with a scalpel, the marked excess skin was removed. The group B participants underwent subsequent removal of an additional strip of the underlying orbicularis oculi muscle (3-4mm). The orbital septum was coagulated and the muscle edges were approximated with bipolar coagulation. The skin was sutured with Ethilon 6-0 (Ethicon, Cornelia, Georgia, USA) intracutaneously in a running fashion and adhesive suture strips were placed. All the other steps of the procedure were identical for both groups A and B.

When indicated, i.e. when a significant amount of protruding medial fat was present, this protruding medial fat was removed after minimally opening the orbital septum.

Statistical analysis

Sample size calculations were based on tear osmolarity. All the measurements were carried out per eye and not by averaging both eyes in one participant. A total of 27 patients (54 eyes) was needed per treatment group to detect a difference of 10 mOsm/L (G*Power version 3.1.9.6, University of Kiel, Germany) between groups A and B (the mean osmolarity of a normal tear film is 298 mOsm/L according to the Baenninger et al.[13] systematic review; and >308 mOsm/L for DED according to the Dry Eye Workshop Report 2017[14], with a two-sided 5% significance level and power of 90%, allowing for a 10% attrition rate and 10% for possible non-parametric testing.

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The data was analysed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Shapiro–Wilk test, Kolmogorov–Smirnov test, and graphical interpretation of Q–Q plots were used to determine the distribution of the data. Independent samples t-test, Chi Square test and Fisher's exact test were used where appropriate to test baseline differences between the groups.

The differences between group A's and B's tear osmolarity, Schirmer Test, TBUT, SICCA OSS, Oxford scheme and OSDI-questionnaire scores were evaluated using generalized estimating equations (GEE). The GEE model included the postoperative outcomes, baseline scores, gender, age, dermatochalasis severity score, amount of removed tissue during surgery, the use of contact lenses and medication used with possible effect on tear secretion or dry eye symptoms[6,21]. P-values <0.05 were considered statistically significant. Missing data were not imputed. All the residuals showed a Gaussian distribution. Different correlation structures (exchangeable, M-dependent, unstructured) were tested and the model with the lowest information criterion was used, which was the M-dependent correlation structure for the tear osmolarity and the exchangeable correlation structure for all the other variables.

Pre-and post-blepharoplasty differences were analysed using the Friedman test and pairwise comparisons were performed whereupon Bonferroni adjusted p-values were applied. Each group's postoperative scores were compared with the baseline scores.

RESULTS

A total of 54 patients was enrolled and 108 eyes were evaluated. The characteristics of the included patients are shown in table I. Group A's and B's characteristics were comparable at baseline. A total of 5 female patients' data were excluded: two group B patients were lost to follow up at 2 months and 12 months; two group A patients were excluded after the 6-month follow-up visits due to burn-out and to health problems related to dysregulated diabetes mellitus; and one group B patient was excluded from the 12-month analysis because of her wish to correct the scar tissue on one eyelid after the initial procedure. The latter patient sutures had become loose which resulted in a widened scar that was corrected after the 6-month follow-up visit. The medications used by the participants, which did not change during the 12 month follow up, are listed in table I. During the baseline ophthalmic examination, one patient displayed very mild asymptomatic conjunctivochalasis (group A) which did not progress during the study. No other abnormalities were observed. None of the patients used artificial tears, eye drops or ointment before or during the course of the study. The use of any contact lenses or contact lens solution was not altered during the study. Participants did not undergo any other ophthalmic surgery or treatment before and during the course of the study.

Objective outcomes (table II)

There were no significant differences between group A and B at the 6 month and 12 month follow ups regarding all primary outcomes (Table II). A significant increase in tear osmolarity (median increase= 10 mOsm/L, $p=0.037$) and TBUT (median increase= 1s, $p=0.037$) was observed in group B at the 6-month follow up, but not at the 12-month follow-up. There were no significant differences in Group A's tear osmolarity and TBUT compared to baseline. Both groups' postoperative Schirmer test I was not significantly different to the baseline test. No significant differences were found between the 6- and 12 month outcomes in both groups.

Table I. Baseline patient characteristics after randomization.

	Treatment A n=27		Treatment B n=27		P value	Total n=54	
Gender (number and % female)	21 (78%)		23 (85%)		*0.484*	44 (82%)	
Age (years; mean±SD)	58±8.6		55±9.1		*0.241*	57±8.9	
Dermatochalasis severity score (number of patients)	*Right eye* Normal: 0 Mild: 11 Moderate: 15 Severe: 1	*Left eye* Normal: 0 Mild: 10 Moderate: 16 Severe: 1	*Right eye* Normal: 0 Mild: 12 Moderate: 13 Severe: 2	*Left eye* Normal: 0 Mild: 13 Moderate: 12 Severe: 2	*Right eye* *p=0.771* *Left eye* *p=0.523*	*Right eye* Normal: 0 Mild: 23 Moderate: 28 Severe: 3	*Left eye* Normal: 0 Mild: 23 Moderate: 28 Severe: 3
Removed skin (g; mean±SD [range])	*Right eye* 0.30±0.08 [0.18-0.42]	*Left eye* 0.32±0.08 [0.21-0.51]	*Right eye* 0.32±0.11 [0.18-0.61]	*Left eye* 0.34±0.12 [0.14-0.65]	*Right eye* *p=0.563* *Left eye* *p=0.703*	*Right eye* 0.31±0.09 [0.18-0.61]	*Left eye* 0.33±0.10 [0.14-0.65)
Removed muscle (g; mean±SD [range])	-	-	*Right eye* 0.11±0.07 [0.05-0.40)	*Left eye* 0.11±0.07 [0.05-0.40]	-	-	-
Medial fat removal (no. of patients)	2*		0		*p=0.552*	2	
Contact lenses (no. of patients regularly using contact lenses)	3		5		*p=0.704*	8	
Any general medication use (no. of patients)	5		6		*p=0.735*	11	
Medication use possibly affecting tear secretion (no. of patients)**	2		2		*p=1.000*	4	

* Removal of medial fat from both eyes.

** Medication use possibly affecting tear secretion or dry eye symptoms[6,21]. The used medications were Amitriptyline (group A), Metoprolol (group A), Citalopram (group B), Amitriptyline (group B).

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Table II. Pre-and post-operative dry eye outcomes (median[Q1;Q3]) and differences between groups.

	Preoperatively		6 months postoperatively			12 months postoperatively		
	Group A *median [Q1;Q3]*	***Group B*** *median [Q1;Q3]*	***Group A*** *median [Q1;Q3] (p-value*)*	***Group B median*** *[Q1;Q3] (p-value*)*	***Adjusted difference** between group A and B (95% CI) and p-value***	***Group A*** *median [Q1;Q3] (p-value*)*	***Group B*** *median [Q1;Q3] (p-value*)*	***Adjusted difference** between group A and B (95% CI) and p-value***
Tear osmolarity (mOsm/L)	304 [294;315]	306 [295;320]	311 [303;321] (p=0.125)	314 [308;326] (p=0.037)	2 (-8-13) p=0.673	304 [294;317] (p=0.125)	309 [302;316] (p=0.136)	5 (-6-15) p=0.339
Schirmer test I (millimetres)	7 [5;10]	8 [5;19]	6 [3;12] (p=0.112)	8 [5;14] (p=0.614)	0 (-5-4) p=0.940	7 [4;16] (p=0.112)	8 [5;17] (p=0.614)	-2 (-6-1) p=0.242
TBUT (seconds)	6 [5;8]	6 [5;8]	6 [5;8] (p=0.775)	7 [5;9] (p=0.037)	1 (-1-3) p=0.464	7 [5;0] (p=0.775)	7 [5;9] (p=0.146)	0 (-1-2) p=0.871
Oxford Score (grade 0-5)	0 [0;0]	0 [0;0]	0 [0;0] (p=0.358)	0 [0;0] (p=0.087)	0 (-1-0) p=0.492	0 [0;0] (p=0.358)	0 [0;0] (p=0.087)	0 (0-1) p=0.676
SICCA OSS (score 0-12)	0 [0;0]	0 [0;0]	0 [0;0] (p=0.318)	0 [0;0] (p=1.000)	0 (-1-0) p=0.425	0 [0;0] (p=0.318)	0 [0;0] (p=0.571)	0 (-1-1) p=0.832
OSDI questionnaire (score 0-100)	13 [4;27]	17 [6;31]	2 [0;8] (p=0.005)	6 [3;13] (p=0.005)	-4 (-11-3) p=0.290	4 [0;15] (p=0.005)	6 [2;13] (p=0.001)	-4 (-11-4) p=0.306

* p-value of the comparison between preoperative and postoperative outcomes within a group.
**The adjusted difference is the regression coefficient from the generalized estimating equation models, which represents the difference of that outcome between the treatment groups (group A–group B), adjusted for baseline values, gender, age, dermatochalasis severity score, amount of tissue removed, the use of contact lenses and medication that might affect tear secretion.

Physician rated dry eye scores

The differences between group A and B regarding Oxford scheme gradings and OSS, at the 6 month and the 12 month follow ups, were not significant (Table II). Both groups' median Oxford scheme gradings were grade '0' at baseline and at 6- and 12 months postoperatively, indicating the absence of dry eye disease. The same applied to the OSS, whose median was also '0' during the postoperative assessments (6- and 12 month follow ups). There were no significant differences between the baseline findings and the 6- and 12 month follow-ups (Table II).

Patient reported dry eye scores

GEE revealed no significant differences between group A and B at the 6 month and the 12 month follow ups regarding OSDI (table II). The median preoperative OSDI scores were 13 [4;27] (group A) and 17 [6;31] (group B) indicating preoperative mild dry eye disease in both groups according to the questionnaire's cut off points[20]. Both groups' OSDI scores decreased significantly to 'normal'[20] at the 6- and 12 month follow-ups. Specifically, an OSDI score of 2[0;8] (group A) and 6[3;13] (group B) during the 6-month follow up, and 4[0;15] (group A) and 6[2;13] (group B) during the 12-month follow up. The 6- and 12-month scores were not significantly different.

DISCUSSION

Historically, upper eyelid surgery is suspected of inducing or worsening dry eye disease or complaints[6,22]. The current randomized controlled trial did not find any clinically meaningful or statistically significant differences in dry eye parameters in both treatment groups' objective and physician assessed scores, i.e. skin only and skin muscle group, during a long term follow-up (12 months) compared to baseline. Subjectively, however, the patients reported that their dry eye symptoms and vision related impairment (OSDI questionnaire score) improved significantly. Thus, a blepharoplasty does not induce or worsen dry eye symptoms but may, potentially, alleviate subjective complaints of dry eyes. It is well described in the literature that dry eye symptoms are poorly correlated with dry eye signs[23] and this discordance may be influenced by several factors such as self-perceived health, mental health, age or allergies[24,25].

Our findings are in line with former literature on this subject[10]. Subjective dry eye complaints were reported to be alleviated by surgery, but this observation was mostly not supported by objective tests, such as the Schirmer test or TBUT[26-28]. Vold et al.[29] assessed whether upper blepharoplasty with skin and muscle excisions was effective in alleviating dry eye symptoms such as burning, itching, redness and foreign body sensation in the eyes. They concluded that the symptoms decreased significantly after surgery[29].

The present study primarily assessed the long term effects of an upper blepharoplasty, whereas most studies have only assessed the short term effects, varying from 7 days[27] to 3 months[26,28] or reported unstandardized patient follow ups ranging from 1 to 132 months[6,30]. Hamawy et al.[31] showed that 98% of the patients with dry eyes recovered fully within 8 weeks after a blepharoplasty, but they did not make a distinction between upper and lower blepharoplasty. Although we did not find any significant differences in the long term (12 months) effects compared to baseline, it is possible that transient dry eye symptoms were present shortly after surgery.

We did find a significant increase in tear osmolarity and in TBUT during the 6-month follow-up after upper blepharoplasty with additional muscle excision. These results are conflicting, since an increase in tear osmolarity indicates a more unstable tear film, whereas an increase in TBUT suggests better tear film stability and quality of the outermost mucus layer. We could not find any significant association between osmolarity and TBUT in the literature[32]. In theory, our findings could be explained by an underlying mechanism of increased evaporation postoperatively due to a more exposed ocular surface leading to hyperosmolarity. None of our patients showed lagophthalmos. The small improvement in TBUT postoperatively might be attributable to an improved eyelid function after removing the redundant eyelid skin. In the introduction we mentioned the theory that resecting the orbicularis oculi may induce dry eye symptoms. On the contrary, the excess eyelid tissue might mechanically hinder the optimal eyelid function preoperatively, and when the excess tissue is corrected, the eyelid function becomes more optimal and mild subjective dry eye complaints (and TBUT) improves. However, this theory has to be supported by further research.

Also, the normal day-to-day variation in TBUT is 3 seconds (30.2% of dynamic range of 10s) in mild/moderate dry eye patients[33]. This suggests that the pre-and postoperative differences in TBUT are not clinically relevant.

A limitation of our study is that it only focuses on long term ophthalmic effects. The question arises whether the changes in tear osmolarity and TBUT were more pronounced shortly after surgery. Therefore, it might be interesting to incorporate the short term effects of upper blepharoplasty in future studies when assessing dry eyes. Another limitation of this study is that we did not evaluate tear clearance rate, which might have provided further insight in the effects of resecting the orbicularis oculi muscle during upper blepharoplasty since this may affect tear clearance.

Furthermore, when interpreting the results reported in this study, it has to be mentioned that dry eyes are difficult to evaluate. Dry eye symptoms have a complex and multifactorial aetiology and there is no single definitive diagnostic test to identify or classify the severity of dry eye disease. Tear production, turnover and volume can be estimated by several methods, but there is limited correlation between different tests[34]. Accordingly, a combination of tests should provide a more reliable diagnosis and increase the specificity and sensitivity of dry eye diagnosis. This is why multiple dry eye tests were performed in this study.

In contrast to older literature, which suggests that excising a part of the orbicularis oculi muscle during upper blepharoplasty may cause dry eye problems[6,22,30], we did not find any differences between the skin only technique and the technique with additional muscle excision when evaluating objective dry eye tests and patient reported dry eye symptoms. In a split-face study[35], where only skin was removed from one eye and skin was removed with muscle from the contralateral side, the patients only reported dry eye on the side where both skin and muscle were removed. In these cases, the mean amount of muscle removed was 9mm or more while we removed no more than 3 to 4mm of muscle. It is important to avoid excising too much tissue during surgery so as to avoid postoperative lagophthalmos, since the latter significantly increases the risk of dry eye symptoms[6].

Clinical implications

Since long-term dry eye signs, and symptoms do not appear to differ between the techniques, the least invasive surgical technique should be used. In clinical practice, patients who attend a consultation for an upper blepharoplasty should be adequately informed about what to expect after surgery regarding dry eyes. According to the results of the current study, this should include that, in general, upper blepharoplasty does not induce long term dry eye symptoms.

CONCLUSION

Upper blepharoplasty alleviates subjective dry eye complaints in the long term while, at the same time, it does not change the tear dynamics. Resecting an additional strip of orbicularis muscle did not influence the results.

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None.

Conflict of interest

None.

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CHAPTER 7

Effects of upper blepharoplasty techniques on headaches, eyebrow position and electromyographic outcomes: a randomized controlled trial

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ABSTRACT

Background

To assess changes in headaches, eyebrow height and electromyographic (EMG) outcomes of the frontalis and orbicularis oculi muscles, up to 12 months after an upper blepharoplasty with or without resecting a strip of orbicularis oculi muscle.

Methods

In a randomized controlled trial, 54 patients received an upper blepharoplasty involving either only removing skin (group A) or removing skin with an additional strip of orbicularis muscle (group B). Preoperative, and 6 and 12 months postoperative, headache complaints were assessed using the HIT-6 scores (Headache Impact Score 6) and eyebrow heights were measured on standardised photographs. Surface EMG measurements, i.e. electrical activity and muscle fatigue, were assessed for the frontalis and orbicularis oculi muscles preoperative and 2, 6 and 12 months postoperative.

Results

Significantly fewer headaches were reported following a blepharoplasty. The eyebrow height had decreased at all landmarks, but did not differ between groups. Regarding the surface EMG measurements, only group A's frontalis muscle electrical activity had decreased significantly during maximal contraction 12 months after surgery (80 vs 39mV, p=0.026). Fatigue of both the frontalis and the orbicularis oculi muscles did not change significantly postoperatively compared to baseline. EMG differences between groups were minor and clinically insignificant.

Conclusion

The eyebrow height decreased and patients reported less headaches after upper blepharoplasty irrespective of the used technique.

INTRODUCTION

Patients with dermatochalasis of the upper eyelids often elevate their eyebrows by recruiting the frontalis muscles in order to compensate for the visual field obstruction caused by sagging of the upper eyelid skin. This elevation may be associated with an increase in frontalis muscle electrical activity[1] and might cause other problems such as tension-type headaches due to constant muscle activation or insufficient relaxation[2]. This relationship is controversial[3].

An upper blepharoplasty can be a solution for dermatochalasis of the eyelids, providing general improvements in functional complaints[4] and an enhancement in facial beauty[5]. During treatment, the redundant skin is removed thereby alleviating any possible visual field obstructions. Postoperatively, it is no longer necessary to elevate and activate the eyebrow muscles. Theoretically, feedback from the brain to the frontalis muscles to continue to elevate the eyebrow is lost. This may result in lowering of the brows and softening of the forehead wrinkles. Also, this relaxation of the frontalis muscle might be the reason for the clinical observation that some patients experience significantly fewer tension type headaches after an upper blepharoplasty.

The literature is inconsistent regarding what happens to the eyebrow height after an upper blepharoplasty[4]. Although they tend to move down, the extent and the influence on aesthetic and functional outcomes is unknown. The lowering of the eyebrows is theoretically regarded to be the result of either the diminished need to elevate the forehead as a compensatory mechanism for elevation of the eyebrows, and thereby the upper eyelids[6], or the mechanical depression of the eyebrow by removing a large amount of eyelid tissue or by more invasive surgery. In theory, when excising more tissue, such as with the traditional upper blepharoplasty technique, more scarring might occur which, in turn, might lead to pulling the eyebrows down. As to whether the lowering of the eyebrows can be explained by changes in muscle activity needs further research. Also, it is unclear whether orbicularis oculi function is compromised after excising a strip of it during an upper blepharoplasty. Traditionally, an upper blepharoplasty entailed the removal of redundant skin with the underlying orbicularis oculi muscle and/or protruding fat. Modern surgical insights emphasize volume preservation and sparing of the orbicularis oculi muscle[7]. Therefore, the more conservative surgical upper blepharoplasty, which consists of only removing redundant skin, is gaining popularity.

The question arises whether a cosmetic upper blepharoplasty has an effect on the eyebrow position, frontalis muscle activation/fatigue and possibly headaches experienced by patients, and whether there is a relationship between these variables. Thus, the aim of this RCT was to assess the electrical activity of the upper facial muscles, eyebrow position and tension type headaches after two surgical upper blepharoplasty techniques.

