

Long-term changes in contrast-sensitivity, corneal topography and higher-order aberrations after upper eyelid blepharoplasty: A prospective interventional study

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Purpose: The aim of this study was to analyze the long-term changes in visual parameters, that is, contrast sensitivity (CS) and higher-order aberrations (HOAs), and corneal topography in the patients undergoing upper eyelid blepharoplasty (UEB) for dermatochalasis. **Methods:** This was a prospective, single surgeon, intervention study including patients (≥ 40 years age) having severe dermatochalasis with a minimum post-UEB follow-up of 12 months. The preoperative readings of CS (using Pelli-Robson chart), HOAs (using WaveLight ALLEGRO analyzer), and corneal topography (using topographic modeling system-4, Tomey corporation) were noted and compared at 3, 6, and 12 postoperative months. **Results:** We studied 30 patients (60 eyes) who underwent bilateral UEB. The majority of patients were females ($n = 21,70\%$), and the mean age of patients was 56.53 ± 9.06 years. The preoperative and postoperative values of LogMAR visual acuity, log CS value, corneal topography measurements (K1, K2, cylinder value, and the axis), optical aberrations (total HOAs; third-order—trefoil & coma; four-order—spherical aberrations and secondary astigmatism, and tetrafoil) were compared. At 12 months, the mean CS value, the majority of HOAs, and corneal topography (only cylinder values) showed a stable, statistically significant difference in the postoperative period. **Conclusion:** The UEB may produce long-term, visually-beneficial, optical, and corneal changes. The patients undergoing cataract surgery aiming for spectacle independence may gain additional visual benefits with UEB.

Key words: Contrast sensitivity, corneal topography, optical aberrations, upper eyelid blepharoplasty

With the global increase in life expectancy, quality, and standards of living, the facial cosmetic concerns of the majority population are on the rise. The most common indication for an upper eyelid blepharoplasty (UEB) is significant upper eyelid dermatochalasis, which causes aesthetic and functional dissonance.^[1] The prevalence of dermatochalasis is 16% among the individuals aged >45 years, more in men (19%) than women (14%).^[1-4] The upper eyelid dermatochalasis, in combination with aponeurotic blepharoptosis and eyebrow drooping, may cause a decrease in the quality of vision.^[5-7] These functional visual issues may eventually lead to the impairment of daily activities.^[1-4]

The vital anatomical (corneal topography) and functional (contrast sensitivity (CS), ocular aberrations) aspects of vision may get affected due to upper eyelid dermatochalasis.^[5-10] The redundant and overhanging upper eyelid skin can cause mechanical obstruction or blockage of the light entering the eye temporally, reducing the peripheral visual field.^[1-3] It can also cause optically significant diffraction, which may cause a reduction of the CS.^[5-7] The mechanical (weight) effect may lead to the topographical changes of the cornea and cause aberrations.^[8-10]

Moreover, misdirected eyelashes, eyelash ptosis, chronic blepharitis, and dry eye may appear or aggravate due to these

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involitional skin and subcutaneous changes.^[1] Atalay *et al.* concluded that severe dermatochalasis was associated with altered corneal biomechanical properties (corneal hysteresis) measured by the ocular response analyzer device.^[11] Hence, various studies have shown improvements in the contrast sensitivity, higher-order aberrations (HOAs), and corneal topography following the UEB procedure.^[5-10]

As there is no such Indian data available, we planned a prospective study analyzing the long-term changes in visual (CS and HOAs) and corneal parameters (corneal topography) in the patients undergoing UEB for significant dermatochalasis.

Methods

This prospective, interventional study was conducted at our tertiary-care referral institute after obtaining approval from the institutional ethics committee. All consecutive patients undergoing UEB, from April 2015 to March 2016, were included. Written informed consent was obtained from each patient before surgery. The *inclusion criteria* were patients aged ≥ 40 years with dermatochalasis planned for UEB, best-corrected visual acuity (BCVA) of 20/40 or better, the margin-reflex

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distance (MRD1) of ≥ 3 mm and the dermatochalasis affecting daily activities of patients. A minimum postoperative follow-up of 12 months was ensured. The *exclusion criteria* were history of corneal refractive surgery, pterygium, glaucoma, nuclear sclerosis > grade 4, severe dry eye, age-related macular degeneration, neuro-ophthalmological diseases, diabetic retinopathy or post-pan-retinal photocoagulation. The corneal pathologies like keratoconus and gross eyelid pathologies like entropion, ectropion and gross eyelid laxity were also excluded.

