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Review

Functional outcomes of upper eyelid blepharoplasty: A systematic review

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Abstract*Objective:* 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 ($n \geq 10$).
Results: A total of 3525 studies were 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

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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).

Contents

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", "eyelid correction", "blepharochalasis", "dermatochalasis" and "eye lid surgery'' (for the full list of keywords, see Appendix 1). 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 Appendix 2.

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) were 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 flowchart).

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 1 provides an overview of the studies selected for review. Below, we describe a synthesis and discuss the included studies.

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

Tabel 1 Study characteristics.

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) 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 6.9 s, post 7.2 s. Mean Schirmer I pre 11 mm and post 17 mm. The inflammatory reaction shown by impression cytology decreased postoperatively. All not significant.	3	11
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 fluorescein 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
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

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Tabel 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
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
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° Postoperative 20.9° Area under the curve: Preoperative 223° Postoperative 798° *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
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

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Tabel 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) 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 2 mm 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
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 1 mm) after surgery. Two patients had a mild descent of the eyebrow (average ≤ 2 mm) two patients were felt to have significant induction of eyebrow ptosis (average ≤ 3 mm).	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 1.5 mm centrally and 2.07 mm laterally, and the mean difference in postoperative brow height was 1.7 mm centrally and 2.07 mm 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

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Tabel 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) 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
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 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	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 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) 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 15.8 mm for the right side and 15.9 mm for the left side. Postoperative mean 15.2 mm for the right side and 15.1 mm 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
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 -1.7 mm, $p \leq 0.04$)	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

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Tabel 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) 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 < 2.5 mm, group 2 ≥ 2.5 mm.	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
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

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Tabel 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
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
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
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

(*continued on next page*)

Tabel 1 (*continued*)

Author (s) and year of publication	Aim	Intervention	Method of measured outcome (s)	No. of (blepharoplasty-only) participants included	Mean age of participants (years)	Gender	Outcomes	Length of follow up (months)	MINORS score
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 ($p = 0.03$)	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
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.

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 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 lagophthalmos 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]

Authors' 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.

Conflict of interest

None.

Appendix 1. 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

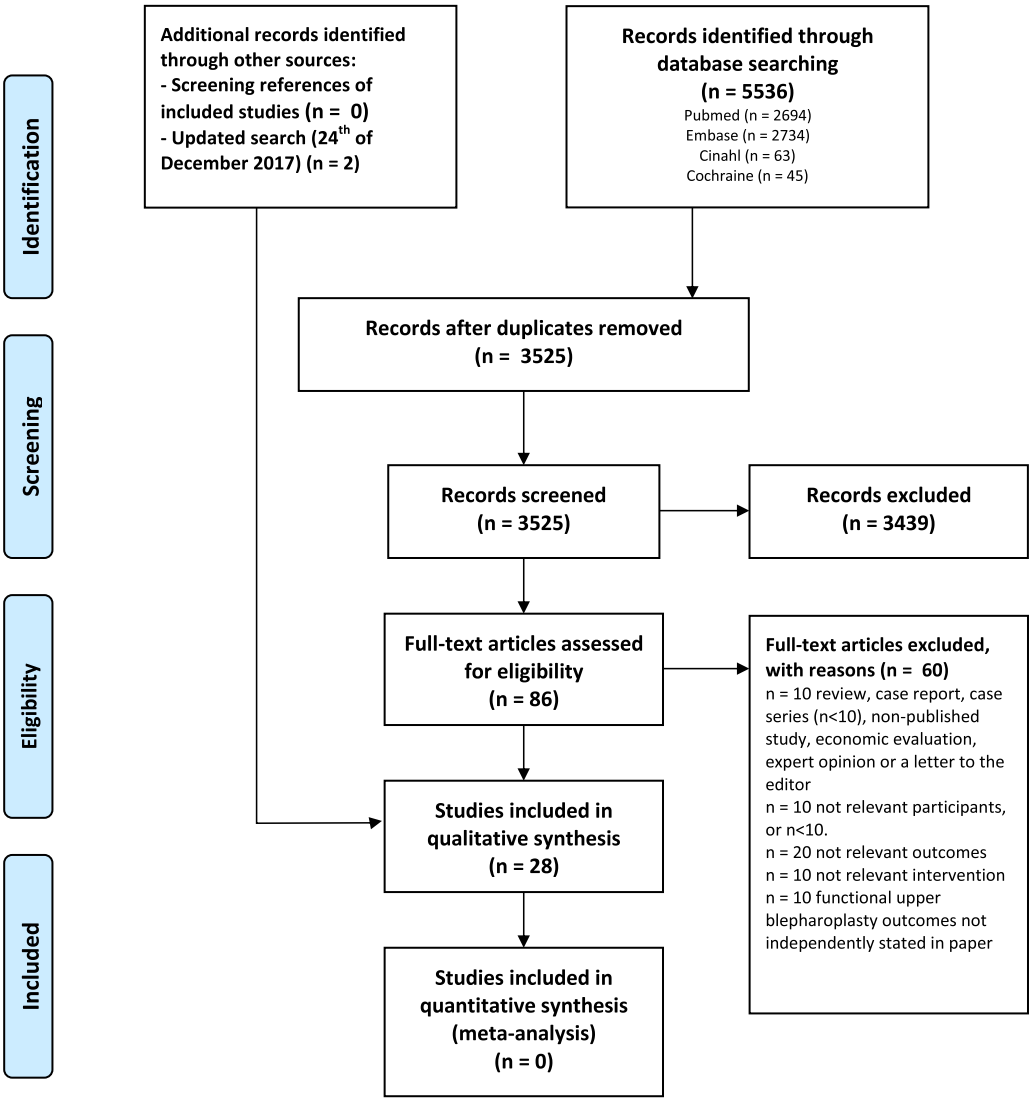
Cinahl search

(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.

Appendix 2. Flow diagram.



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