METHODS

Study design

A prospective single-centre randomized, double-blind, controlled trial investigated eyebrow position, electrical activity of the upper facial muscles and headaches after upper blepharoplasties. The study protocol was approved by the institutional review board (METc2017/451) and registered in the Netherlands Trial Register (ID NL7886). Written informed consent was obtained from all the study participants.

Study population

All consecutive Caucasian patients between 30 and 70 years of age who consulted the Department of Oral and Maxillofacial Surgery at the University Medical Center Groningen for an upper blepharoplasty, between February 2018 and October 2019, were asked to participate (figure I). Patients were included if they showed dermatochalasis of both upper eyelids and an upper eyelid blepharoplasty was indicated. The consultations were performed by two maxillofacial surgeons (J.J., R.H.S.) with extensive experience in upper blepharoplasties. The patients had to be fluent in Dutch in order to fully understand the Dutch questionnaires. Patients were excluded if they had a history of ocular- or orbital trauma, trauma of the upper half of the face, a history of eyelid or eyebrow region surgery, had been subjected to other cosmetic surgical or non-surgical procedures, had ophthalmic disease, or suffered from blepharoptosis. Patients suffering from any other medical condition that could affect the electromyogram were also excluded.

Blinding and randomization

The eligible participants were randomly assigned to treatment group ‘A’ (resection of skin only) or ‘B’ (resection of skin and a strip of underlying orbicularis oculi muscle) according to the ‘blocks of four’ list created prior to the start of the study by a randomization computer tool (Sealed Envelope Ltd. 2017). The participants received an unique code in consecutive order, i.e. the first included participant received the first code on the list. The investigators and participants were blinded in that the latter were informed about both surgical procedures, but did not know which treatment they had undergone, and received identical information about the possible postoperative course of events. Only the surgeons knew which was treatment ‘A’ or ‘B’ until the completion of the trial.

Outcomes

Demographic data were recorded including age, gender, medical history and use of medication. The severity of the dermatochalasis was assessed before the upper blepharoplasty and categorized according to a 4-level photonumerical severity scale using anatomical cut-off points: normal, if the upper eyelid skin was not touching the eyelashes; mild, if the upper eyelid skin was touching the eyelashes; moderate, if the upper eyelid skin was hanging over the eyelashes; and severe, if the upper eyelid skin was hanging over the eye[8]. The removed tissue was weighed per eye and recorded in grams.

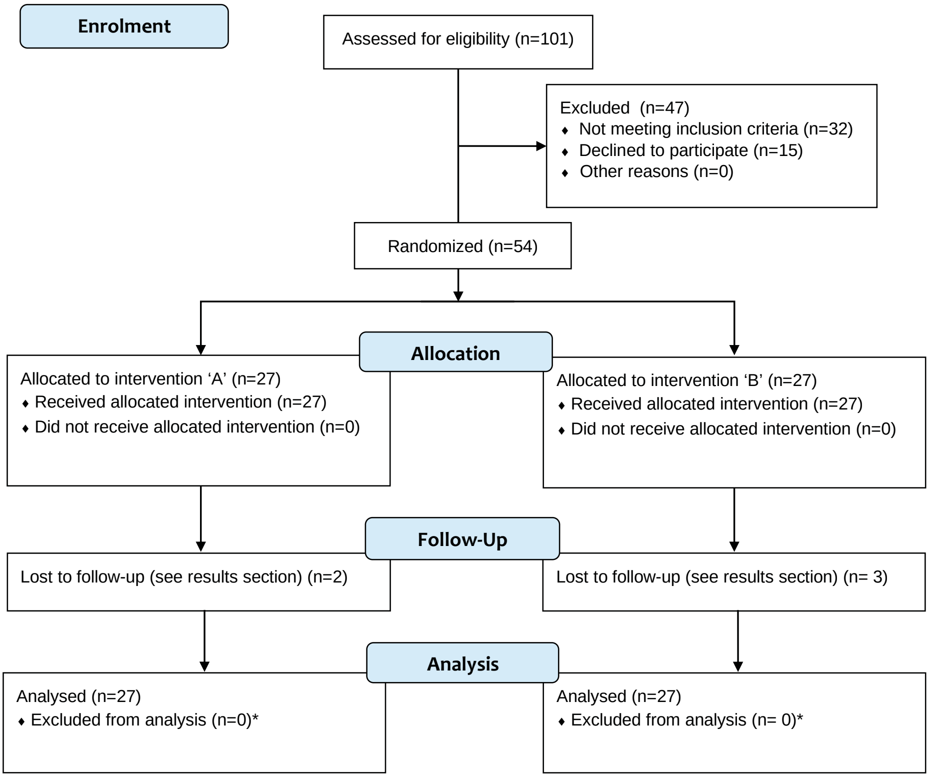

Figure I. Flow diagram of participant enrolment

* Only the 'lost to follow up' missing values were excluded from analysis.

a. Headache Impact

The Headache Impact Test 6 (HIT 6), a questionnaire consisting of 6 items (pain intensity, social functioning, role functioning, vitality, cognitive functioning and psychological distress), was used to assess headaches[9-11]. Each question can have a score between 6 and 13, so the minimum score is 36 and the maximum score is 78. A score of 60 or more is indicative of extremely severe headaches, a score between 56-59 severe headaches,

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a score between 50-55 moderate headaches and a score between 36 and 49 indicates non to mild headaches[12]. The questionnaire was completed directly preoperative and postoperatively at 6 and 12 months.

b. Eyebrow height

Standardised digital 2D photographs of the primary gaze were taken just before the surgery and 6 and 12 months postoperatively, with the head in a natural position, to assess eyebrow height. Each photograph was taken by the same researcher (M.H.J.H.) under the same lighting conditions, at a fixed distance and with the same camera (Nikon D5600 AF-S DX NIKKOR VR, Minato, Tokyo, Japan). To account for size discrepancy between photographs, a horizontal visible iris diameter of 11.71mm was used for calibration purposes[13-16]. The distances on the photographs were measured digitally using the NIH ImageJ software (Version 1.53a, National Institutes of Health, USA) as illustrated in figure II. First a horizontal line was drawn through the exocanthion. Then the following distances were measured:

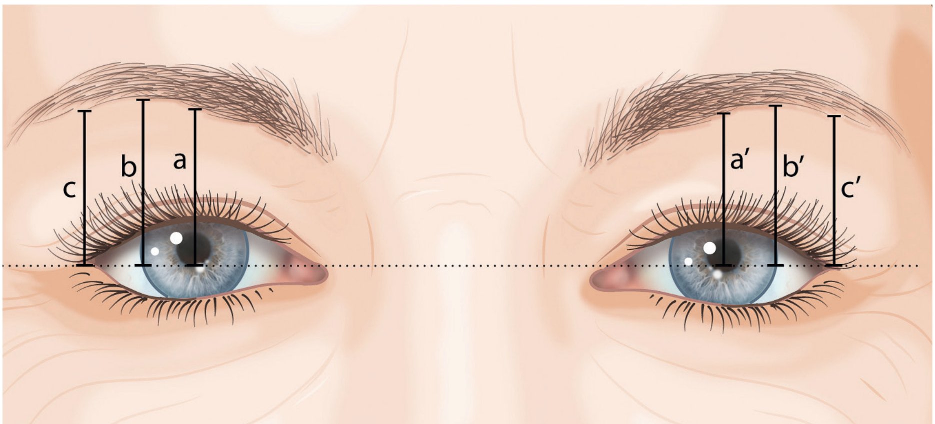

Figure II. Eyebrow height measurements.

- a and a′: vertical line to the lower boundary of the eyebrow at the pupil's midline;
- b and b′: vertical line to the lower boundary of the eyebrow at the lateral border of the iris;
- c and c′: vertical line to the lower boundary of the eyebrow at the exocanthion.

The eyebrow height measurements were performed by one researcher (M.H.J.H.) and then repeated by an independent researcher (M.C.) to assess inter-observer variability.

c. Electromyography

Directly before the blepharoplasty and 2, 6 and 12 months postoperatively, an electromyography of the frontalis muscles and orbicularis oculi muscles was performed. All the electromyography signals were recorded (unfiltered) with the BrainRT system with a 1kHz reach, a Duo 44 US EEG-PSG amplifier (Natus Europe GmbH, Germany), without a notch-filter. First, the skin of the upper face was cleaned with alcohol and abrasive gauze before attaching the surface electrodes. The Ag/AgCl-electrodes were rectangular (22x32mm; 3M Red Dot™ 3M Center, St. Paul Minnesota, USA) and contained conductive adhesive. The reference electrodes were attached to the skin covering the temporalis muscles (both sides; figure III). The active electrodes were attached to the muscle belly of the frontalis muscles right above the pupils and 15mm above the eyebrows on both sides. The grounding was attached midline, just below the hairline. Also, in order to measure the electrical activity of the orbicularis oculi muscle, another surface electrode was attached to the laterocaudal part of the orbicularis oculi (left and right eye). The patients sat in an upright position and were instructed to look at a fixed point on the wall. Then the different tasks were rehearsed, consisting of closing the eyes gently, raising eyebrows maximally, neutral gaze (looking at the fixed point), and closing the eyes firmly. This was repeated and the electromyography signal was stored together with the integrated video footage of the face during the tasks in the BrainRT software (RT Software Suite version 3.1, O.S.G. bvba, Belgium). We recorded 10 seconds of every task, of which 5 seconds were used for analysis[17]. The first 2 seconds were excluded from the analysis due to movement artefacts when performing the tasks, as well as the last 3 seconds. During the analysis, the video footage was checked in order to confirm correct movement execution.

In order to assess whether the muscle fatigue was caused by constantly raising the eyebrows preoperatively, multiple aspects of the EMGs were evaluated. During isometric contraction, muscle fatigue causes a decrease in the motor unit firing rate and the power density shift to lower frequencies. Then, additional fibres are recruited to maintain the muscle contraction which results in increased EMG amplitude and RMS (root-mean-square) values[18]. We, therefore, hypothesized that after blepharoplasty, electrical activity and muscle fatigue of the frontalis muscle might be less during the same isometric muscle contraction, since the constant raising of the eyebrow is no longer needed. Isometric contraction of the frontalis muscle was assessed by raising the eyebrow maximally, and the orbicularis oculi muscles by closing the eyes firmly. To assess these aspects, the root-mean-square (RMS) and the median frequency (Fmed) of the acquired EMG episodes were calculated and used to evaluate the electrical activity (RMS) and local fatigue (Fmed) of the muscles, which was processed by Matlab (version R2020b, The MathWorks, Inc., Massachusetts, USA). The EMG signal was analysed using the root-mean-square (RMS) method, which represents the square root of the average squared power of the EMG signal over a given period of time. To assess muscle fatigue, the median frequency was evaluated during the same 5 seconds of the surface EMGs (sEMGs). Also, to assess the Fmed shift in more detail, the median frequency of the 3rd and 9th second (of the 10 recorded seconds during maximal contraction) were calculated and compared.

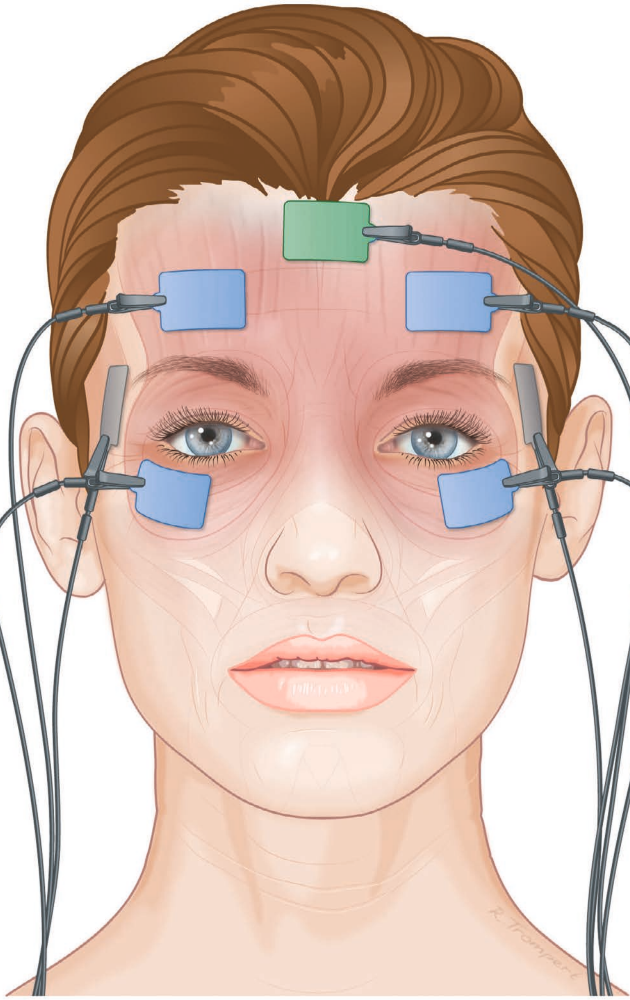

Figure III. Surface electromyography electrode placement.

During the Matlab processing, filters were applied, i.e. a high pass filter of 20Hz as recommended by Van Boxtel et al.[19], and a low-pass filter frequency of 300Hz. These filters were also chosen based on the visual interpretation of the EMG signals in BrainRT, which showed that all the signals were within these limits. Also, a Butterworth filter of 50Hz (and its harmonics) was used to compensate for the standard frequency of Europe's electricity grid.

Then, a proportional index was provided by RMS/maximal amplitude of the maximal contraction to normalise the frontalis and orbicularis oculi activity values among the individuals.

Surgical procedure

The upper blepharoplasties were performed by two surgeons (J.J., R.H.S.) in an outpatient environment. The surgical procedure was standardised prior to the study. The patients underwent the removal of upper eyelid skin only (group A) or the additional removal of a strip of orbicularis oculi muscle (group B); all the other steps were identical. The surgical landmarks and planned skin excisions were marked on the patient whilst in an upright position. Approximately 1.7 ml of Ultracaine DS Forte (40 mg Articain, 10 µg Epinephrine per ml), a local anaesthetic fluid, was injected subcutaneously per side. A scalpel was used to remove the marked excess upper eyelid skin and, in group B, 3-4mm of the underlying orbicularis oculi muscle. The orbital septum was coagulated and the muscle edges were approximated with bipolar coagulation. The skin was sutured with Ethilon 6-0 (Ethicon, Cornelia, Georgia, USA) intracutaneously in a running fashion and adhesive suture strips were placed. When indicated, the patients underwent removal of the significant amount of protruding medial fat.

Statistical analysis

Twenty-seven patients were needed per treatment group to detect a difference of 8.3 in the HIT-6 score between groups A and B at 6 and 12 months, with a two-sided 5% significance level and a power of 85%, allowing for a 15% attrition rate and 10% for possible non-parametric testing (G*Power version 3.1.9.6, University of Kiel, Germany). The mean HIT-6 score is based on pre-and postoperative differences between two groups, i.e. the blepharoplasty and ptosis surgery groups[20].

The data were analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test, Kolmogorov–Smirnov test, and graphical interpretation of Q–Q plots were used to determine the distribution of the data. All the tests were carried out for both sides of the patients' faces (left and right) and were included in the data set. The independent samples t-test, Chi Square test and Fisher's exact test were applied where appropriate to test baseline differences between the groups.

Pre-and post-blepharoplasty differences in eyebrow height and HIT-6 score within groups were analysed using the Friedman test followed by pairwise comparisons and Bonferroni adjusted p-values were applied. Differences between groups A and B regarding HIT-6 score, baseline HIT-6 scores, gender, age, dermatochalasis severity score and removed tissue during surgery, were evaluated using generalized estimating equations (GEE). All the residuals showed a Gaussian distribution and the models had a lowest information criterion in the exchangeable correlation structure. Additionally, the 'responders' baseline HIT-6 scores were compared, i.e. the participants who displayed a decrease of ≥8 points on the HIT-6 score postoperatively[21], and then the 'non-responders', i.e. the participants who displayed a decrease of <8 points on the HIT-6 score postoperatively, using the Mann-Whitney U test.

Differences between groups A and B regarding eyebrow height in millimetres, baseline eyebrow height, gender, age, dermatochalasis severity score and amount of removed tissue during surgery, were also evaluated using GEE. The residuals showed a Gaussian distribution and the model with the lowest information criterion was used (i.e., m-dependent for the a and b landmarks; exchangeable correlation structure for landmark c).

The differences in eyebrow height change between the landmarks were also evaluated using the Friedman test with pairwise comparisons and applying Bonferroni adjusted p-values.

To assess inter-observer agreement in measuring patients' eyebrow height, all the measurements were performed by two raters (M.H.J.H. and M.C.) and intraclass correlation coefficient (ICC, two-way mixed effects model, single measurement, absolute agreement) was calculated. All the patients' eyebrow height measurements were repeated to provide an intraclass correlation coefficient (ICC, two-way mixed effects model, single measurement, absolute agreement). The ICC values were interpreted as follows: 0.00-0.20, poor; 0.20-0.40, fair; 0.40-0.60, moderate; 0,60-0.80, good; 0.80-1.00, excellent[22].

The Friedman test was used to compare the post-surgical RMS, median frequencies and the index (RMS/maximal amplitude) with the preoperative EMGs within each treatment group. Subsequently, a post-hoc test was carried out and Bonferroni adjusted p-values were applied.

The differences between groups A and B were evaluated using GEE. The GEE model included the EMG values, baseline sEMG values, gender, age, dermatochalasis severity score and the amount of tissue removed during surgery. The residuals showed a Gaussian distribution and the model with the lowest information criterion was used (i.e., exchangeable correlation structure). Only the RMS and median frequency values were transformed (log10) to achieve a Gaussian distribution of the residuals.

The correlation between the pre-and postoperative change in EMG-values (mean frontalis muscle RMS of right and left eye), eyebrow height (mean height at the b and 'b landmarks) and HIT-6 score were analysed with the Spearman correlation coefficient. The correlation coefficients, r values, were interpreted as follows: between 0-0.19, very weak; 0.2-0.39, weak; 0.40-0.59, moderate; 0.6-0.79, strong; and 0.8-1, very strong[23].

Also, the baseline variables were correlated with changes in any other variable during the follow-up.

The baseline variables were EMG-values (mean frontalis muscle RMS of right and left eye), eyebrow height (mean height at the b and 'b landmarks) or HIT-6 score. The pre- and both the 6- and 12 month postoperative changes in these variables were used. This was done in order to investigate if baseline values could 'predict' the change in outcomes.

RESULTS

Table I shows the characteristics of the 54 patients divided between groups A and B (Figure I). The patients' characteristics were comparable at baseline. A total of 5 female patients was excluded from the analysis: two patients (group B) were lost to the 2 month and 12 month follow-ups, two patients (group A) were excluded after the 6-month follow-up visit due to burn-out and multiple health problems related to a dysregulated diabetes mellitus, and one patient (group B) was excluded from the 12-month analysis because of her wish to correct the scarred tissue of one eyelid shortly after the initial procedure. The latter patient's sutures had become loose which resulted in a widened scar that was corrected after the 6-month follow-up visit. The participants underwent upper blepharoplasty mainly for cosmetic reasons.

Table I. Patient characteristics after randomisation.