At presentation, a detailed history and routine ophthalmic examination were performed for all included patients. The Snellen's chart was used to record BCVA and was later converted to a logarithm of minimal angle of resolution (logMAR) equivalents for statistical analysis. The MRD1, palpebral fissure height, and eyelid contour were noted. The UEB work-up included measurements of the upper eyelid position, eyelid crease, eyelid fold distance, and eyebrow position. The peripheral visual fields were recorded using a 60-4 protocol. The grading of dermatochalasis was done as suggested by Shah *et al.*^[12]; Grade (0)- no excess skin, Grade (-1)- mild overhang of skin over eyelid crease, Grade (-2)- excess skin with a moderate overhang over eyelid crease and Grade (-3): Severe excess skin with much of lashes covered.

The contrast sensitivity, corneal topography, and optical aberrometry were performed preoperatively and at 3, 6, and 12 months in the postoperative period. The contrast sensitivity was measured with the Pelli-Robson contrast sensitivity chart (Clement Clarke International Ltd.), read at a distance of 1 meter under standard lighting conditions. This chart provides the result in log contrast sensitivity, which was used for analysis.

The corneal topography was performed using the Topographic Modelling System (TMS-4) (Tomey Corporation Japan, Nagoya, Japan). The data were obtained and calculated by a built-in software application by Klyce corneal statistics (Stephen D Klyce, University of Louisiana). In his topography, the green shows a normal corneal surface; red shows abnormal areas, and the intermediate stage is yellow. The K1 (standard dioptre value of simulated keratometry on the steepest axis), K2 (simulated keratometry on the flattest axis), CYL (cylinder value), and AXIS, were noted for all patients.

The optical aberrometry was performed using the WaveLight® ALLEGRO Analyzer (Alcon Laboratories, Inc. USA). This device uses Tscherning sensor architecture and has a range of +6.0 D to -12.0 D sphere, up to 6.0 D of cylinder and up to sixth-order HOAs. It quantifies the distortion of a grid pattern observed on the retina; a Zernike expansion series describes the wavefront. Following HOAs were documented at 4 mm and 6 mm pupil size: total HOAs, 3rd order (trefoil, coma), 4th order (spherical aberration, secondary astigmatism) and tetrafoil.

Surgical technique of UEB

All surgeries were performed under local anesthesia by a single, senior-most surgeon using the standard described surgical technique in our previous publication.^[1] Customized sculpting of both the central and medial fat pads was performed in all patients depending on the grade of dermatochalasis and presence of aesthetically significant steatoblepharon. In grade -1 dermatochalasis only central fat pad sculpting with skin excision was done, while in grade -2 and grade -3 dermatochalasis, both medial and central fat pads were sculpted along with skin excision. For extensive grade -3 dermatochalasis with lateral hooding [Fig. 1a], the marking technique was modified as lateral 'W' shape [Fig. 1b-d]. This shape provided an extra

'lift' and widened the visual field on the lateral side. Similar postoperative advice was given to all patients tailored according to their specific needs.^[1] Except for the routine postoperative ophthalmic examination, the specific evaluation tests were scheduled at month- 1, 3, 6, and 12 months. Specifically designated technicians or machine operators performed the CS, corneal topography, and HOAs tests.

For statistics, the sample size was computed by using SAS 9.3 (SAS Inc. USA, JMP software). A paired t-test was applied for testing the significant differences and development in accordance with time, utilizing the SPSS 15.0 and SAS 9.3 JMP software. The Student t-test was used to test the differences between two groups for continuous variables. The *P* value of <0.05 was considered statistically significant.

The primary outcome measures were changes in the contrast sensitivity, corneal topography, and higher-order aberrations in the patients of UEB. The eyelid parameters (position, fold, crease) and peripheral visual fields (60-4) were noted but not included as a part of the current study.