	Treatment A **n=27**		**Treatment B** **n=27**		**P value**	
Gender (number and % female)	21 (78%)		23 (85%)		*0.484*	
Age (years; mean ± SD [range])	58 ± 8.6 [43-70]		55 ± 9.1 [39-70]		*0.241*	
Dermatochalasis severity score (number of patients)	*Right eye* Normal: 0 Mild: 11 Moderate: 15 Severe: 1	*Left eye* Normal: 0 Mild: 10 Moderate: 16 Severe: 1	*Right eye* Normal: 0 Mild: 12 Moderate: 13 Severe: 2	*Left eye* Normal: 0 Mild: 13 Moderate: 12 Severe: 2	*Right eye* *p=0.771*	*Left eye* *p=0.523*
Removed skin (g; mean ± SD [range])	*Right eye* 0.30 ± 0.08 [0.18-0.42]	*Left eye* 0.32 ± 0.08 [0.21-0.51]	*Right eye* 0.32 ± 0.11 [0.18-0.61]	*Left eye* 0.34 ± 0.12 [0.14-0.65]	*Right eye* *p=0.563*	*Left eye* *p=0.703*
Removed muscle (g; mean±SD [range])	-	-	*Right eye* 0.11±0.07 [0.05-0.40)	*Left eye* 0.11±0.07 [0.05-0.40]	-	
Medial fat removal (no. of patients)	2		0		*p=0.552*	

HIT-6

The median HIT-6 scores are displayed in table II. There were no significant differences in HIT-6 scores between groups A and B during the 6- and 12-month follow-ups. Both groups demonstrated a significant improvement (group A p=0.003; group B p=0.029) in HIT-6 scores at the 12 month follow-up compared to baseline.

The responders (participants with a decrease of ≥8 points on the HIT-6 score postoperatively compared to baseline) showed a significantly higher baseline HIT-6 score (baseline median {Q1;Q3] HIT-6 score responder: 49[46;61]; non-responder: 40[37;43]) compared to the non-responders (p<0.001).

Eyebrow height

The inter-observer reliability of the eyebrow height measurements showed an excellent ICC of 0.967 (p<0.001; 95% CI 0.917-0.986). Eyebrow heights were not significantly different at the 6- and 12-month follow-ups between groups A and B (table III). All the median postoperative eyebrow height measurements were significantly lower compared to baseline; the median eyebrow height decreased between 1.4 to 4.3mm (table IV). This applied to all the landmarks. When comparing the baseline and post-operatively measured landmarks, no significant differences were found in the change in eyebrow height (at the 6 month follow up, group A's p=0.936; group B's p=0.193; at the 12 month follow up, group A's p=0.938; group B's p=0.624).

Table II. Median HIT-6 scores [Q1;Q3] and differences between groups.

	Group A ***median [Q1;Q3] (p-value*)***	**Group B** ***median [Q1;Q3] (p-value*)***	**Adjusted difference between groups A and B** (95% CI) and p-value**	
Preoperatively	46[40;55]	42[40;58]	*n.a.*	
6 months postoperatively	40[36;44] (p=0.126)	38[36;45] (p=0.052)	-2 (-7 - 3)	p=0.383
12 months postoperatively	37[36;42] (p=0.003)	38[36;41] (p=0.029)	3 (-3 - 9)	p=0.301

* p-value of the comparison between the preoperative and postoperative outcomes within a group (including Bonferroni correction).
**The adjusted difference is the regression coefficient from the generalised estimating equation models, which represents the difference in HIT-6 score between the treatment groups (group A–group B), after adjusting for baseline HIT-6 score, gender, age, dermatochalasis severity score and amount of tissue removed.

Table III. Eyebrow height in millimetres (median[Q1;Q3]): differences between groups.

	Preoperatively		***6 months postoperatively***	***12 months postoperatively***
	Group A median [Q1;Q3]	**Group B median [Q1;Q3]**	**Adjusted difference* between groups A and B (95% CI) and p-value**	**Adjusted difference* between groups A and B (95% CI) and p-value**
Landmark a and a'	15.8 [13.6;19.3]	16.5 [14.6;19.1]	-0.3 [-1.0;0.5] p=0.502	0.1 [-0.9-1.1] p=0.897
Landmark b and b'	16.7 [13.5;19.8]	17.5 [15.4;20.5]	-0.8 [-1.6 ;0.1] p=0.082	-0.3 [-1.3 ;0.7} p=0.575
Landmark c and c'	16.7 [13.2;18.6]	16.8 [15.2;19.7]	-0.7 [-1.8;0.3] p=0.169	-0.4 [-1.6;0.7] p=0.474

*The adjusted difference is the regression coefficient from the generalised estimating equation models, which represents the difference in eyebrow height (in millimetres) between the treatment groups (group A–group B), after adjusting for baseline eyebrow height, gender, age, dermatochalasis severity score and amount of tissue removed.

Table IV. Eyebrow height in millimetres (median[Q1;Q3]): pre-and postoperative differences.

	Preoperatively	**6 months postoperatively**		**12 months postoperatively**	
	Median [Q1;Q3]	*Median [Q1;Q3]*	*Difference compared to baseline (p-value)*	*Median [Q1;Q3]*	*Difference compared to baseline (p-value)*
Group A					
Landmark a and a'	15.8 [13.6;19.3]	13.2 [11.7;16.2]	-2.6 (p<0.001)	13.6 [11.4;16.9]	-2.2 (p<0.001)
Landmark b and b'	16.7 [13.5;19.8]	14.0 [11.7;16.6]	-2.7 (p<0.001)	13.1 [11.7;16.7]	-3.6 (p<0.001)
Landmark c and c'	16.7 [13.2;18.6]	13.7 [11.4;16.2]	-3.0 (p<0.001)	12.4 [11.1;16.4]	-4.3 (p<0.001)
Group B					
Landmark a and a'	16.5 [14.6;19.1]	14.4 [13.0;16.4]	-2.1 (p<0.001)	15.1 [13.1;17.3]	-1.4 (p<0.001)
Landmark b and b'	17.5 [15.4;20.5]	14.6 [12.8;16.7]	-2.9 (p<0.001)	15.5 [12.9;18.1]	-2.0 (p<0.001)
Landmark c and c'	16.8 [15.2;19.7]	14.3 [11.9;16.8]	-2.5 (p<0.001)	14.5 [12.7;16.9]	-2.3 (p<0.001)

Electromyography

Group A's frontalis muscle EMG RMS value was significantly lower compared to group B 2 months postoperatively (p=0.042), but group B's orbicularis oculi RMS value was significantly lower compared to group A 12 months postoperatively (p=0.020). Yet, no differences were found between groups regarding the normalized EMG values (RMS/maximal amplitude) and median frequency.

The median sEMG RMS and the median frequency of the frontal muscles and orbicularis oculi muscles are shown in table V. Group A's 12 month post upper blepharoplasty RMS values had decreased significantly compared to baseline (p=0.026). There were no significant differences in the normalized EMG outcomes (index RMS/maximal amplitude) during maximal contraction in the postoperative course compared to baseline.

During the maximal contraction period, the median frequencies had shifted at the end, becoming lower than at the start (table VI), which indicates muscle fatigue. The median frequency shift seemed to improve postoperatively with time for group B's frontalis and orbicularis oculi muscles. Group A only showed a decrease in median frequency shift in the frontalis muscle 12 months postoperatively. However, these pre-and postoperative differences in median frequency shifts were not significant.

Table V. Pre-and post-operative EMG values (median[Q1;Q3]) and differences between groups.

	Preoperatively	2 months postoperatively		6 months postoperatively		12 months postoperatively		
	median [Q1;Q3]	*Median [Q1;Q3] (p-value*)*	*Adjusted diffe-rence between groups A and B** (95% CI) and p-value*	*Median [Q1;Q3] (p-value*)*	*Adjusted diffe-rence between groups A and B** (95% CI) and p-value*	*Median [Q1;Q3] (p-value*)*	*Adjusted diffe-rence between groups A and B** (95% CI) and p-value*	*Group*
RMS during maximal contraction (mV)								
Frontalis muscle	80 [22;125]	73 [42;157] p=0.255	-0.225 (-0.441- -0.008) p=0.042	49 [29;97] p=0.525	-0.131 (-0.338-0.076) p=0.215	39 [18;107] p=0.026	0.090 (-0.134-0.314) p=0.430	**Group A**
Frontalis muscle	46 [32;73]	62 [23;113] p=0.253		76 [43;123] p=0.253		59 [27;119] p=0.253		**Group B**
Orbicularis oculi muscle	51 [27;96]	44 [31;100] p=0.145	-0.020 (-0.196-0.157) p=0.826	51 [30;104] p=0.145	-0.117 (-0.301-0.067) p=0.211	40 [22;70] p=0.145	0.282 (0.045-0.520) p=0.020	**Group A**
Orbicularis oculi muscle	61 [22;100]	50 [28;96] p=0.801		66 [34;118] p=0.801		56 [36;111] p=0.801		**Group B**
Index (RMS/maximal amplitude) during maximal contraction (normalised value)								
Frontalis muscle	0.21 [0.13;0.30]	0.21 [0.16;0.25] p=0.392	-0.02 (-0.07-0.03) p=0.386	0.18 [0.15;0.21] p=0.392	-0.04 (-0.09-0.02) p=0.225	0.19 [0.15;0.22] p=0.392	-0.03 (-0.09-0.04) p=0.459	**Group A**
Frontalis muscle	0.20 [0.12;0.27]	0.19 [0.14;0.22] p=0.840		0.19 [0.13;0.22] p=0.840		0.19 [0.16;0.24] p=0.840		**Group B**

Table V. (Continued)

	Preoperatively	2 months postoperatively		6 months postoperatively		12 months postoperatively		
	median [Q1;Q3]	*Median [Q1;Q3] (p-value*)*	*Adjusted diffe-rence between groups A and B** (95% CI) and p-value*	*Median [Q1;Q3] (p-value*)*	*Adjusted diffe-rence between groups A and B** (95% CI) and p-value*	*Median [Q1;Q3] (p-value*)*	*Adjusted diffe-rence between groups A and B** (95% CI) and p-value*	*Group*
Orbicularis oculi muscle	0.21 [0.16;0.24]	0.20 [0.18;0.26] p=0.187	-0.001 (-0.04-0.04) p=0.958	0.17 [0.12;0.20] p=0.187	0.03 (-0.01-0.07) p=0.102	0.19 [0.16;0.22] p=0.187	0.01 (-0.02-0.04) p=0.666	**Group A**
Orbicularis oculi muscle	0.18 [0.16;0.21]	0.19 [0.17;0.23] p=0.535		0.18 [0.13;0.22] p=1.000		0.18 [0.14;0.22] p=1.000		**Group B**
Median frequency during maximal contraction (Hz)								
Frontalis muscle	71 [62 ;85]	77 [60;100] p=0.102	-0.066 (-0.134-0.001) p=0.054	65 [59;74] p=0.102	-0.037 (-0.090-0.016) p=0.169	65 [59;77] p=0.102	0.004 (-0.050-0.058) p=0.889	**Group A**
Frontalis muscle	64 [56;72]	64 [60;74] p=0.172		64 [57;69] p=0.172		66 [58;100] p=0.172		**Group B**
Orbicularis oculi muscle	100 [95 ;122]	110 [100;123] p=0.724	-0.035 (-0.106-0.036) p=0.337	106 [95;122] p=0.724	-0.033 (-0.085-0.020) p=0.222	108 [100;118] p=0.724	0.044 (-0.009-0.096) p=0.101	**Group A**
Orbicularis oculi muscle	98 [73 ;116]	100 [80;114] p=0.086		97 [71;106] p=0.086		110 [100;124] p=0.086		**Group B**

* p-value of the comparison between preoperative and postoperative outcomes within a group (including Bonferroni correction).
**The adjusted difference is the regression coefficient from the generalised estimating equation models, which represents the difference in HIT-6 score between the treatment groups (group A–group B), after adjusting for baseline values, gender, age, dermatochalasis severity score and amount of tissue removed. The raw values were transformed before undertaking the generalised estimating equations analysis. The estimates of the adjusted differences represent differences in the transformed scale (i.e., 10log) for the 'RMS during maximal contraction' and 'Median frequency during maximal contraction' values. The 'Index (RMS/maximal amplitude)' values were not transformed.

Table VI. Median frequency shift during maximal contraction (Fmed shift).

Group A	**Frontalis muscle**				**Orbicularis oculi muscle**			
	Median frequency (Hz) start	Median frequency (Hz) end	Difference (%)	p-value*	Median frequency (Hz) start	Median frequency (Hz) end	Difference (%)	p-value*
Preoperatively	71 [62;79]	67 [58;77]	-5.6 %	-	112 [91;133]	101 [70;121]	-9.8%	-
2 months postoperatively	75 [61;126]	69 [58;102]	-8.0%	0.381	124 [103;146]	105 [80;133]	-15.3%	0.345
6 months postoperatively	69 [60;75]	66 [57;77]	-4.3%	0.381	106 [84;125]	99 [64;121]	-6.6%	0.345
12 months postoperatively	66 [57;83]	69 [59;85]	+4.5%	0.381	111 [96;130]	97 [52;117]	-12.6%	0.345
Group B	**Frontalis muscle**				**Orbicularis oculi muscle**			
	Median frequency (Hz) start	Median frequency (Hz) end	Difference (%)	p-value*	Median frequency (Hz) start	Median frequency (Hz) end	Difference (%)	p-value*
Preoperatively	65 [54;71]	56 [51 ;71]	-13.8%	-	95 [67;113]	67 [55;98]	-29.5%	-
2 months postoperatively	65 [57;76]	58 [53;73]	-10.8%	0.331	110 [90;125]	85 [54;106]	-22.7%	0.417
6 months postoperatively	62 [55;73]	60 [53;71]	-3.2%	0.331	97 [63;107]	91 [58;106]	-6.2%	0.417
12 months postoperatively	63 [57;85]	65 [57;96]	+4.8%	0.331	114 [98;135]	105 [77;128]	-7.9%	0.417

* P-value of the comparison between the postoperative median frequency shift and the baseline (preoperative) median frequency shift.

7

Correlation

There was no significant correlation between the pre-and postoperative changes in the different variables (see table VII).

Regarding the baseline values and their correlation with changes in all variables, a significantly low positive correlation was found between the baseline eyebrow height and change in the 6 month postoperative HIT-6 values ($r_s(48) = 0.367$, $p=0.009$), but not in the 12 month follow up values ($r_s(33) = 0.088$, $p=0.617$). There were no other significant correlations between the variables (see table VII).

Table VII. Correlation between variables.

	Change in headache (r_s and p-value)	Change in eyebrow height (r_s and p-value)	Change in EMG frontalis muscle (r_s and p-value)
Correlation between the changes (pre-and postoperative values) in the different variables			
6 months follow up			
Change in headache	-	-0.060, p=0.681	-0.083, p=0.615
Change in eyebrow height	-0.060, p=0.681	-	0.080, p=0.627
Change in EMG frontalis muscle	-0.083, p=0.615	0.080, p=0.627	-
Correlation between baseline values and pre-and postoperative changes in the variables			
Baseline headache	-	-0.123, p=0.394	-0.078, p=0.653
Baseline eyebrow height	0.367, p=0.009	-	0.133, p=0.420
Baseline EMG frontalis muscle	0.292, p=0.071	-0.134, p=0.414	-
Correlation between the changes (pre-and postoperative values) in the different variables			
12 month follow up			
Change in headache	-	-0.043, p=0.814	-0.115, p=0.630
Change in eyebrow height	-0.043, p=0.814	-	0.136, p=0.465
Change in EMG frontalis muscle	-0.115, p=0.630	0.136, p=0.465	-
Correlation between baseline values and pre-and postoperative changes in the variables			
Baseline headache	-	0.097, p=0.518	0.193, p=0.291
Baseline eyebrow height	0.088, p=0.617	-	0.056, p=0.760
Baseline EMG frontalis muscle	0.154, p=0.473	-0.195, p=0.261	-

DISCUSSION

In this study, we demonstrate a decrease in eyebrow height and in headache complaints after an upper blepharoplasty, regardless of whether only skin or skin with an additional strip of orbicularis oculi muscle is resected.

After an upper blepharoplasty, the frontalis muscles do not need to lift the eyebrows anymore to compensate for excessive eyelid skin. Subsequently, the frontalis muscles can relax and, as a result, the eyebrows tend to move down postoperatively. An anatomic and physiological relationship between the eyebrows, eyelid opening and frontalis activation is suggested. When raising the eyebrows, the eyelid opening increases[24] which may be beneficial when the upper visual field is restricted or in the presence of heavy eyelids due to redundant upper eyelid skin.

Multiple studies have assessed the occurrence of brow ptosis after an upper blepharoplasty and, in general, the eyebrows tend to move down postoperatively[5], although not all studies have found significant differences between the pre-and postoperative measurements. However, the studies applied different methods to measure eyebrow height such as angular measurements[25], eyebrow height change reported as percentages[26] and ratios[27] or digitally calibrated measurements[15,28-31]. Also, different landmarks such as the vertical eyebrow height at the exocanthion, endocanthion, mid-pupillary line or lateral limbus were used. We chose the exocanthus as an anatomical landmark since it is a clear landmark that does not change after surgery.

Whether lowering the eyebrows has a negative effect on the aesthetic results is unclear. When the eyebrows move down postoperatively, the tarsal platform show may be less visible with time and may lead to a recurrence of excess upper eyelid skin. Whether this results in a softening of the forehead wrinkles is not clear. Another important factor is the shape and inclination of the eyebrows, since this affects eyebrow aesthetics[32]. It might be possible that the shape of the eyebrow is more important than the eyebrow height, and that patients are not really bothered by the lowering of the eyebrows postoperatively. The effect of lowering the eyebrow on the aesthetic results as perceived by patients has to be elucidated further in future studies.

In theory, preoperatively, continuous eyebrow elevation during the day may lead to problems such as tension-type headache. We found a low positive correlation[33] of 0.4 between the baseline eyebrow height and the postoperative change (after 6 months) in HIT-6 scores. This means that the higher the preoperative eyebrow, the more the HIT-6 score might be reduced.

Although the relationship between muscle activation and tension-type headache in controversial[3], we did find a significant improvement in headache complaints (HIT-6) 12 months postoperatively in both groups. This finding is in line with similar studies[20,34]. Castien et al.[21] proposed that a clinically relevant improvement in headaches is reflected by a decrease of at least 8 points on the HIT-6 questionnaire. Although both groups showed significant improvement in HIT-6 score, only group A showed a decrease of more than 8 points 12 months postoperatively, while group B only decreased by 4 points. However, in group B the preoperative HIT-6 value was lower, so that a decrease of more than 8 points was not feasible.

We also found a significant decrease in group A's RMS sEMG during maximal contraction 12 months after the upper blepharoplasty. This is an indication that the frontalis muscle requires less motor recruitment to elevate the eyebrow to the same height during maximal contraction compared to baseline. This is in line with the expectation of less local muscle fatigue (electrical activity) of the frontalis muscle postoperatively, but we do not know why we did not observe this in the skin/muscle group. One explanation could be that the delicate balance between the frontalis muscle and its antagonist orbicularis oculi muscle differs between the skin-only blepharoplasty and when the orbicularis oculi muscle is resected.

In general, during isometric contraction, muscle fatigue is accompanied by a decrease in motor unit firing rate. The EMG power density shifts to lower frequencies and, consequently, the median frequency decreases. As the muscle fatigues, additional fibres have to be recruited in order to generate the same force. This results in an increase in EMG amplitude and an increase in RMS values[18]. We assessed muscle fatigue using median frequencies. Muscle fatigue is generally defined as an activity induced loss of the ability to produce force with the muscle and is often the result of prolonged use[35]. We hypothesized that, when the eyebrows are constantly raised preoperatively, the frontalis muscles might be at risk of muscle fatigue. However, the changes within the groups in median frequency were not significant during the course of this study. We also studied the median frequency shift in more detail by comparing the start of the maximal contraction with the end of the maximal contraction. Although we observed that the frequency shifts became smaller after surgery, which indicates less muscle fatigue, these differences are not significant. We, therefore, cannot proof that muscle fatigue changes substantially after a blepharoplasty.

Our study did not assess the levator palpebrae superioris muscle, whose primary function is to elevate the upper eyelid. Excess eyelid skin might lead to muscle fatigue and so the frontalis muscle is recruited to elevate the eyelid-eyebrow unit as a whole. However, we could not acquire an sEMG of this muscle due to practical difficulties. The surface EMG electrodes would interfere with normal eyelid opening and we would have had to resort to invasive techniques such as needle or wire electrode EMGs. Also, due to the position of the muscle, it is difficult to acquire an EMG measurement. Kim et al.[1], who also concluded that upper blepharoplasty is associated with a gradual decrease in frontalis muscle activity, used needle electromyography. The disadvantage of needle-EMG is that only a small part of the muscle is recorded, whereas surface EMG covers a larger part of the muscle[36] and may therefore be more representative of the electrical activity of the muscle. The downside of surface EMG is that it suffers from crosstalk with neighbouring muscle activity, which can interweave with that of the target muscle[37]. This seems unlikely for the frontalis muscle. On the other hand, even the smallest electrode can potentially interfere with the movements of small muscles such as those of the face. The Kim et al.[1] study also used comparable methods to our study, such as normalized EMG data. The reason why we added the normalized (RMS/maximal amplitude) EMG values to our study was to compare the results better within and between the groups. The anthropomorphic differences between recording sites and between individuals might affect comparisons. These differences may include subcutaneous adipose tissue thickness, muscle resting length, contraction velocity, subtle changes in posture, interelectrode distance and impedance of the skin. However, the normalised EMG values did not differ between groups and within groups.

The non-normalised frontalis muscle RMS values showed that the electrical activity of the frontalis muscle was significantly lower in group A compared to group B two months postoperatively. This indicates that the skin-only participants' muscles required less motor recruitment to elevate the eyebrow to the same height during maximal contraction (raising the eyebrows maximally) compared to the skin/muscle group. Although group A demonstrated lower electrical activity of the frontalis muscle, this did not lead to significant differences in patient reported headaches between the groups.

Regarding the 12 month follow up of orbicularis oculi muscle RMS results, the group B value was lower compared to group A. Therefore, it seems that the skin/muscle group needed less motor recruitment to achieve the same amount of muscle contraction compared to the skin-only group. This implies that a skin-only blepharoplasty possibly induces minor difficulties in contraction of the orbicularis oculi. However, it is important to mention that the differences between the groups regarding sEMG do not seem to be clinically relevant. When the regression coefficients were subjected to backtransformation with the log transformed raw values, an adjusted difference of -1.7mV (RMS) in the frontalis muscle between groups was found, and 1.9mV (RMS) in the orbicularis oculi muscle between groups. These differences are smaller than the intra-individual day to day variability (13% during maximal contraction) in healthy subjects[38], and therefore we consider them, although statistically significant, not clinically relevant.

A limitation of our study is that our patients only showed mild headache symptoms preoperatively, so we could not assess the effect of an upper blepharoplasty on moderate to severe headaches. Also, the HIT-6 questionnaire was designed to provide a global measure and does not differentiate between various types and causes of headache. Another thought for future studies entails the eyebrow height measurements. Although, our eyebrow measurements showed excellent repeatability, some improvements in eyebrow height measurements are possible. For example, the upper limit of the eyebrows could be used as a cut-off point, since this area is usually not subjected to eyebrow epilation. Future studies should standardise and make eyebrow height measurements uniform since a variety of methods have been used so far.

CONCLUSION

The eyebrow height decreased and patients reported less headaches after upper blepharoplasty which irrespective of the used technique.

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Conflict of interest
None.

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CHAPTER 8

Reproducibility of 3D scanning in the periorbital region

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ABSTRACT

Background

The objective is to assess the reproducibility of scanning in the periorbital region with 3D technology to enable objective evaluations of surgical treatment in the periorbital region.

Methods

Facial 3D-scans of 15 volunteers were captured at different time points with a handheld Artec Space Spider structured light scanner. Two scans were made with a one minute interval and repeated after one year; for both a natural head position and with the head in a fixation-device.

Results

On assessing the area between the eyelashes and eyebrows, the medians of the average deviations between the various cross-sections of the one minute interval 3D-scans ranged from 0.17 to 0.21mm at baseline, and from 0.10 to 0.11mm when the minute-interval scanning was repeated one year later. The systematic differences when scanning in a natural head position and fixated position were comparable. The reproducibility of the 3D processing was excellent (intraclass correlation coefficient >0.9). The repeated scanning deviations (baseline versus one year data) were well within the accepted clinical threshold of 1mm.

Conclusions

Scanning with a hand-held 3D-scanning device (Artec Space Spider) is a promising tool to assess changes in the periorbital region following surgical treatment since the median deviations are well below the clinically accepted 1mm measuring error, for both the natural head and fixated positions.

INTRODUCTION

Three-dimensional (3D) scanning is a practical method for objective visual comparisons of surgical results. To assess treatment outcomes accurately following facial surgery, pre- and post-treatment 3D-photographs must be captured with the same facial expression[1]. Since 3D-imaging is affected by changes in facial expression, muscle tone and head posture, it is of key importance to minimize such variability to obtain a reproducible 3D-scan. If the variation within the face in a resting position is large, the evaluation of the effect of surgery based on a pre- and postoperative 3D-photograph will be inaccurate, especially when only minor improvements are anticipated. Two main optical 3D-scanning technologies are commonly applied to evaluate human subjects, i.e. image-based scanners and range-based scanners[2-4]. Image-based scanners (stereophotogrammetry) reconstruct the surface geometry with the use of two or more photographic images taken from different positions and this creates a point cloud of 3D coordinates. Stereophotogrammetry is an accurate user friendly image-based scanner method for comparing 3D-photographs of the same individual at different time points[5-9]. For this reason, stereophotogrammetry has been used to evaluate postoperative changes in the soft tissues of the face following orthognathic surgery and cranio-maxillofacial surgery[7,10]. Range-based scanners, such as structured light scanners, project a series of linear patterns of light onto the object to scan and capture its reflection with a sensor. Trigonometric triangulation is used to calculate the reflection angle of the structured light, and the three-dimensional coordinates are used to digitally reconstruct the object.

Irrespective of the type of scanner applied, the obtained point clouds are mathematically fused to polygonal 3D-meshes.

Although the accuracy of the above mentioned 3D-systems have been validated[2,8,9,11-14], scanning the periorbital region in a reproducible way remains challenging. Maal et al.[1] found a mean overall variation of 0.25 mm within the face at rest with the largest variations occurring in the mouth and eye regions. This larger variation in the eye region may be explained by the difficulty in capturing the eyes correctly when using 3D stereophotogrammetry[5]. The Verhulst et al.[2] study, which compared three different 3D-systems (3dMDface system, Vectra XT, Artec Eva), even excluded the periorbital area from the analysis because of the significant errors in this region. The advantage of the structured light scanning technique over 3D-stereophotogrammetry is that a hand-held construction enables scanning from multiple angles, which may be beneficial for capturing the periorbital region. Also, the position of the patient is of importance when capturing the eyes and peri-orbit because a change in gaze direction may alter the amount of visible eyelid skin. Therefore, the frequently used natural head position (NHP) might not be sufficient for accurate 3D-scans. Additional measures, such as fixing the head, might be needed to limit these movement artefacts during scanning.

It would be of great value for clinical decision making to be able to perform reproducible 3D measurements of the area around the eye. This would enable objective evaluations of surgical treatments in the periorbital region, such as blepharoplasties. Thus, it is important that the 3D-reconstruction of this area is reproducible. Hence, we assessed the reproducibility of using the Artec Space Spider, a 3D-scanning technological device on the periorbital region, first when the head is in a natural unsupported position and second when supported with a frame.

METHODS

All the employees of the Department of Oral and Maxillofacial Surgery of the University Medical Center Groningen, the Netherlands, were invited to participate. Anyone who was healthy was eligible, of whom the the first 15 volunteers were included. Volunteers were excluded if they had any history of epilepsy or facial deformities. The study was approved by the medical ethics committee of the University of Groningen and University Medical Center Groningen (study number METc2018/531). The study protocol was in accordance to institutional guidelines and the Declaration of Helsinki. Informed consent was obtained from all the participants prior to the study.

To test the reproducibility of periorbital 3D-scans, full face 3D-scans of the volunteers were captured at different time-points using the handheld Artec Space Spider scanning device (Artec 3D, Luxembourg). Data acquisition and processing was performed with Artec Studio Professional (version 13.0).

The volunteers's head were scanned in two different positions in order to determine the most reproducible method, first in the Jakobsone et al.[16] determined natural head position (figure I) and second by fixating the head in a head frame designed for this purpose (figure II). Fixation was achieved by placing earbuds, that were attached to the device by bars, in both of the participant's ears. The bars were slightly curved in order not to interfere with the scanning surface of the cheeks. The bars could be moved away and towards each other, enabling optimal positioning of the head. The distance between the bars was recorded in millimetres. Next, a small mouthpiece was placed between the anterior teeth to restrict movements in the sagittal plane. The distance of the mouthpiece was also recorded in millimetres. The volunteers were asked to look at a mark on the wall during the 3D-scanning and the height of the whole fixation-device was based on the marking on the wall. The fixation device was made of metal to avoid bending and movement during the scanning procedure. The volunteers were asked not to wear any make-up.

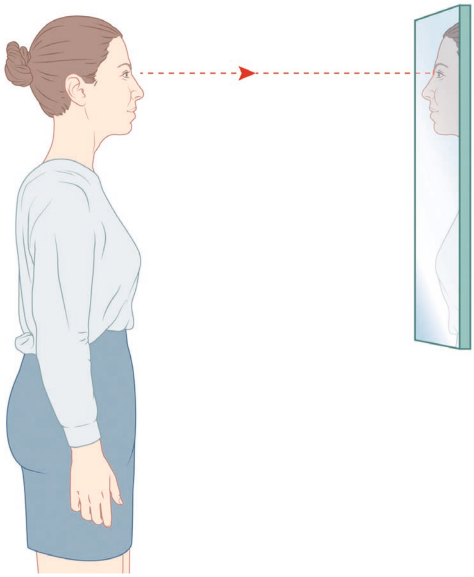

Figure I. Natural head position.

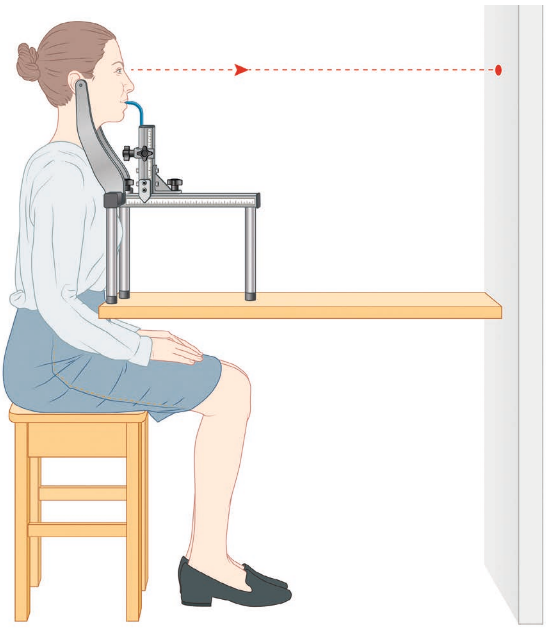

Figure II. Fixation device.

Scanning technique

Before scanning, the 3D-scanner was warmed up according to the recommendations of the manufacturer to achieve maximum accuracy. During the first scan (T1), to achieve a natural head position and habitual occlusion, the volunteers had to stand upright and were asked to swallow and keep their molars softly in occlusion, while looking at themselves (into their own eyes) in the mirror with their habitual facial expression[15]. The volunteers were then placed in the fixation device for the second scan (T2), while continuously looking with a habitual facial expression at a fixed point on the wall (at eye height). After this, another 3D-scan was made in the natural head position (T3) and then another with the head fixated in the frame (T4). One year later, the volunteer was scanned in the natural head position (T5) and then while fixated (T6), after identical instructions. Immediately after this, another 3D-scan of the head in the natural head position (T7) and with fixation (T8) was performed. This resulted in scanning every volunteer eight times.

The scanning after one year took place at the same time of day as the first scans in order to minimize the possibility of circadian volume shifts of the face. The volunteers were checked for changes in body weight, medication, medical condition and lifestyle. All the scans were made by the same trained investigator (MH) and were taken in the same room and under the same lighting conditions. Also, the 3D-analysis was done by a single investigator (AMLM).

To capture the upper face fully, each face was scanned in multiple passes, with significant overlap in the object coverage to allow for successful individual rigid scan alignment and registration. Different angles were used in a fluent movement in order to fully capture the whole periorbital area. Real-time fusion enabled visual control of completeness during and immediately after the scanning. A range indicator was available in Artec Studio 13.0 (Artec, Luxembourg) which visualized the distance between the scanner and the object. The working distance was always within 0.2 to 0.3 metres.

Data processing (figure III and IV)

The Artec Space Spider makes multiple image frames during acquisition. Afterwards, the Artec software processes the geometrical data of all the frames to calculate a 3D-model. During the acquisition time, movement artifacts can occur such as blinking of the eyes. Therefore, all the frames were first assessed by the investigator to eliminate scans in which the eyes were not fully open. Each completed scan was manually subjected to a serial registration procedure (Artec Studio 13.0). A fine, and thereafter global registration of all the selected frames in an individuals' scan, was performed followed by visual inspection of the results. Any artifacts were removed using the 'small object filter-function' (to remove small surfaces unconnected to the main surface of the face) and 'outlier removal' (filtering algorithm to remove outliers; standard deviation multiplier 0.3), and the scans were fused using the Sharp Fusion-function (reconstruction of polygonal model, resolution 0.3, holes were not filled). These pre-processed 3D-images were exported as stereolithography files (STL-files) and stored for comparison purposes. The STL files of the multiple recordings (different time points, T1-T8) were imported into the 3dMDvultus Software (3dMD LLC, USA, Atlanta, GA) to perform a rigid surface based registration using the best fit surface-based method for every volunteer based on the selected region comprising the forehead (the area from below the hairline to above the eyebrows) and the upper nasal dorsum[1,16]. The quality of the alignment was assessed by visual inspection of the registered images and by providing the root mean square error (RMS-error) of the selected area (quality checks).

Following the surface based registration, the pre-processed 3D-images of the different time points (T1-T8) were exported from the 3dMDvultus Software to the 3-Matic software 13.0 (Materialise, Leuven, Belgium) for further analysis. In this stage, T1 was matched with T3 (natural head position comparison); and T2 was matched with T4 (head frame comparison). Also, T1 was matched with T5 (natural head after 1 year) and T2 was matched with T6 (head frame after 1 year). After that, T5 was matched with T7 (second natural head comparison with one minute in between) and T6 was matched with T8 (second head frame comparison with one minute in between). A landmark based reference frame was defined for every individual and was applied to all the scans after matching (T1-T8). Based on this reference frame, multiple cross-sections through the area of interest (peri-orbit) were obtained (see figure IV). The areas of interest (i.e., where the cross-sections were made) were the lateral canthus, the lateral border of the iris, and the medial border of the iris, on both eyes. After trimming the cross sections to the peri-orbital area only, leaving only two curves for each matched pair of 3D scans, a deviation analysis was performed. To determine the average deviation, i.e. the average difference in distance, (in millimetres) between the curves (cross-sections of T1-T8) the curves were exported to Matlab (The MathWorks, Inc., Natick, MA, USA). This function calculates the distance between the two curves by measuring the nearest opposing point of the counter parting curve, along the whole curves. These distance measurements served as a measure of the reproducibility of the 3D-images of the peri-orbital region made by the Artec Space Spider 3D-scanner.

The average deviations (D) were calculated per anatomical area as follows (Figure III):

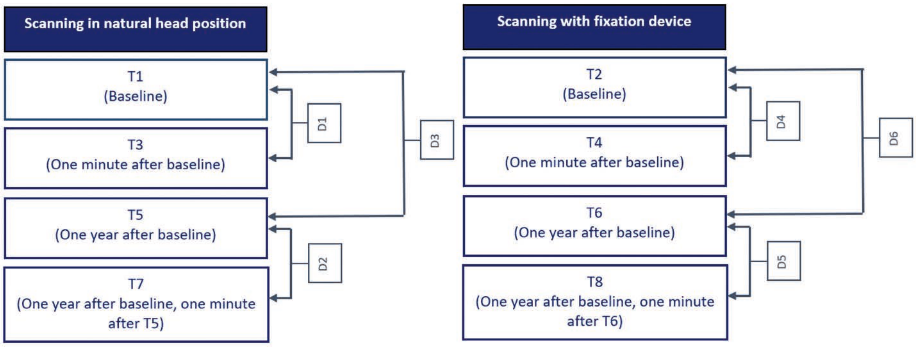

Figure III. 3D scanning and comparisons of deviations between 3D-scans. 'D' indicates the deviation of the 3D-scans between the different measurements.

- D1= NHP scan at baseline (T1) versus NHP scan after 1 minute (T3)
- D2= NHP scan one year after baseline (T5) versus NHP scan one minute after T5 (T7)
- D3= NHP scan at baseline (T1) versus NHP scan one year after baseline (T5)
- D4= fixed position scan at baseline (T2) versus fixated position scan after 1 minute (T4)
- D5= fixed position scan one year after baseline (T6) versus fixated position scan one minute after T6 (T8)
- D6= fixed position scan at baseline (T2) versus fixation position scan one year after baseline (T6)

Intra-tool reliability was assessed for the natural head position based on D1 and D2. Similarly, intra-tool reliability was assessed for the fixed head position based on D4 and D5. Inter-tool reliability was assessed for the natural head position and the fixed head position based on D1 and D4.

Statistical analysis

The data was analysed with SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Q–Q plots were used to determine the distribution of the data. When the data did not show a normal distribution, descriptive statistics in the form of median and interquartile ranges (IQR:Q3-Q1) were provided.