Results

A total of 60 eyes of 30 patients with dermatochalasis qualified for our study and underwent bilateral UEB after a detailed preoperative workup and evaluation. The majority of patients were females ($n = 21, 70\%$). The mean age of patients was 56.53 ± 9.06 years. The dermatochalasis patients were categorised as grade -1 ($n = 28$), grade -2 ($n = 20$) and grade -3 ($n = 12$). The preoperative LogMAR BCVA was 0 in 53.3% ($n = 32$) patients, 0.1 in 26.6% ($n = 16$) patients and 0.2 in 20% ($n = 12$) patients. The mean preoperative and post-operative LogMAR vision was same that is, 0.7 ± 0.08 , hence, no statistical difference. The mean preoperative CS log value was 1.34 ± 0.13 , which showed a statistically significant difference ($P < 0.0001$) in the post-operative period (1.53 ± 0.11) at 12 months.

In the corneal topography measurements, K1 (simulated keratometry value in dioptres on the steepest axis), K2 (on the flattest axis), cylinder value and the axis was noted and analyzed. The Student's *t* test found a significant difference ($P < 0.0001$) between the preoperative and postoperative cylinder values [Fig. 2], while other topography parameters were found to be having no statistically significant difference [Table 1].



Figure 1: (a) A 62-year-female showing grade -3 dermatochalasis with significant lateral hooding. (b) The upper eyelid skin marking showing a lateral 'W' shaped configuration for additional 'lift' for the lateral hooding. The marking is done in the pre-operative room with the patient in an upright position. (c and d) A close-up of the right and left upper eyelids after the 'W' shaped marking before the bilateral simultaneous UEB surgery

The documented and analyzed HOAs included- total HOAs, third order (trefoil, coma), fourth order (secondary astigmatism, spherical aberrations), and tetrafoil [Fig. 3]. All values were obtained at the pupil sizes of 4 mm and 6 mm each. There was no significant difference in patients undergoing either the 'skin only' and 'skin+fat' excision. The pre- and postoperative values of each HOA have been tabulated systematically in Table 2, for 4 mm and 6 mm, respectively. The graphical description of the same is shown in Fig. 4.

The changes in all parameters persisted similarly over the 1-year follow-up without any significant change. No patient required any resurgery for additional improvement of contrast-sensitivity, corneal topography, and higher-order aberrations after upper eyelid blepharoplasty within the follow-up period of 1 year. However, the visual acuity deteriorated secondary to the maturity of the nuclear cataract. This shows long-term stable changes in the visual functions after UEB.

Discussion

Ours is a first of its kind study showing the anatomical (corneal topography) and functional (CS and HOAs) aspects of the vision, which showed long-term improvement in our patients. A detailed PubMed search revealed no such study in the Indian population, technically, the north-east Indian population. In our people, the incidence of dermatochalasis is higher than in other ethnic groups owing to the Asian eyelid configuration.^[1,13]

In the literature, the mean age of patients is less for the Korean group (Kim JW^[6] *et al.* 47.4 years) as compared to ours (56.53 years) and UK group (Rogers^[5] *et al.* 63.5 years). This might be due to an increasing trend of getting UEB in the Korean population. The same Korean^[6] study reported 62.5% of males undergoing UEB as compared to our predominant female group (70%). Our study showed no change in the visual acuity after the UEB in the early postoperative period. Lee *et al.* also reported no significant change in the visual acuity of their patients.^[14]

Dermatochalasis is an involuntional process characterized by excessive redundant eyelid skin, which may get aggravated by additional fat prolapse through the weak orbital septum.^[15,16] These large fat pads may alter the pressure over the cornea

and change its shape, resulting in additional astigmatism. The orbital fat reduction during the UEB may induce significant changes in corneal shape, which have been correlated with the corneal topographical measurements.^[15-18]

Fowler *et al.* showed a significant change in the contrast sensitivity after UEB surgery from the mean preoperative reading of 1.30 to the postoperative of 1.51.^[7] Rogers *et al.* also documented a similar significant improvement in the postoperative contrast sensitivity, that is, from 1.50 to 1.64 ($P = 0.00002$).^[5] Our study also showed a similar trend of the improvement in CS with a statistically significant difference. Kim JW *et al.* measured the CS by Contrast Glare Tester and also found a significant increase in CS after UEB. The test was performed in both mesopic and scotopic conditions.