To assess the reproducibility of the data processing (see Figure IV: Flowchart data processing), all the steps were repeated for a randomly chosen cross-section of the natural head position and of the fixated head position, namely the lateral iris of the left eye. The data processing was carried out by the same researcher (AMLM) two months after the first data-processing round was completed. The limits of agreement between the first processing round and the second processing round were shown in a Bland Altman plot and reliability was calculated by estimating the intraclass correlation (ICC; two-way mixed effects model, single measurement, absolute agreement) and 95% confidence interval (CI).

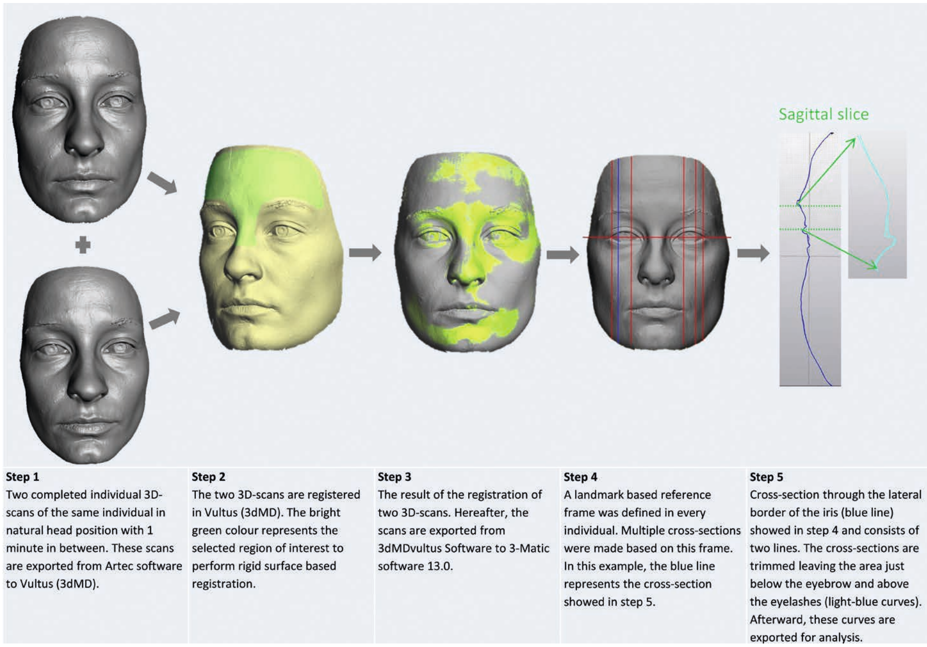

Figure IV. Data processing flowchart. All the depicted data-processing steps are from scanning one volunteer's natural head position. Used software to create the images in this figure: Artec Studio version 13.0 (Artec, Luxembourg, www.artec3d.com), 3dMDvultus Software version 2.6.0.1 (3dMD LLC, USA, Atlanta, GA, www.3dmd.com) and 3-Matic software version 13.0 (Materialise, Leuven, Belgium, www.materialise.com).

Plots were made in order to investigate possible systematic differences between the minute-interval scanning moments for the natural head position (D1 vs D2) and the fixated head position (D4 vs D5). A red intermittent line was marked to show the 1mm deviation cut-off, which is commonly considered to be the clinical acceptable deviation[6,17-19]. Bland Altman plots showed the differences in the deviations were normally distributed, as assessed from the Q-Q plots, and therefore the assumptions were proven to be valid.

The ICC values were interpreted as follows: 0.00-0.20, poor; 0.20-0.40, fair; 0.40-0.60, moderate; 0,60-0.80, good; 0.80-1.00, excellent[20]. When interpreting the results for research purposes (comparing groups), the ICC should be at least 0.70, while for clinical practice, the ICC should at least be 0.90[22].

The test-retest reliability (reliability of replications of the minute-interval 3D-deviation measurements; D1 and D2, D4 and D5) was evaluated by calculating the intraclass correlation coefficient (ICC) and confidence intervals. The average deviations between the 3D-scans when performing consecutive 3D-scans (one minute interval; n=15; D1 and D4) and when repeating this one year later (second one minute-interval; n=14; D2 and D5) were calculated using Matlab. Two comparisons were made per scanning technique, NHP and fixated head position, in order to assess the ICC between both minute-interval scanning-events.

RESULTS

A total of 15 healthy volunteers participated in this study with a median age of 47 years (range: 30-63 years, IQR: 42-58 years). Of these 15 volunteers, 10 were female (67%). After one year, no changes were reported by the participants in medication, medical history and lifestyle, but weight changes had occurred by a median +1kg (range: -2kg to +7kg, IQR: 0 kg to 2kg). One male volunteer was excluded from the year follow-up due to personal circumstances and one female because of pregnancy.

Reproducibility of 3D processing

The 3D-processing was repeated to assess the reproducibility between the facial models of the two processing-rounds. Two Bland Altman plots (fixation and NHP) were drawn (Figures V and VI) and the agreement limits were between -0.05 mm and 0.05 mm.

The ICC of the same cross-section on the 3D NHP scans was 0.96 (95% CI: 0.87-0.99) and on the fixation device scans it was 0.97 (95% CI: 0.90-0.99).

Reproducibility of 3D-scans

The descriptive statistics of the cross-section curves are given in table 1. On comparing the one minute interval 3D-scans of the area between the eyelashes and eyebrows (D1, D4), the median of the average deviations between the cross-sections ranged from 0.17-0.21mm. After performing the one minute-interval scans one year later (D2, D5), the median differences were 0.10-0.11mm. All the patients' one minute-interval scanning deviations and differences between the intervals were less than 1mm.

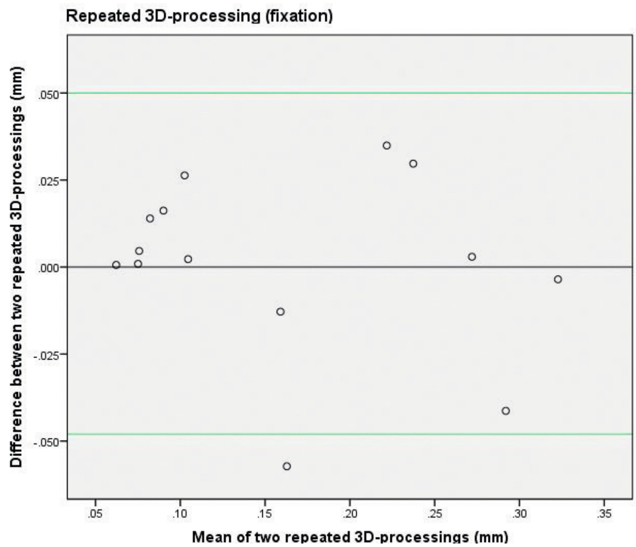

Figure V. Bland Altman plot of repeated data processing (fixation). The 3D-data processing was repeated for the second minute-interval scans and comprised the cross section of the lateral iris of the left eye during fixation. The green lines represent the upper and lower limits of agreement between the two 3D-data processing rounds.

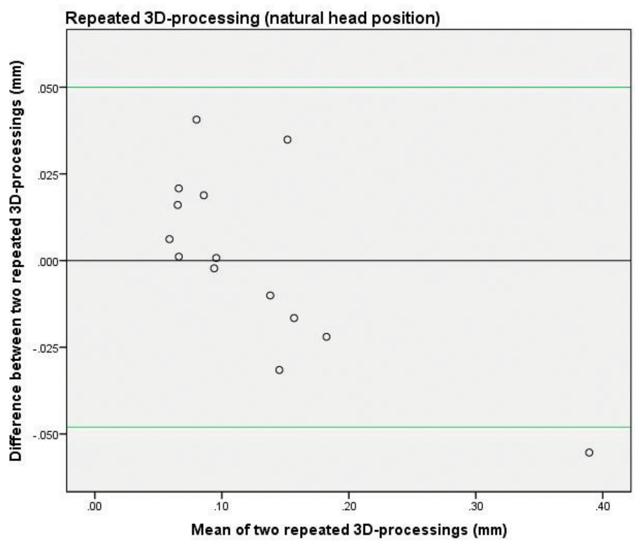

Figure VI. Bland Altman plot of repeated data processing (NHP). The 3D-data processing was repeated for the second minute-interval scans of the natural head position and comprised the cross section of the lateral iris of the left eye. The green lines represent the upper and lower limits of agreement between the two processing rounds.

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Table I. Descriptive statistics and intra-tool reliability (ICC and 95% confidence intervals).

	First minute-interval scanning (baseline)	**Second minute-interval scanning**	**Year-interval scanning**	**First minute interval deviations (baseline) vs second minute interval deviations**	**First minute interval deviations vs second minute interval deviations**
	Average deviation between two subsequent scans (median and Q1-Q3 in mm)	Average deviation between two subsequent scans (median and Q1-Q3 in mm)	Average deviation between two scans with one year in between (median and Q-1-Q3 in mm)	ICC and 95% confidence interval	Number of patients with a difference of ≥1mm between D1 and D2
Natural head position	***D1***	***D2***	***D3***	***D1 vs D2***	***D1 vs D2***
OD lateral canthus	0.14(0.11-0.34)	0.10(0.09-0.13)	0.44(0.33-0.75)	0.07 (-0.27-0.50)	0
OD lateral iris	0.15(0.12-0.32)	0.11(0.09-0.16)	0.52(0.34-0.72)	0 (0-0.41)	0
OD medial iris	0.16(0.12-0.29)	0.12(0.07-0.14)	0.43(0.32-0.69)	0 (0-0.33)	0
OS lateral canthus	0.21(0.17-0.33)	0.12(0.08-0.15)	0.36(0.29-0.58)	0.01 (0-0.40)	0
OS lateral iris	0.22(0.13-0.33)	0.10(0.08-0.15)	0.38(0.28-0.69)	0.09 (0-0.50)	0
OS medial iris	0.15(0.10-0.32)	0.11(0.08-0.13)	0.43(0.24-0.60)	0.05 (0-0.47)	0
Average of all cross-sections combined (in mm)	*0.17*	*0.11*	*0.43*		
Fixated head position	**D4**	**D5**	**D6**	**D4 vs D5**	**D4 vs D5**
OD lateral canthus	0.16(0.12-0.27)	0.09(0.08-0.11)	0.48(0.31-0.75)	0.17 (0-0.62)	0
OD lateral iris	0.19(0.14-0.28)	0.09(0.08-0.11)	0.48(0.26-0.69)	0 (0-0.35)	0
OD medial iris	0.17(0.14-0.29)	0.08(0.07-0.10)	0.39(0.29-0.59)	0 (0-0.43)	0
OS lateral canthus	0.26(0.20-0.31)	0.10(0.08-0.23)	0.48(0.38-0.84)	0.22 (0-0.64)	0
OS lateral iris	0.27(0.16-0.41)	0.13(0.09-0.26)	0.44(0.31-0.68)	0.32 (0-0.72)	0
OS medial iris	*0.19(0.12-0.37)*	0.10(0.08-0.18)	0.46(0.26-0.72)	0 (0-0.32)	0
Average of all cross-sections combined (in mm)	*0.21*	*0.10*	*0.46*		

Table I. One minute-interval versus one year-interval: Median of average deviations between the two curves from the natural head position (NHP) and the two curves from the fixated head position (in mm). The shown intraclass correlation coefficients (ICC) and 95% confidence intervals are all <0.9. OD= oculus dexter (right eye), OS= oculus sinister (left eye).

On comparing the baseline-scans with those after one year (D3, D6), the median deviations between the cross-sections had increased to 0.43-0.46mm, but all of them remained below the 1mm (clinical) limit.

Figures VII and VIII show the systematic differences of the fixed position and NHP between the first minute-interval deviations (D1, D4) and the second minute-interval deviations (D2, D5). The graphs show that all the mean deviations were below 1mm. When the mean deviations were small, the differences between the repeated measurements were also small. However, when the mean deviations were greater, the differences between the repeated measurements were greater and therefore less reliable, even though they were always within the 1 mm criterion. Also, the differences between the repeated measurements were predominantly positive. Therefore, the baseline deviations were greater than those of the second interval scans. The ICC between the first minute-interval scanning deviation (D1, D4) and second minute-interval scanning deviation (D2, D5) was <0.7 (table I).

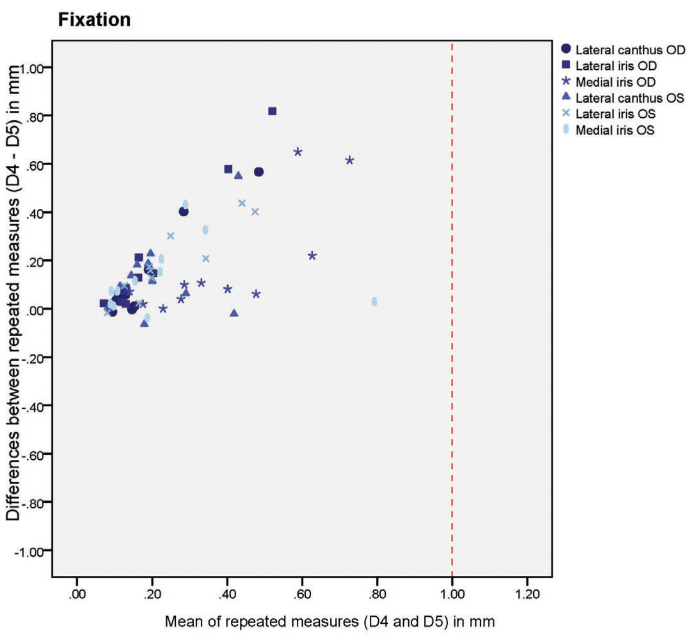

Figure VII. Systematic differences of different anatomical sites after scanning the head in a fixed position. Differences between the first minute-interval deviations and second minute-interval deviations were computed by the following subtraction: first minute-interval deviations (D4) – second minute-interval deviations (D5). OD= oculus dexter (right eye), OS= oculus sinister (left eye). The red intermittent line shows the clinical 1mm mean deviation cut-offs in subsequent scans. All the mean deviations were below this cut-off.

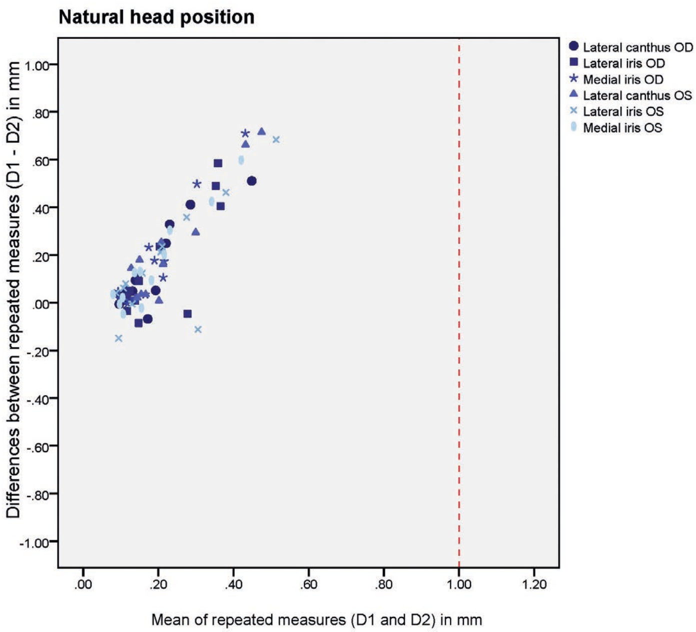

Figure VIII. Systematic differences of different anatomical sites after scanning the head in a natural position.
Differences between the first minute-interval deviations and second minute-interval deviations were computed by the following subtraction: first minute-interval deviations (D1) – second minute-interval deviations (D2). OD= oculus dexter (right eye), OS= oculus sinister (left eye). The red intermittent line shows the clinical 1mm mean deviation cut-offs in subsequent scans. All the mean deviations were below this cut-off.

Comparison of scanning methods: NHP and fixation

The median of the average differences between the NHP and fixation was small (table I). Figures V and VI show that the pattern of the systematic differences between scanning the natural head position and in the fixated position were comparable.

Evaluation of variations in cross-section locations

Figures V and VI show that the systematic differences between the cross-section locations follow a similar pattern. However, the cross section of the medial iris of the right eye, when the head is in a fixated position, shows the most favourable pattern (medium blue asterisks in figure VII).

Quality checks

The quality of the alignment during the data processing was assessed by inspecting the registered images visually and by providing the root mean square error (RMS-error) of the selected area. Visual inspection did not reveal any incorrect registrations. The median RMS-error of the registration during the first one minute-interval (T1 and T3) was 0.13 (range 0.05-0.81, Q1-Q3 0.07-0.27) for the natural head position and for the fixated position (T2 and T4) it was 0.11 (range 0.01-0.39; Q1-Q3 0.06-0.17). When performing the one minute-interval registrations a year later (T5 and T7, T6 and T8), the median RMS-error for the natural head position was 0.04 (range 0.02-0.18; Q1-Q3 0.03-0.06 and for the fixated head it was also 0.04 (range 0.03-0.12; Q1-Q3 0.03-0.08).

The one year interval 3D-scan registrations provided an RMS-error of 0.17 (range 0.08-0.30; Q1-Q3 0.10-0.22) for the natural head position (T1 and T5) and 0.15 (range 0.11-0.37; Q1-Q3 0.14-0.19) for the fixated head (T2 and T6).

DISCUSSION

For objective evaluation of surgical treatment in the periorbital region 3D-imaging of this area should be reproducible. To our knowledge, this is the first study to specifically assess the reproducibility of 3D-imaging of the periorbital area between the upper eye lashes and the brow. There is a trend to preserve and redistribute volume during aesthetic periorbital surgery. Hence, the three-dimensional periorbital imaging proposed in this study could provide more insight into the effects of such procedures.

In the literature, the region of the eyes is known to be accompanied by significant errors in 3D-imaging and is often excluded from analyses[2,7,22]. This is due to difficulty in capturing the eyes correctly because the light pattern used to reconstruct a 3D-photograph interferes with the light reflection in the eyes' lenses whereby the lenses appear to be concave instead of convex. Also, the position of the eyes in relation to the supraorbital ridge and eyebrows might influence 3D-scanning of this area. Deep-set eyes with prominent supraorbital ridges, which is commonly seen male eye-and-eyebrow complex[23], might be more difficult to capture in 3D images. In addition, differences in facial expression or posture during separate scans can also result in registration error[5], and the eyes are difficult to capture due to frequent blinking movements.