Various authors have described the corneal topography changes by in different groups of UEB, that is, 'skin-only' UEB or 'skin+fat' UEB. Zinkernagel *et al.*^[19] ($n = 43$ patients, 82 eyes) compared the effect of 'skin-only' vs. 'skin+fat' UEB group and found a significant difference in both groups as compared to their preoperative values. However, the 'skin+fat' group (0.21 D astigmatism) did better as compared to the 'skin-only'

Table 1: Corneal topographic measurements: Preoperative and 1-year postoperative

Pair	Paired differences				t (59)	P
	Mean	SD	Mean	SD		
1						
Cylinder (Pre)	0.67	0.27	0.19	0.09	16.30	<.0001**
Cylinder (Post)	0.48	0.25				
2						
AXIS (Pre)	93.87	16.59	4.43	8.98	1.83	0.63
AXIS (Post)	89.43	17.53				
3						
K1 (Pre)	42.41	1.08	0.02	0.01	0.894	0.27
K1 (Post)	42.40	1.08				
4						
K2 (Pre)	42.30	1.05	0.24	0.06	1.73	0.57
K2 (Post)	42.06	1.05				

**highly significant

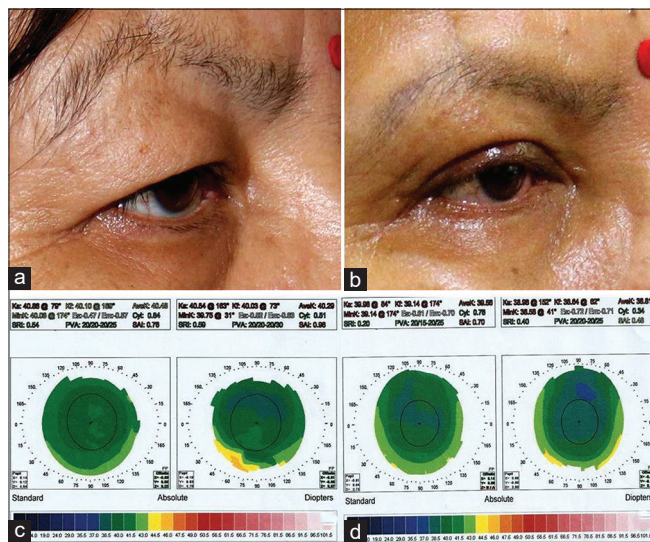


Figure 2: The pre- (a) and postoperative (b) photograph of a 60-year-female who underwent UEB. The color graphs of corneal topography, pre-(c) and postoperative (d), show a change in the cylinder values

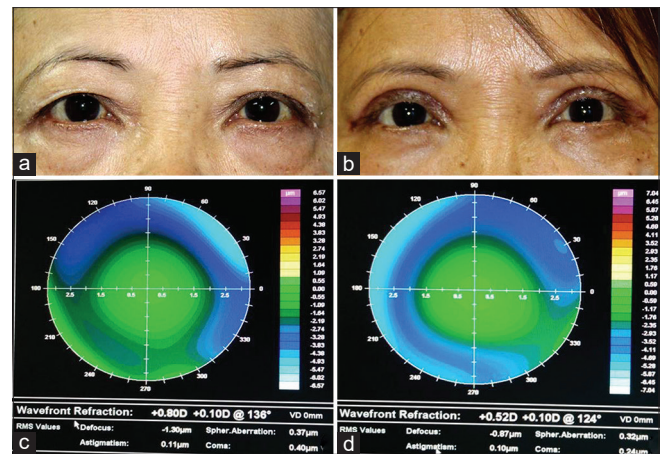


Figure 3: The pre- (a) and postoperative (b) photograph of a 55-year-female. The color-graph of pre-(c) and postoperative (d) wavefront aberrometry showing a change in the HOAs and wavefront refraction