The current study focused on minimizing the factors hindering the assessment of 3D-images of the periorbital area and so areas like the cornea, eyelashes and eyebrows were not included in the final analysis. On applying our technique, the median average deviation between two subsequent scans was approximately 0.1-0.2 mm, significantly below the 1mm cut-off, which is proposed as an acceptable deviation in clinical practice. Yet, although the 3D-processing method showed excellent reproducibility, scanning the individuals repeatedly resulted in lower reproducibility. However, when assessing the systematic differences between the scans taken of each subject, these differences were predominantly positive. This means that the deviating differences seen at baseline had reduced further on scanning the same person one year later, implying a positive scanning learning curve, which explains the low ICC. Additionally, slight changes in muscle tone or expression between the scanning events can also cause small differences in 3D-scans. We have to also take the system and 3D-processing errors into account. The latter was found to be between -0.05 mm and 0.05 mm in this study but, according to the manufacturer, the system's error is also 0.05 mm (the 3D-point accuracy of the scanner is 0.05 mm or less). Irrespective of this, some uncertainties might be present regarding the accuracy of the scanner, such as a possible cumulation of error due to the iterative mesh build of the 3D-points and one study found that the scanner does not meet the declared precision[13]. Further research has to be done to elucidate this issue. Nevertheless, the effects of a blepharoplasty, for example, will result in alterations of several millimetres, which can thus be captured adequately with the technique.

The median of the average difference between the scans made at baseline and after one year was approximately 0.45 mm. The scans were repeated after one year because, in clinical practice stable results are usually obtained before the end of the first year after surgery. Presumably, natural changes such as weight[9,24,25], tiredness[26] and aging[27] occur in the face, so it could be justified that, when applying a very sensitive scanning method, there will be differences between the baseline and the measurements taken one year apart. We assessed a group of 15 participants to evaluate repeatability in a group with a variety of age-categories and gender because this reflects daily clinical practice.

The median of the average deviations found in our study for the orbital region are in the same order of magnitude as described in the literature for the total face; in the literature, 100 3D-images of one individual had a RMS-error of 0.36 mm after 6 weeks for the overall face[1], yet the RMS-error for the periorbital area was 0.38 mm (1.02 mm 95th percentile). Unfortunately, it is unclear whether this error was calculated from subsequent scans or from comparing those with 6 weeks in between. Johnston et al.[28] found a deviation of 0.74 mm for the overall face at rest when assessing the reproducibility, but the upper eyelids' region was not an included landmark. Kau et al.[29] found an average mean deviation of 0.25 mm, with a maximum of 0.49 mm, in adults when scanning subsequently using a Minolta Vivid 900 laser scanner. Ma et al.[30] scanned participants at baseline and again after 1 day, 3 days, 1 week and 3 weeks and used a structured light system. The mean deviation of the whole 3D facial image was

0.20 mm and the maximum deviation was 0.32 mm. The latter is quite small compared to the maximum deviations in our study but, in their article, the 3D facial image did not capture the upper eyelids completely.

When assessing the periorbital area scans, we tried to eliminate any possible hindering factors, such as difficulties to capture the eyelids completely. The largest variations found by other authors who collected data with a 3D-stereophotogrammetric camera setup were in the periorbital area[7]. The disadvantages of such a setup is that the camera is not mobile and that certain areas of the face are not imaged completely due to a fixed camera orientation and focus point of the camera. In contrast, the Artec Space (Artec 3D, Luxembourg) is a structured light hand-held scanning device. The technique combines structured light 3D-scanning (blue LED), for assessing the shape, with an image-based approach (white flash light) to add supplementary shape information and colour textures. Thus, we could capture the eyelids completely with this device. Also, to eliminate variations in the amount of eyelid exposed during scanning caused by a changed point of gaze, we compared the effect of using a fixation-device with the frequently used natural head position. In contrast to our expectations, median deviations and the comparable patterns in the plots of the scanning-deviations were comparable for both methods. Although no scanning method seems to be superior to the other, the natural head position is more comfortable for the participant and therefore preferable.

To eliminate movement artifacts caused by blinking, all the separate frames of the 3D-scans were screened. So, of the approximately 400 frames of each scan, a maximum of 5 frames had to be excluded due to blinking. Within the anatomic units, we used the most stable regions (i.e., the forehead and nose[1]) to be registered with each other. The region of interest, in this case the periorbital region, was intentionally excluded from the registration process. It is important that, for clinical purposes, the registration process is accurate, with less than 1 mm variation[31]. In the current study, all the RMS-errors of the registered areas were all below this range and registrations were therefore considered successful. After establishing a reliable registration, further analyses were carried out of the area between the upper eyelashes and below the eyebrow by evaluating the cross-section curves of this area. The cross-sections were considered to be stable and clearly definable and were therefore chosen to provide information on the areas of interest.

The scanning method itself has a few disadvantages. First, the used structured light system needs to be operated by a trained person. Although our 3D-scans were made by a trained operator, a learning curve was still observed. Furthermore, the time needed to capture a 3D-image of a face with the Artec Space Spider is longer than when using stereophotogrammetry. In theory, the longer a 3D-scan takes, the more artifacts can be caused by the subject moving. Another possible disadvantage is that the strobing structured light flashes might make it more difficult for participants to relax their eyes fully, although this was not observed here. Also, the moving scanner might distract the patient from gazing continuously at a fixed point throughout the scanning period.

The stereophotogrammetry 3dMD scanner is the most widely used scanning system for obtaining 3D scans of the face surface. Several hand-held scanners have been studied and compared to the 3dMD; the Artec EVA was shown to be less accurate than the 3dMD system[2-4]. However, the Artec Space Spider has better 3D-point accuracy, compared to the Artec Eva and 3dMD-sytem, based on scanning geometrically stable reference bodies[13]. Winkler et al.[32] assessed the trueness and precision of scanners intended for scanning smaller areas (i.e., intraoral scanners), including the Artec Space Spider, and concluded that the latter was superior to the intraoral scanners. The high resolution makes it even possible to capture fingerprints accurately[33]. Nevertheless, further research has to be done with patients to compare the widely used 3dMD-system with the Artec Space Spider scanner.

CONCLUSION

Scanning with a hand-held 3D-scanning device (Artec Space Spider) is a promising tool to assess changes in the periorbital region following surgical treatment since the median deviations are well below the clinically accepted 1mm measuring error, for both the natural head and fixated positions.

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Conflict of interest
None.

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CHAPTER 9

General discussion

GENERAL DISCUSSION

An upper eyelid correction (blepharoplasty) comprises the removal of redundant tissue for aesthetic and/or functional reasons. Although a blepharoplasty is a very common procedure, i.e. it was among the top five most performed cosmetic surgical procedures worldwide in 2019[1], the scientific background is limited. There is a need for a better understanding of the functional and aesthetic effects of an upper blepharoplasty and which surgical technique provides the most favourable effects. Although upper blepharoplasty surgery is seen by many as an art, a more scientific basis can help in planning the treatment. In this thesis, we tried to elucidate the effects of an upper blepharoplasty and which surgical technique is favourable.

The various surgical techniques include the removal of excess skin together with a strip of orbicularis oculi muscle, sometimes combined with excision or redistribution of fat from the medial and central fat compartments, or the more conservative approach of sparing the orbicularis oculi and orbital fat. A concern about resectioning a strip of the orbicularis oculi muscle is the addition of more morbidity or a prolongation of the patients' recovery period. The conservative approach seems preferable since it is less invasive, which might result in less postoperative adverse effects, but we did not find any differences in the long term postoperative adverse effects between the tested techniques. The most feared complication of a blepharoplasty is permanent visual loss due to retrobulbar haemorrhage, which has an incidence of 0.05%[2]. However, the existing literature cannot verify the risk of haemorrhage in relation to the surgical techniques[2,3].

In daily practice, many surgeons perform a non-conservative blepharoplasty, i.e. 86% of the American Society of Ophthalmic Plastic and Reconstructive Surgery Members[4], as the rationale for resectioning muscle along with skin is uncertain. The popularity of any of these techniques generally depends on the experience and personal preference of the surgeon. We believe that dealing with the periorbital tissues in a proper way is key during an upper blepharoplasty, but there is no consensus about what should be done with the orbicularis oculi muscle[5]. Therefore, we aimed to assess the effects of the an upper blepharoplasty when only skin is removed or when a strip of additional orbicularis oculi muscle is resected, and which excision shape is preferable.

AESTHETIC RESULTS

Upper eyelid

When appraising the aesthetic results of an upper blepharoplasty, it is very important to keep in mind that the eyes are a very important feature of a face. When looking at a face, the eyes are the first and most looked at region[6]. Age and fatigue judgements are made upon specific attention towards the eye region[7]. Age-related changes in the periocular region are particularly noticeable in the aging face. Aesthetic surgery may therefore be one of the most effective interventions to rejuvenate the face[8].

However, it is difficult to measure aesthetic results objectively. Beauty is in the eye of the beholder and therefore the definition of a beautiful eye varies, but it is generally agreed that youthfulness correlates with attractiveness. In other words, an eye is considered to be 'attractive' when it has typical youthful features instead of aging ones. A beautiful youthful eye is described as full and convex. During aging, the upper eyelid undergoes 3 types of changes: dermatochalasis, blepharoptosis and fat atrophy. The eyelid and periocular skin is the thinnest in the body, has minimal subcutaneous fat, and is constantly subjected to the external environment and sun[9]. Therefore, these factors commonly result in excessive skin laxity and redundancy (dermatochalasis). In contrast to dermatochalasis, blepharoptosis primarily refers to an anatomic inferior displacement of the upper eyelid but this is outside the scope of the research described in this thesis.

The upper eyelid fat also undergoes changes with age. The medial fat pad can become more prominent, altering the medial contour of the eyelid, resulting in localized spherical bulging medially. In contrast, the central fat pad can atrophy with age which can cause hollowing of the superior sulcus and thus appearing "skeletal". Therefore, an aging eye looks more hollowed due to volume loss.

Traditionally, a non-conservative blepharoplasty includes the removal of excess skin together with a strip of orbicularis oculi muscle (with or without handling periorbital fat). Currently, there is a trend towards the more conservative treatment mode of only removing excess skin, presumably preventing the hollowing of the aging eye. Histological studies have revealed that changes in the aging upper eyelid occur primarily in the skin and subcutaneous layers, with characteristic loss of collagen elastic fibres, while the whole muscle layer remains histologically intact, with no signs of thinning or atrophy[10]. Therefore, preserving the orbicularis muscle during an upper blepharoplasty, to supposedly maintain a fuller and more youthful upper eyelid, is postulated to be a wise approach. We concluded in our systematic review (chapter 3) that patients are generally satisfied with the overall aesthetic result after the upper blepharoplasty. Based on the results of the systematic review in chapter 3, the technique used (skin only or additional muscle resection) does not seem to influence the aesthetic outcomes. However, only a few sound split-face or randomized controlled trials were available which had compared surgical techniques and aesthetic outcomes. Since the sparse information shows that the used technique does not seem to influence patient satisfaction or the physician's assessed aesthetic outcomes, it seems rational to perform the least invasive method (skin only).

In chapter 4, we assessed the Patient Reported Aesthetic Results (PRARs) after upper blepharoplasty. The patients reported significant improvements postoperatively regarding satisfaction with the eyes and eyelids, and satisfaction with their facial appearance and aging appraisal. However, the aesthetic outcomes from the randomized controlled trial were interesting (chapter 4). We compared the patient reported aesthetic results between the skin-only technique and the technique with additional removal of a strip of orbicularis oculi muscle. We did not observe significant differences when comparing the skin-only excision technique with the skin-muscle excision, except for the 'satisfaction with the eyes' questionnaire which favoured the skin-only group with a markedly 17.5% more improvement. This means that both surgical techniques provide relief from the negative sequelae (such as being bothered by skin on the eyelashes, saggy upper eyelids, droopy upper eyelids, appearance of eyelid folds, heavy upper eyelids, and how tired and how old your upper eyelids make you look), but the skin only technique resulted in much higher (17.5%) satisfaction with the eyes (better shape, attractiveness, alert, open, bright eyed, nice, youthful) compared to the skin/muscle technique.

In our study, we used a series of very specific questionnaires that focused on various anatomical areas to assess aesthetic outcome. Also, different aspects of the aesthetic results were included in the questionnaires. By contrast, previous studies often used global questionnaires to assess upper blepharoplasty results. In general, the global questionnaires do not show a difference in the long term aesthetic outcomes following the two procedures as demonstrated by LoPiccolo et al.'s[11] left-right split face study (resection of only skin on one side and resection of additional orbicularis oculi muscle on the other side of the participant). Damasceno et al.[12] concluded after a left-right split face study that upper blepharoplasty causes more postoperative symptoms (oedema, haematoma and pain) and presents worse initial aesthetic outcomes when the preseptal orbicularis oculi muscle is excised, but the long-term aesthetic outcomes are not different. However, Samargandi et al.'s[13] systematic review showed that the skin plus muscle resection was initially associated with higher ophthalmological morbidity (oedema, bruising, pain, dry eye, sluggish eye closure and lagopthalmos) during the first postoperative week compared to the skin only procedure and should therefore not be recommended as a standard procedure.

Another important aspect of the aesthetic outcome is the amount and visibility of scarring after surgery. The optimal scar is invisible. There are various aspects of scarring, such as pigmentation, vascularity, irregularities, length and width, either patient-reported or assessed by experts or by a panel. In our RCT in chapter 4, we found no significant differences in scarring between both surgical techniques, as assessed by the patients and the observers. This is in line with Saalabian et al.[14] who compared the satisfaction levels of patients according to tissue resection categories (skin, skin/muscle, skin/muscle/fat) and concluded that there were no differences in relation to scar aspects, recovery period and complication rates.

Thus, based on the systematic review (chapter 3) and the RCT on PRARs (chapter 4), there is no need for additional muscle resection as a routine procedure during an upper blepharoplasty to improve patient satisfaction.

Eyebrows and forehead

The eyebrows are also an important part of the periorbital aesthetic unit. Decreased eyebrow height (predominantly in the lateral area) and dermatochalasis are the two main causes of excess eyelid skin. Consequently, the pre- and post-blepharoplasty aesthetics are affected by both the amount of excess skin and the possible change in the position of the eyebrow. Therefore, the peri-orbital region, including the eyes and eyebrow, needs to be addressed as one aesthetic unit.

Although it is not entirely clear what happens with the eyebrows during aging, it is commonly assumed that progressive sagging of the eyebrow occurs as part of the facial aging process[15].

The remodelling and subsequent thinning of the superomedial and inferolateral orbital rim in the middle and late ages, along with lipoatrophy and progressive loss of collagen fibre elasticity with increased skin laxity, results in an inferior descent of the brows,[16] especially in the lateral part of the eyebrow[17]. Although the normal position of the eyebrow is at or just above the supraorbital ridge[15], there could be variations in length, thickness and contour of the eyebrows. The concept of the ideal eyebrow has changed over the decades, and is influenced by cultural trends, gender, age, facial shape and ethnicity[18]. An important factor is the shape of the eyebrow, which may be more important than the actual eyebrow height[19]. During the normal aging process, the descent of the temporal brow tends to occur earlier and is more pronounced due to decreased deep tissue support and lack of suspension from the more centrally placed dynamic frontalis muscle[17]. This causes a change in the shape and downward slope of the eyebrow[20]. Prantl et al.[19] showed that the higher the eyebrow inclination, the more attractive and younger the eyes look.

In the systematic review on the aesthetic results of an upper blepharoplasty (chapter 3), we concluded that the eyebrows seem to move down after a blepharoplasty which can have an impact on the aesthetic unit of the eye. So, in chapter 7, we assessed the possible eyebrow changes after an upper blepharoplasty, and concluded that the eyebrows do, indeed, move down postoperatively. However the influence on the aesthetic result is not really clear.

A remarkable result in our study (chapter 4) is the more positive appraisal by our participants of their forehead and eyebrows after an upper blepharoplasty, despite the decreased eyebrow height. Satisfaction with the forehead and eyebrows increased with a median of 6 to 10 points, which indicates a 6-10% improvement. However, whether the patients were more satisfied with their eyebrows or their forehead remains unclear. The shape of the eyebrows might have changed due to an unevenly distributed eyebrow descent postoperatively. Interestingly, we did not find any significant differences in the amount of eyebrow descent between the eyebrow height at the exocanthion, lateral iris and the centre of the pupil.

We hypothesize that a downward movement of the eyebrows tends to smoothen-out the wrinkles on the forehead. This theory is in part supported by the Huijing et al.[21] study which showed that forehead lines diminish significantly after an upper blepharoplasty, but they did not see a significant lowering of the eyebrows. Also, no significant relationship was observed between eyebrow height and horizontal forehead lines pre- and postoperatively[21]. Another explanation might be that patients regard themselves as more appealing after an upper blepharoplasty and therefore appraise their general appearance (including eyebrows and forehead) more positively.

More research has to be done to elucidate this issue further.

Lateral hooding

Due to the descent of the lateral eyebrow during aging, lateral hooding is a frequent problem in patients who are candidates for an upper blepharoplasty. Lateral hooding results in an uneven pretarsal show. Regarding the attractiveness of the eyes, the more homogeneous and even the pretarsal show, the more attractive the eye[19]. Therefore, lateral hooding affects the peri-orbital aesthetics negatively and should be addressed appropriately. This can be done by removing upper eyelid skin and/or by elevating the eyebrow. When eyebrow ptosis is present, i.e. the eyebrow position is below the supraorbital rim, an eyebrow elevation intervention may be suitable. However, elevating the eyebrows cannot always be advocated. When a patient displays normally positioned eyebrows, eyebrow surgery should not be performed to avoid an unnatural appearance. Another way of dealing with lateral hooding is optimal removal of redundant skin on the temporal side of the eyelids. So, in these cases, special attention has to be paid to the shape of the skin excision of the upper eyelid in order to achieve a homogenous distribution of the pretarsal show.

Excision shape

In the literature, surgeons use a variety of different skin excision designs, varying from the traditional elliptical shape[22] to the lenticular or trapezoid shape[23], a scalpel blade shape[24] and excisions that extend beyond the lateral orbital rim[24, 25]. Har-shai et al.[24] and Bellinvia et al.[25] proposed a technique that includes extending the upper incision further laterally[24] and upwards[25], towards the tail of the eyebrow. Some authors state that skin resections should not be extended beyond the lateral orbital rim because the scar will not be hidden within the natural skin fold[26], while other authors state that the scars will scarcely be noticeable if they fall within a pre-existent crow's feet crease[24].

Different excision shapes might result in different aesthetic outcomes, and therefore an important factor to consider when planning an upper blepharoplasty. However, the literature included in the systematic review in chapter 3 is inconclusive regarding this subject and no comparative study of different excision shapes has been published to the best of our knowledge.

In an observational study described in chapter 5, we compared the traditional elliptical excision with the laterally extended excision shape on subjects. Both excision shapes give positive aesthetic results, but the laterally extended skin excision technique is accompanied by a slightly more favourable outcome. The homogeneity of the pretarsal show only improved with a lateral extension of the excision. This suggests that a laterally extended skin excision may address the lateral hooding more suitably. The literature does not have any papers on the homogeneity of pretarsal show distribution after a blepharoplasty. Although the increased pretarsal show in our blepharoplasty patients was in line with the literature[27-29] the other studies did not mention the shape of the excisions.

Some authors expressed their concerns about the visibility of the scars postoperatively when extending the excision more laterally during an upper blepharoplasty[26]. In theory, the scarring would be more noticeable in the laterally extended group, but neither the patients nor the physicians reported significant differences in scar noticeability between the groups.