Table 2: Higher order aberrations at 4 mm pupil and 6 mm pupil size

	Paired Differences (Mean±SD)		t (59)	P
Pupil size=4 mm				
Total HOA (Pre)	0.29±0.14	0.08±0.02	24.72	<.0001**
Total HOA (Post)	0.22±0.14			
Trefoil (Pre)	0.1±0.05	0.03±0.04	1.63	0.183
Trefoil (Post)	0.07±0.03			
COMA (Pre)	0.13±0.04	0.02±0.01	20.6	<.0001**
COMA (Post)	0.11±0.04			
Secondary Astigmatism (Pre)	0.1±0.02	0.02±0.01	1.04	0.186
Secondary Astigmatism (Post)	0.07±0.02			
Spherical Aberration (Pre)	6.41E-02±4.80707E-02	0.0026±0.0014	1.72	0.175
Spherical Aberration (Post)	6.15E-02±4.80683E-02			
Tetrafoil (Pre)	0.14±0.1	0.05±0.03	1.32	0.164
Tetrafoil (Post)	0.09±0.07			
Pupil size=6 mm				
Total HOA (Pre)	0.63±0.10	0.19±0.05	29.22	<.0001**
Total HOA (Post)	0.45±0.10			
Trefoil (Pre)	0.28±0.12	0.04±0.02	1.26	0.16
Trefoil (Post)	0.24±0.12			
COMA (Pre)	0.30±0.07	0.14±0.04	29.40	<.0001**
COMA (Post)	0.16±0.08			
Secondary Astigmatism (Pre)	0.09±0.02	0.05±0.02	0.79	0.38
Secondary Astigmatism (Post)	0.04±0.02			
Spherical Aberration (Pre)	0.26±0.06	0.02±0.01	0.87	0.28
Spherical Aberration (Post)	0.24±0.06			
Tetrafoil (Pre)	0.11±0.11	0.04±0.01	0.94	0.24
Tetrafoil (Post)	0.08±0.12			

**Highly significant

group (0.09 D) in improving the corneal topography. Brown *et al.* used a corneal video keratographer for his study on two groups undergoing blepharoplasty and ptosis surgeries. In the UEB group, the mean astigmatic change was 0.55 D, which is higher as compared to our study. However, in our study all patients had undergone skin+fat UEB with customized fat sculpting depending on the grade of dermatochalasis and the amount of steatoblepharon.

However, Dogan *et al.* used suggested that the UEB surgery does not lead to significant changes in the leading corneal indices on Pentacam.^[8] Simsek *et al.* ($n = 23$ patients, 43 eyes) found that 60.5% of eyes had a measurable increase in corneal astigmatism after the UEB.^[10] The mean change in astigmatism was 0.15 D. This finding is contrary to our results as we have recorded a decrease in the corneal astigmatic values due to customized fat removal in all patients. The amount was decided on-table to produce maximum satisfaction with minimal fat sculpting.

The HOAs are an index of visual quality, and its reduction improves contrast sensitivity and visual acuity.^[20] The UEB may reduce the ocular aberrations, specifically the HOAs, resulting in improved point-spread function and more vivid retinal images. Kim JW *et al.* measured HOAs in 22 eyelids of 16 patients and attributed the improvements in HOAs to the UEB after one month of surgery.^[6] They used KR-1W Wavefront Analyser (Topcon Inc., Tokyo, Japan), but it revealed similar results with a significant difference in ocular aberration at the 4 mm and 6 mm pupil size. The values of total HOA, third-order, fourth-order, trefoil, coma,

second astigmatism, decreased substantially ($P = 0.008, 0.011, 0.028, 0.033, 0.038,$ and $0.049,$ respectively).

In a study by Lee *et al.*, the HOAs were quantified and compared in children after epiblepharon surgery.^[14] At postoperative 12 months, they found that the eyelid surgery significantly reduced fourth-order aberrations and tetrafoil in the 4 mm zone; and coma, tetrafoil, and secondary astigmatism in the 6 mm zone. The differences were statistically significant ($P = 0.038$ and 0.006 in 4 mm; $P = 0.018$ and 0.000 in 6 mm). Our study also revealed a statistically significant difference in ocular HOAs at a pupil size of 4 mm and 6 mm. We provide the first evidence of this kind from our country, which encounters the majority of UEB patients from the region and nation. We have described our experience in a previous study focused on UEB.^[1]

We report that the preoperative optical evaluations such as corneal topography and HOAs can highlight the functional visual compromise in patients having dermatochalasis. We found consistent results in CS improvement in all of our subjects following UEB. Hence, we recommend the *contrast sensitivity testing* as an alternative method to be used where access to expensive types of equipment like corneal topographer and aberrometry machines are not available. The limitations of our study include a lack of measurements in scoring the improvement in dry eye status and eyelash ptosis of the patients. We have purposefully not discussed the eyelid related evaluations and visual-field changes for better focus on the current topic.