In our study (chapter 5), we concluded that the extended excision technique results in less eyebrow descent. The explanation for the latter remains uncertain. In theory, the heavy skin that is resected with the lateral extension technique may have a positive effect on the gravitational forces that pull the lateral eyebrows downwards.

Although the lateral extension technique seems to provide slightly more favourable results, not all patients might be good candidates for this technique. Brow elevation surgery might be more suitable for those who display significant lateral brow ptosis to create optimal eyebrow aesthetics, as discussed before. Also, patients who only show dermatochalasis in the central area of the eyelid (and not lateral hooding) may not need a lateral extension of the incision. That is why a thorough preoperative physical examination of the face is crucial.

FUNCTIONAL RESULTS

To look into the functional effects of an upper blepharoplasty in general, we systematically appraised the literature and performed multiple studies. Our systematic review (Chapter 2) revealed that an upper blepharoplasty is accompanied by a great variety of beneficial functional outcomes including an increase in visual field and an improvement in headache- and vision-related quality of life. However, the effect of eye dryness and eyebrow height was inconclusive in the literature. This is in line with the report by the American Academy of Ophthalmology on functional indications for an upper blepharoplasty[30]. In clinical practice, current functional surgical indications include impaired visual acuity, decreased peripheral vision, a compensatory chin-up backward head tilt, eye strain and fatigue[30]. However, insurance companies disregard the beneficial functional outcomes by not reimbursing the costs of an upper blepharoplasty in most cases, except when central vision is impaired by overhanging skin (blepharoptosis).

We consider that eyebrow height is not only an aesthetic outcome but also a functional outcome since the eyebrow height is influenced by the functioning of the frontalis muscle and the orbicularis oculi muscle.

Headache and muscle activity/fatigue

Patients with dermatochalasis of the upper eyelids often elevate their eyebrows. The frontal muscles are recruited to lift the eyebrows to compensate for the visual field obstruction or the eyelids feeling heavy due to sagging of the upper eyelid skin. This elevation may be associated with increased muscle frontalis electrical activity[31] and might cause other problems such as tension-type headaches due to constant muscle activation or insufficient relaxation[32]. An upper blepharoplasty may lead to a decline in the electrical activity or muscle fatigue of the frontalis muscles which may, in turn, lead to a relief from tension headaches. In chapter 7 we demonstrated that the eyebrows move down after a blepharoplasty, regardless of whether only skin is resectioned or both skin and muscle. Previous studies were inconclusive regarding this aspect, with some results being significant and others not (chapter 3). The results of our study (chapter 7) suggest that the frontalis muscle activity declines after surgery and that the eyebrows descend accordingly. Concordantly, the surface EMG measurements indicated less muscle fatigue in the long term upper blepharoplasty follow up (chapter 7), but this was not significant. This was also found by Kim et al.[31] who performed needle EMGs of the frontalis muscle instead of surface EMGs. Furthermore, the patients reported fewer headaches one year after the upper blepharoplasty. This underlines the theory that the constant need to elevate the eyebrows diminishes after the surgery and the frontalis muscles are less fatigued which might also affect headache complaints positively.

Dry eye

In the past, an upper blepharoplasty was postulated to affect dry eye symptoms since the function of the orbicularis oculi muscle is closely related to the tear fluid passage system[22,33]. In theory, violating the orbicularis oculi muscle during an upper blepharoplasty may lead to blink alterations, which might account for decreased mechanical tear film distribution, reduced outflow of lipid secretion from the meibomian glands, and reduced tear drainage with impaired debris removal from the ocular surface[34,35]. This, in turn, may cause irritation and/or dry eye symptoms. Regarding the orbicularis oculi muscle, no clinically meaningful differences in electrical activity or local muscle fatigue were found by our study after surgery (chapter 7), regardless of whether only skin or additional orbicularis oculi muscle was resectioned. Abell et al.[36] also evaluated the effect of an upper blepharoplasty on blink dynamics. This was done to test the hypothesis that partial orbicularis oculi removal causes alterations in blinking. Despite the muscle resection, the latter study did not see significant changes in blink dynamics.

We found in chapter 6 that an upper blepharoplasty alleviates subjective dry eye complaints in the long term, while not changing the objective tear dynamics. The improvement was independent of the blepharoplasty technique used (chapter 6). Resecting an additional strip of orbicularis muscle did not influence the results. Although, short term dry eyes may be present postoperatively, according to Hamawy et al.[37]. Our findings are in line with the previous literature on this subject, as summarized in our systematic review (Chapter 2) that dry eye complaints can be alleviated by surgery or at least do not worsen[38-42], but their observations were generally not supported by objective tests, such as the Schirmer test or TBUT[39-41].

Quality of life

Satisfaction with appearance and improved quality of life are important outcomes for patients undergoing facial aesthetic procedures. The quality of life (QoL) improved after a blepharoplasty, regardless of whether only skin or additional orbicularis oculi muscle was resected. The enhanced QoL was related to fewer headaches (chapter 2 and 7) and an improvement in vision (chapter 2), which is in line with the literature[42,43]. Jacobsen et al.[44] described the functional and psychological impact of an upper blepharoplasty on patients and also reported improvements. We showed in our study (chapter 4) that upper blepharoplasty patients report significant improvements postoperatively in the satisfaction with their facial appearance and aging appraisal. Also, the patient-perceived age had decreased, which infers that patients think they look more youthful than before the surgery. The patients also considered themselves to be more social and confident after the upper blepharoplasty. Concordantly, Herruer et al.[45] concluded in their study that an upper blepharoplasty can result in great improvement in patient satisfaction, self-consciousness of own appearance and benefits in daily life. Paixão et al.[46] also found an improvement in the quality of life postoperatively, and reported that post surgery satisfaction levels were significantly related to the absence of undesirable effects.

Clinical implications

Since the long-term functional signs and symptoms do not appear to differ between the techniques we tested, we feel that the least invasive surgical technique should be used. Furthermore, the skin-only technique provides a more favourable patient reported aesthetic outcome with respect to satisfaction with the eyes. All outcomes in this thesis point in the same direction, that is that there are no differences in outcomes between the skin-only technique or when additional orbicularis oculi muscle is resected, or the outcomes favour the skin-only technique. Therefore, we recommend implementing the skin-only blepharoplasty as a standard procedure. The surgical technique should, of course, be tailored to the individual, but there is no need for standard removal of the orbicularis oculi muscle. This muscle resection was originally introduced for patients that showed an exaggerated individual development of the orbicularis that caused bulkiness[47] or in patients with loose festoons of orbicularis oculi muscle[48] and then, somehow, it became a widely used standard procedure. We recommend to only perform additional muscle resections on uncommon cases and according to the surgeon's insights, for example when there is excess volume.

Special attention has to be paid to the shape of the skin excision of the upper eyelid in patients with dermatochalasis who have normally positioned eyebrows in order to achieve homogenous distribution of the pretarsal show. The laterally extended excision shape might address lateral hooding more suitably and should therefore be considered for those patients.

Patients who attend a consultation for an upper blepharoplasty should be adequately informed about what to expect after surgery regarding dry eyes, i.e. that is does not worsen dry eye complaints in the long term. Patients should also be adequately informed about the fact that the eyebrows move downwards after surgery and that headache complaints may decrease during the first year after surgery.

Future perspectives

One reason for being more conservative by sparing the orbicularis oculi muscle and orbital fat is the preservation of the fullness of the upper eyelid. Although we got a more aesthetic result (reported by patients) when only skin is removed during an upper blepharoplasty, it is not really clear why. Patients do not appraise their eyes as more hollowed (FACE-Q questionnaire), but the patient may not specifically recognize this feature since they are not trained physicians. It would be interesting to objectify any hollowing by means of a volumetric analysis such as the proposed three-dimensional analysis method described in chapter 8. Also, current concepts of periorbital rejuvenation focus on adding volume to the aging peri-orbital area with the use of hyaluronic acid fillers or by fat grafting in conjunction with an upper blepharoplasty. The results described in the literature seem promising, as measured by patient satisfaction and expert opinions[49-52]. Although adding volume to the peri-orbital area seems beneficial for the aesthetic appearance, more research should be done to assess the patient reported aesthetic results and objective outcomes, especially between different techniques. The proposed three-dimensional analysis method could be used to compare these volume-adding techniques.

Finally, the upper blepharoplasty participants assessed in the current literature were predominantly female. This was also the case in our study. It would be interesting for future research to specifically assess male participants, since attractive and aesthetically appealing periorbital features may differ in males compared to those in females.

In conclusion, an upper blepharoplasty results in aesthetically and functionally pleasing outcomes that are most favourable when using a minimally invasive (skin-only) surgical technique, and special attention should also be paid to the excision shape.

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APPENDICES

Summary

Samenvatting

Dankwoord

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SUMMARY

Although upper blepharoplasty is a common cosmetic surgical intervention, there is still a need for better scientific understanding of the functional and aesthetic results. Patients generally indicate they are satisfied with the results of their cosmetic surgery, but the functional and aesthetic upper blepharoplasty outcomes reported in the literature still vary. Therefore, the general aim of this thesis was to gain insight into the functional and aesthetic results of an upper blepharoplasty.

In **Chapter 2**, a systematic review of literature was described to explore the functional effects of an upper blepharoplasty. After a systematic search of four search engines (Pubmed, Embase, Cinahl and Cochraine), any study on objective and subjective (patient reported) functional outcomes after an upper blepharoplasty was subjected to a quality assessment for possible inclusion in the review. The intervention had to be defined as a solitary surgical upper blepharoplasty containing the removal of skin, with or without the removal of a strip of orbicularis oculi muscle and/or upper orbital fat. Randomized controlled trials, controlled trials, cohort studies and case series (n≥10) were eligible for inclusion.

A total of 3525 studies was assessed, of which 28 studies were included in the systematic review. The reported favourable outcomes after an upper blepharoplasty were an increase in visual field, enhanced quality of life related to fewer headaches and improved vision. Furthermore, a decrease in eyelid sensitivity was noted, but with differences in recovery. The outcomes regarding eyebrow height, astigmatism, contrast sensitivity and eyelid kinematics were not consistent between the studies. No meta-analysis could be performed due to the limited scope of the included studies and the great variety in outcomes and blepharoplasty techniques. It was concluded that an upper blepharoplasty is accompanied by a great variety of beneficial functional outcomes. However, some results were conflicting, such as the effects on eye dryness and eyebrow height and/or the data was limited (contrast sensitivity, astigmatism).

In Chapter 3, a systematic review of on aesthetic outcomes after upper blepharoplasty was performed with four search engines (Pubmed, Embase, Cinahl and Cochraine). Any study on aesthetic outcomes after a solitary upper blepharoplasty was subjected to a quality assessment for possible inclusion. The intervention had to be defined as a solitary surgical upper blepharoplasty consisting of removal of skin, with or without the removal of a strip of orbicularis oculi muscle and/or upper orbital fat. Eligible studies were randomized controlled trials, controlled trials, cohort studies and case series (n≥10). A total of 4043 studies was assessed, of which 26 studies were included.

Aesthetic outcomes included patient reported outcome measures, scarring, eyebrow height, tarsal platform show and panel or expert evaluation. A meta-analysis could not be performed due to the limited scope of the included studies and the great variations between the blepharoplasty techniques and outcomes. The conclusion from the included studies is that the patients were generally satisfied with the aesthetic result and scar formation after an upper blepharoplasty. The amount of tarsal platform show increased and the eyebrows seem to move down slightly. The used surgical technique (skin only or skin/muscle removal) did not influence patient satisfaction, nor did the physician's assessed aesthetic outcomes. Nevertheless, the optimal design of the skin excision is still a matter of debate, especially when addressing lateral hooding. Only few sound split-face or randomized controlled trials compared surgical techniques and aesthetic outcomes, illustrating the need for further objective research.

Although patients are generally satisfied with the result of their upper blepharoplasty, a better understanding of which surgical technique is desirable, especially from a patient perspective regarding the aesthetic results, seems necessary. It is not set yet whether additional orbicularis oculi muscle excision leads to better patient reported aesthetic results (PRARs) compared to a skin-only resection blepharoplasty. In **Chapter 4** we assessed the patient reported aesthetic results following these two techniques. A double blind randomized controlled trial of an upper blepharoplasty, with or without muscle excision, was performed on 54 healthy Caucasian patients who assessed the procedure via PRARs. Validated FACE-Q questionnaires (self-evaluation of the eyes in general, upper eyelids, forehead and eyebrows, overall face, age appearance appraisal, age appraisal, social functioning, satisfaction with the outcome, adverse effects) were completed preoperatively, and 6 and 12 months after an upper blepharoplasty. The Patient and Observer Scar Assessment Scale was used to assess scarring. The skin only and skin/muscle upper blepharoplasty FACE-Q scores were not only similar regarding the upper eyelids, forehead and eyebrows, overall face, patient perceived aging and age, social functioning and satisfaction with the results, but also increased with time after both procedures. Only the FACE-Q score regarding 'the eyes in general' was higher (17.5%) in the skin-only group at the 12 month follow-up. Scarring and adverse effects did not differ between the groups. Additional muscle resection does not seem to influence patient satisfaction in general, but the skin-only technique results in better satisfaction with the eyes. Thus, when performing an upper blepharoplasty, an additional muscle resection is not routinely needed to improve patient satisfaction.

Furthermore, different skin excision shapes may result in different aesthetic outcomes when performing an upper blepharoplasty. Two excision shapes, namely traditional elliptical skin excisions and wide lateral skin excisions, were compared to assess the possible differences in the aesthetic result regarding pretarsal show and eyebrow height measurements, patient reported aesthetic results (PRARs) and scarring (**Chapter 5**). The two skin-only excision shapes were evaluated objectively and subjectively in 28 matched patients. The pretarsal show, lateral eyebrow height, amount of scarring (Patient and Observer Scar Assessment Scale), and patient reported aesthetic results (FACE-Q questionnaires) were scored and compared at 6 and 12 months postoperatively. Although both groups' pretarsal show improved significantly after the blepharoplasty, the lateral extension group had slightly more pretarsal show (0.5–0.8 mm at central pupil region) at the 6 and 12 month follow ups compared to the traditional excision group (p=0.004). A trend was also observed in the Exocanthion45°(EX-EX45) measurement where the skin-only group showed 0.6mm more pretarsal show 6 months postoperatively. The homogeneity of the lateral extension group's pretarsal show had improved significantly 12 months after the blepharoplasty, but not in the traditional excision group. No other significant differences were observed between the groups regarding the pretarsal show measurements or FACE-Q scores. Both groups' lateral eyebrows had descended, but this was only significant in the traditional excision group which showed 1.4 to 2.0mm more descent compared to the lateral extension group. Both groups' scarring and adverse effects scores were low and did not differ. It was concluded that both excision shapes result in positive aesthetic results, but the laterally extended skin excision technique is accompanied by a slightly more favourable outcome.

Upper blepharoplasty has been postulated to affect dry eye symptoms since the function of the orbicularis oculi muscle is closely related to the tear fluid passage system. In the study described in **Chapter 6**, we aimed to assess the effect of a blepharoplasty, with or without the removal of a strip of orbicularis oculi muscle, on tear film dynamics and dry eye symptoms. A double blind randomized controlled trial comparing upper blepharoplasty without (group A) or with (group B) orbicularis oculi muscle excision was performed on 54 healthy Caucasian patients. Tear film dynamics and dry eye symptoms were evaluated using multiple dry eye parameters, i.e. tear osmolarity, Schirmer test I, corneal/conjunctival staining, tear break-up time (TBUT), Oxford Scheme, Sicca Ocular Staining Score, and the Ocular Surface Disease Index questionnaire. All the parameters were assessed preoperatively, and 6 and 12 months after the upper blepharoplasty. All the groups' outcomes were compared. The differences were not significant between the two upper blepharoplasty techniques regarding most of the above mentioned outcomes. Subjective symptoms of ocular irritation, consistent with dry eye disease and vision-related impairment, were reduced after an upper blepharoplasty independent of the type of the technique applied, while the pre- and postoperative outcomes of the objective tear dynamics did not differ 12 months after the surgery. However, group

B demonstrated a slight increase in tear osmolarity and TBUT at the 6-month follow-up visit. Based on this study, it was concluded that upper blepharoplasty alleviates subjective dry eye complaints in the long term, while not changing the tear dynamics. The improvement was independent of the technique used.

In **Chapters 2 and 3** we established that the eyebrows tend to move down after an upper blepharoplasty. The question arises whether eyebrow position, frontalis muscle activation/fatigue and possible headache change in patients after undergoing a cosmetic upper blepharoplasty and whether there is a relationship between these variables. The study described in **Chapter 7** entails the assessment of changes in headache, eyebrow height and electromyographic (EMG) outcomes of the upper facial muscles through a randomized controlled trial where 54 patients received an upper blepharoplasty by removing skin only or skin with additional orbicularis muscle. Preoperatively, and 6 and 12 months postoperatively, headache complaints were measured using the HIT-6 scores (Headache Impact Test) and eyebrow height was measured on standardized 2D photographs. Surface EMG measurements, i.e. electrical activity and muscle fatigue, were assessed for the frontalis and orbicularis oculi muscles preoperatively, and 2, 6 and 12 months postoperatively. The patient reported headaches decreased significantly after a blepharoplasty. Also, the eyebrow height decreased at all the landmarks, and did not differ between the groups. Regarding the surface EMG measurements, the electrical activity of the frontalis muscle during maximal contraction only decreased significantly 12 months after surgery in (skin only) group A (80 vs 39, p=0.026). The postoperative changes in muscle fatigue were not significant compared to baseline, for both the frontalis and the orbicularis oculi. The electrical activity of the frontalis muscle was lower in group A 2 months postoperatively (p=0.042), and the electrical activity of the orbicularis oculi was lower in group B 12 months postoperatively (p=0.020). Although the EMG differences between groups where significant, we do not consider them clinically relevant. A significant low positive correlation was found between the baseline eyebrow height and change in HIT-6 score (0.367, p=0.009). It was concluded that no significant differences regarding headache and eyebrow descent were detected between the patients undergoing upper blepharoplasty with or without resectioning a strip of orbicularis oculi muscle. The eyebrows moved downwards and both groups' patients reported fewer headaches. The changes in the observed electromyography indicate less muscle fatigue of the frontalis muscles after a blepharoplasty.

The study described in **Chapter 8** aimed to assess the reproducibility of scanning the periorbital region with 3D technology to enable objective evaluations of surgical treatment in this area. Since volumetric changes of the upper eyelid region may affect aesthetic outcomes, it is important to be able to measure this in a reproducible way.

Facial 3D-scans of 15 volunteers were captured at different time points with a handheld Artec Space Spider structured light scanner. Two scans were made with a one minute interval and were repeated after one year; both in a natural head position and with the head in a fixation-device. On assessing the area between the eyelashes and eyebrows, the medians of the average deviations between the various cross-sections of the one minute interval 3D-scans ranged from 0.17 to 0.21mm at baseline, and from 0.10 to 0.11mm when the minute-interval scanning was repeated one year later. The systematic differences when scanning in a natural head position and fixated position were comparable. The reproducibility of the 3D processing was excellent (intraclass correlation coefficient >0.9). The repeated scanning deviations (baseline versus one year data) were well within the accepted clinical threshold of 1mm. It was concluded that scanning with a hand-held 3D-scanning device (Artec Space Spider) is a promising tool to assess changes in the periorbital region following surgical treatment since the median deviations are well below the clinically accepted 1mm measuring error, for both the natural head and fixated positions.

The results described in the various chapters were discussed in a broader perspective in **Chapter 9**.

Based on the chapters in this thesis it can be concluded that an upper blepharoplasty results in aesthetically and functionally pleasing results, with the most favourable results occurring after a skin-only upper blepharoplasty whereas special attention should be paid to the excision shape.

SAMENVATTING

Een bovenste ooglidcorrectie, ofwel blepharoplastiek, bestaat uit het corrigeren van overtollig weefsel van het bovenooglid om esthetische of functionele redenen. Het is een zeer frequent uitgevoerde cosmetische ingreep, maar de wetenschappelijke achtergrond is beperkt. Patiënten zijn erna over het algemeen tevreden, maar de esthetische en functionele resultaten zijn nog onvoldoende bekend.

Het primaire doel van dit proefschrift is om het effect van een bovenste ooglidcorrectie op esthetische en functionele vlakken te evalueren. Hiertoe is literatuuronderzoek verricht en zijn de effecten van een bovenste ooglidcorrectie in een prospectieve cohortstudie en gerandomiseerde klinische trial onderzocht.

Hoofdstuk 2 beschrijft de uitkomsten van een systematisch literatuuronderzoek. Het doel van dit onderzoek was het in kaart brengen van de huidige kennis met betrekking tot de functionele effecten van een bovenste ooglidcorrectie. Met behulp van vier verschillende zoekmachines (Pubmed, Embase, Cinahl, Cochraine) werden artikelen gezocht die de subjectieve of objectieve functionele uitkomsten beschreven van een bovenste ooglidcorrectie. De ooglidcorrectie moest bestaan uit een op zichzelf staande ingreep, waarbij huid, spier (m. orbicularis oculi) of onderliggend vet werd verwijderd. Klinische studies, zoals gerandomiseerde en niet gerandomiseerde onderzoeken, cohort onderzoeken en case-series (n≥10) kwamen in aanmerking voor inclusie. In totaal werden 28 artikelen (van de 3525) geschikt bevonden voor nadere analyse. De data bleek niet geschikt voor het uitvoeren van een meta analyse. Uit dit literatuuronderzoek bleek dat de gunstige functionele effecten van een bovenste ooglidcorrectie divers zijn, zoals het vergroten van het bovenste perifere blikveld, verhoogde kwaliteit van leven, minder hoofdpijn en een verbeterd zicht. Daarnaast werd een tijdelijke vermindering van het gevoel van de ooglidhuid vastgesteld, waarbij verschillende herstel-termijnen werden beschreven. De literatuur was tegenstrijdig, niet eenduidig en/of beperkt omtrent het effect op de wenkbrauwhoogte, astigmatisme, contrast sensitiviteit, ooglidbewegingen en droge ogen.

Hoofdstuk 3 beschrijft eveneens een systematisch literatuuronderzoek. Hier werden de esthetische effecten na een bovenste ooglidcorrectie in kaart gebracht met behulp van de huidige literatuur over dit onderwerp. Vier zoekmachines werden gebruikt (Pubmed, Embase, Cinahl, Cochraine). De ooglidcorrectie moest bestaan uit een opzichzelfstaande ingreep, waarbij huid, spier (m. orbicularis oculi) of onderliggend vet werd verwijderd. Gerandomiseerde en niet gerandomiseerde onderzoeken, cohort onderzoeken en case-series (n≥10) kwamen in aanmerking voor inclusie. Van

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de 4043 gevonden artikelen, werden 26 artikelen geschikt bevonden voor inclusie. Uit dit literatuuronderzoek is gebleken dat patiënten over het algemeen tevreden zijn met het esthetische resultaat en de littekens na een bovenste ooglidcorrectie. De hoeveelheid zichtbaar ooglid neemt toe na de ingreep hetgeen mogelijk een positieve invloed op het esthetische resultaat heeft. Tevens lijken de wenkbrauwen iets te zakken na de behandeling. De gebruikte chirurgische techniek leek geen duidelijke invloed te hebben op het esthetische resultaat volgens zowel patiënten als hun behandelend artsen. Echter, de artikelen over dit onderwerp waren schaars. Er kon geen meta-analyse worden uitgevoerd. Geconcludeerd werd dat er nog onvoldoende bekend is over de optimale chirurgische techniek, in het bijzonder het design van de huidexcisie en het wel of niet verwijderen van een deel van de onderliggende spier.

Patiënten zijn dus over het algemeen tevreden over een bovenste ooglidcorrectie, maar beter inzicht in de effecten van verschillende chirurgische technieken is noodzakelijk. Een traditionele bovenste ooglidcorrectie bestaat uit het verwijderen van overtollige ooglidhuid, met een strook van de onderliggende spier (m. orbicularis oculi) en zo nodig het verwijderen van orbitaal vet. Chirurgen zijn tegenwoordig meer geneigd om alleen huid te verwijderen, om op die manier het natuurlijke volume van het ooglid-gebied te behouden. Een jeugdig oog wordt namelijk gekenmerkt door voldoende volume. Het is echter onduidelijk of, vanuit een patiënt-perspectief, deze conservatieve techniek een mooier resultaat oplevert. Daarnaast is het niet duidelijk of er effecten zijn van beide technieken op de traanvochtproductie en of er een effect is op de hoogte van de wenkbrauw. In **hoofdstuk 4** beschrijven we derhalve een prospectieve gerandomiseerde klinische trial, waarbij we de esthetische uitkomsten van een traditionele bovenste ooglidcorrectie (bestaande uit het verwijderen van huid en spier) hebben vergeleken met de conservatieve ooglidcorrectie (verwijderen van alleen huid). In totaal werden 54 gezonde Kaukasische patiënten geïncludeerd. De esthetische uitkomsten van de ooglidcorrectie werden gemeten aan de hand van verschillende zelf-evaluatie vragenlijsten (FACE-Q scorelijsten betreffende: bovenste oogleden, ogen in het algemeen, voorhoofd en wenkbrauwen, het gehele gezicht, veroudering, sociaal functioneren, tevredenheid en ongewenste effecten). Deze vragenlijsten werden direct voor de ingreep, en na 6 en 12 maanden door de patiënten ingevuld. Tevens werden de littekens geëvalueerd met behulp van de 'Patient and Observer Scar Assessment Scale' (POSAS) 12 maanden na de ingreep. Deze scoringslijst werd ingevuld door de patiënt zelf en door een arts. De tevredenheid van de patiënt, ofwel alle FACE-Q scores, verbeterde na de ingreep. De uitkomsten tussen de 2 chirurgische technieken waren niet significant verschillend qua bovenste oogleden, voorhoofd en wenkbrauwen, het gehele gezicht, veroudering, sociaal functioneren, tevredenheid, ongewenste effecten en littekenvorming. De tevredenheid over de ogen in het algemeen was na de conservatieve ingreep (alleen huid) groter dan na de traditionele ingreep. Op basis van deze gegevens werd geconcludeerd dat het verwijderen van de onderliggende spier (m. orbicularis oculi) tijdens een bovenste ooglidcorrectie over het algemeen niet nodig is ter verbetering van het esthetische resultaat.

Bij de uitvoering van een ooglidcorrectie kunnen verschillende ontwerpen van huidexcisie mogelijk leiden tot verschillende esthetische uitkomsten. Er zijn verschillende ontwerpen van de huidexcisie mogelijk. Een traditioneel huidexcisie ontwerp bestaat uit een ellips-of scalpelvorm die de ooglidplooi volgt. Een andere techniek bestaat uit een huidexcisie die in de richting de zijkant van de wenkbrauw reikt (lateralo-craniale extensie). Deze laatste techniek zou in theorie het huidoverschot aan de zijkant van het oog beter corrigeren dan het traditionele excisie ontwerp. In **hoofdstuk 5** beschrijven we de uitkomst van een observationele studie, waarbij de hiervoor genoemde huidexcisie ontwerpen zijn vergeleken. De uitkomsten waren de hoeveelheid zichtbaar ooglid (pretarsal show), de gelijkmatige verdeling van het zichtbare ooglid (homogeniteit), wenkbrauwhoogte, littekenvorming en zichtbaarheid van de littekens (POSAS) en zelf-evaluatie van het esthetische resultaat (FACE-Q vragenlijsten). Twee groepen van 14 gematchte patiënten werden geëvalueerd aan de hand van deze subjectieve en objectieve uitkomstmaten. Dit werd gemeten direct voorafgaand aan de ooglidcorrectie en 6 en 12 maanden na de ingreep. Na de ingreep nam de hoeveelheid zichtbare ooglidhuid in beide groepen toe, maar de zichtbare ooglidhuid was over het algemeen gelijkmatiger verdeeld in de groep waarbij het laterale extensie ontwerp werd toegepast. Daarnaast was er iets meer ooglid zichtbaar in het midden van het ooglid en waren er aanwijzingen dat er aan de zijkant van het oog iets meer ooglid zichtbaar was in deze groep. Er waren geen significante verschillen tussen de groepen wat betreft de esthetische zelf-evaluatie vragenlijsten (FACE-Q), ongewenste negatieve effecten, hoeveelheid zichtbaar ooglid en litteken-evaluaties. De zijkant van de wenkbrauw zakte in beide groepen na de ingreep, maar dit was alleen significant in de groep met het traditionele huidexcisie ontwerp. Uit deze studie werd geconcludeerd dat beide huidexcisie ontwerpen positieve esthetische resultaten geven, maar dat het huidexcisie ontwerp met de laterale extensie (lateralo-craniale extensie) mogelijk gepaard gaat met de meest positieve resultaten.

Hoofdstuk 6 beschrijft een prospectieve gerandomiseerde klinische trial, waarbij de effecten op traanvocht werden geëvalueerd tussen twee ooglidcorrectie technieken: de techniek waarbij we alleen huid verwijderen (conservatieve techniek) en de techniek waarbij we huid en onderliggende spier verwijderen (traditionele techniek). Het is bekend dat de onderliggende spier (m. orbicularis oculi) invloed heeft op de traanpassage. Het verwijderen van een deel van deze spier tijdens een ooglidcorrectie zou daarom mogelijk invloed kunnen hebben op kenmerken of symptomen van droge ogen. In totaal werden 54 gezonde Kaukasische patiënten geïncludeerd in dit onderzoek. De droge ogen na een ooglidcorrectie werden gemeten aan de hand van verschillende specifieke droge ogen tests: traanfilm osmolariteit, Schirmer test, kleuringen van cornea en conjunctiva, TBUT (tear break up time), Oxford Scheme, Sicca Ocular Staining Score en een droge-ogen zelf-evaluatie vragenlijst (Ocular Surface Disease Index questionnaire). Deze testen werden preoperatief en 6-en 12 maanden postoperatief afgenomen en vergeleken tussen de groepen. Proefpersonen rapporteerden minder droge-ogen klachten na de ingreep. De andere variabelen (traanfilm osmolariteit, Schirmer test, kleuringen van cornea en conjunctiva, TBUT (tear break up time), Oxford Scheme, Sicca Ocular Staining Score) toonden geen veranderingen 12 maanden na de ingreep. Tijdens de 6-maanden controle werd een kleine toename in traanfilm osmolariteit en TBUT gevonden in de traditionele-techniek groep. Er werden geen significante verschillen tussen beide groepen gevonden 12 maanden na de ooglidcorrectie. Op basis van deze studie concludeerden we dat een ooglidcorrectie van het bovenooglid subjectieve klachten van droge-ogen op lange termijn vermindert en zeker niet verergert. Deze verbetering treedt op ongeacht de gebruikte techniek.

Een ander aspect van een bovenste ooglidcorrectie is het effect op de wenkbrauwhoogte. In de **hoofdstukken 2 en 3** werd duidelijk dat wenkbrauwen waarschijnlijk zakken na een ooglidcorrectie, maar dat het mechanisme nog onduidelijk is. Door het huidoverschot dat preoperatief aanwezig is en het blikveld dat mogelijk beperkt is, worden in theorie de wenkbrauwen constant opgetrokken en het voorhoofd aangespannen. Door deze spierspanning zou spierspanningshoofdpijn uitgelokt kunnen worden. Na de ooglidcorrectie is er geen huidoverschot meer en zou wederom in theorie het voorhoofd ontspannen en de wenkbrauwen kunnen zakken. Er is nog onvoldoende bewijs om deze theorie te bevestigen. Daarom werd een prospectieve gerandomiseerde klinische trial verricht, waarbij we de uitkomsten van een traditionele ooglidcorrectie (bestaande uit het verwijderen van huid en spier) vergeleken met de conservatieve ooglidcorrectie (verwijderen van alleen huid) aan de hand van metingen van de wenkbrauwhoogte, de elektrische activiteit en vermoeidheid van de m. frontalis en m. orbicularis oculi en hoofdpijnklachten (**hoofdstuk 7**). In totaal werden 54 gezonde Kaukasische patiënten geïncludeerd in dit onderzoek. Pre- en postoperatief (2, 6 en 12 maanden) werd oppervlakte elektromyografie uitgevoerd om de elektrische activiteit en mate van vermoeidheid van de spieren te analyseren. Ook werd pre- en postoperatief (6 en 12 maanden) de wenkbrauwhoogte gemeten op gestandaardiseerde portretfoto's en beoordeelden patiënten hun hoofdpijnklachten aan de hand van de HIT-6 scorelijst (Headache Impact Test). Na de ooglidcorrectie daalden de wenkbrauwen. Ook rapporteerden patiënten minder hoofdpijnklachten postoperatief. Er waren geen significante verschillen tussen de groepen wat betreft de wenkbrauwhoogte en hoofdpijnklachten. In de conservatieve techniek groep (alleen huid) werd een sterke afname van elektrische activiteit van de m. frontalis ten opzichte van preoperatief waargenomen. De elektrische activiteit van de m. orbicularis oculi toonde geen significante veranderingen postoperatief. Klinisch significante verschillen in vermoeidheid van beide spieren postoperatief werden niet gezien, alleen zeer kleine verschillen in elektrische activiteit tussen beide groepen. Op basis van deze studie werd geconcludeerd dat de wenkbrauwen dalen en de hoofdpijn afneemt na een bovenste ooglidcorrectie. De veranderingen in de elektromyografie postoperatief impliceren minder vermoeidheid van de voorhoofdsspieren (m. frontalis) na de ingreep.

Om in de toekomst chirurgische resultaten in het peri-orbitale gebied goed in kaart te brengen, kunnen we 3D-technologie gebruiken. Volumetrische veranderingen van de oogleden of wenkbrauwen kunnen namelijk van invloed zijn op het esthetische resultaat, waardoor het belangrijk is om dit objectief te kunnen meten. Echter, in de huidige literatuur wordt het scannen van het periorbitale gebied vaak buiten beschouwing gelaten, omdat dit een lastig gebied is om reproduceerbaar te scannen. **Hoofdstuk 8** toont een evaluatie van een 3D scanning methode van het peri-orbitale gebied. Met behulp van de draagbare Artec Space Spider 3D scanner werden op meerdere momenten 3D scans gemaakt van het gezicht van 15 vrijwilligers. Twee 3D scans werden vervaardigd met een minuut ertussen. Dit werd een jaar later herhaald. De scans werden gemaakt in een neutrale positie van het hoofd (natural head position) en met het hoofd in een speciaal hiervoor vervaardigd fixatie-apparaat. In totaal werden 8 3D scans per vrijwilliger gemaakt. De foutmarge tussen de verschillende 3D scans werd bepaald. Het gebied tussen de wimpers en de wenkbrauwen werd geanalyseerd. De mediane foutmarges in de minuut-interval 3D scans bedroegen 0.17-0.21mm en 0.10-0.11mm bij de minuut-interval 3D scan een jaar later. De twee scantechnieken (neutrale positie hoofd versus fixatie apparaat) lieten geen duidelijke verschillen in uitkomsten zien. De foutmarges tussen de herhaalde 3D scans van het peri-orbitale gebied lagen ruimschoots binnen de klinisch relevante grens van 1mm. Ook werd de 3D verwerkingsmethode geëvalueerd en zagen we een goede reproduceerbaarheid (intraclass correlation coefficient >0.9). Deze techniek-evaluatie toonde aan dat herhaaldelijk scannen van het peri-orbitale gebied met slechts een kleine foutmarge (<1mm) gepaard gaat, ongeacht of het hoofd in neutrale positie of in het fixatie apparaat wordt gescand.

De resultaten beschreven in de voorgaande hoofdstukken werden bediscussieerd in **hoofdstuk 9.** Gebaseerd op de hoofdstukken uit dit proefschrift blijkt dat een bovenste ooglidcorrectie gepaard gaat met gunstige esthetische en functionele effecten. De meest gunstige effecten zijn te verwachten als een conservatieve ooglidcorrectie (alleen verwijderen van overtollige huid) wordt uitgevoerd. Het gestandaardiseerd verwijderen van een deel orbicularis oculi spier is tijdens de ingreep niet gewenst. Bij patiënten met dermatochalasis lateraal van het ooglid valt uitbreiding van de excisie naar latero-craniaal te overwegen.

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ABOUT THE AUTHOR

Marijke Hollander is born in Kampen, the Netherlands, on December 22nd, 1989. After finishing secondary school at the 'Ichthus College' in Kampen, she started medical school at the University of Groningen, Groningen, the Netherlands in 2009. Throughout medical school, she provided municipal home care for geriatric patients and was regularly working in the commercial pleasure sailing fleet of Kampen. She performed her clinical internships at the University Medical Center Groningen and TREANT hospital in Emmen/Hoogeveen. In 2015, as part of medical school she performed a research study which focused on anxiety and heart rate variability in patients undergoing removal of third molars. The presentation of this study was awarded the Dentoalveolar Presentation Price and was included in the 'Tandheelkundig Jaar', a compilation of most recent developments in dental care. After this, a period of postgraduate physician functions in Internal Medicine, Cosmetic Medicine and Hyperbaric Oxygen Therapy followed. In 2017, she started a PhD project at the Department of Oral and Maxillofacial Surgery at the University Medical Center Groningen, Groningen, the Netherlands, concerning the aesthetic and functional effects of upper blepharoplasties in cooperation with the department of Ophthalmology, Clinical Neurophysiology and the 3D Lab Groningen. This project was supervised by prof. dr. A. Vissink, dr. J. Jansma and dr. R.H. Schepers. She combined her PhD project with the Dentistry study at the University Groningen as part of the preparation for her residency in Oral and Maxillofacial Surgery at the University Medical Center Groningen. Meanwhile, Marijke worked as a clinical resident at the department of Oral & Maxillofacial Surgery at the Scheper hospital in Emmen. She received the Marten Hut price for her presentation 'Blepharoplastiek van het bovenooglid' on the preliminary results of this thesis. Currently, Marijke has started her residency in Oral & Maxillofacial surgery at the UMCG. Marijke lives with her partner Jurjen Schortinghuis in Groningen, the Netherlands.

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