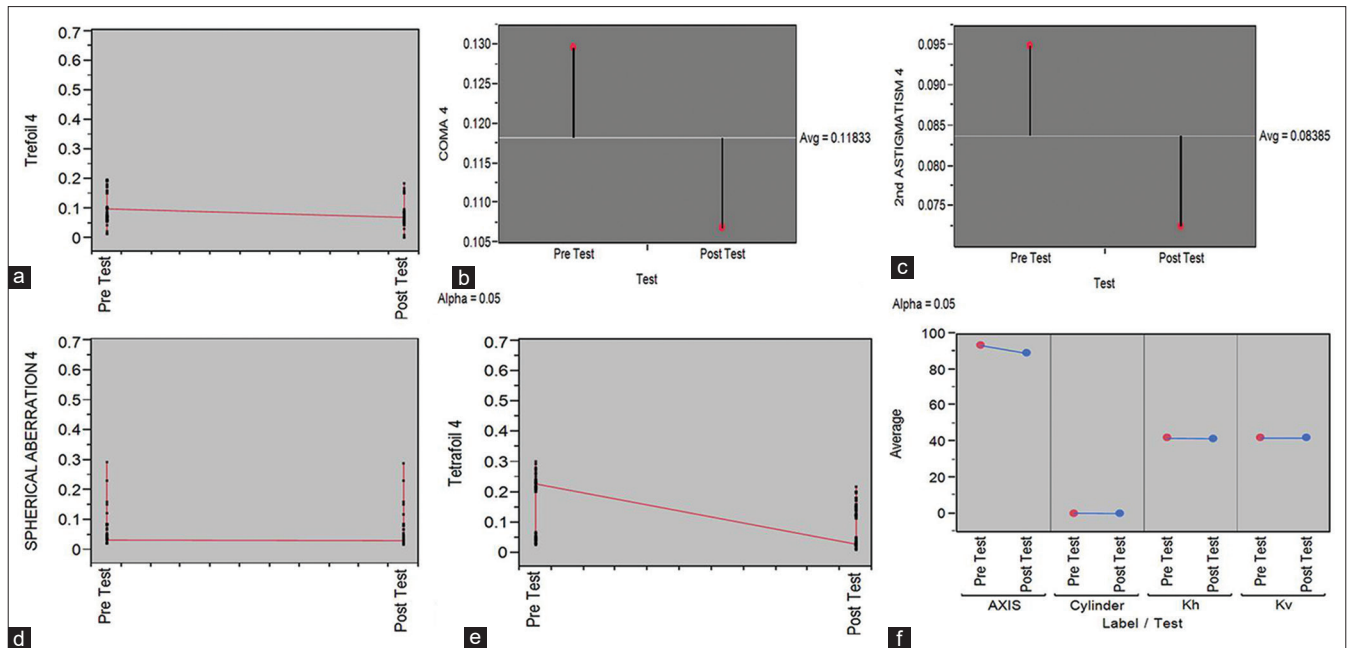


Figure 4: The graph plots depicting the pre- and postoperative (6 months) HOAs at 4 mm pupil. (a) Trefoil, (b) Coma, (c) Tetrafoil, (d) Secondary astigmatism, (e) Spherical aberration (f) Corneal topography

Conclusion

In conclusion, the UEB may increase the contrast sensitivity and reduce HOAs in patients with dermatochalasis. The UEB procedure, when performed before or after the cataract surgery with or without multifocal lenses, will lead to better visual functions. This overall improves the quality of life of our patients.

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Conflicts of interest

There are no conflicts of interest.

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