

Impact of Single Eyelid on Superior Visual Field

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Abstract: A puffy eyelid without a crease, also known as single eyelid, is a common characteristic in East Asians. Existence of a lid crease is generally considered an aesthetic concern for both patients and surgeons, and postoperative evaluations have mainly focused on the appearance of the eye. The aim of this study was to clarify the functionality of the superior visual field (SVF) with single eyelid.

This prospective cohort study compared edge of the upper eyelid to central corneal light reflex distance (edge reflex distance [ERD]) preoperatively and postoperatively and examined the SVF, as measured by Goldmann perimetry, in single-eyelid patients who underwent blepharoplasty.

Twenty patients (40 eyelids) with a median age of 21 years were examined. The median preoperative and postoperative ERDs were 1.45 and 3.4 mm, respectively. The median areas of the SVF preoperatively and postoperatively were 34,443 and 50,796 degrees², respectively. Although a positive correlation existed between preoperative ERD and SVF, no correlation was observed between postoperative ERD and SVF.

The SVF of the single eyelid is narrower than that of the double eyelid, even under circumstances of equivalent palpebral fissure height. The single eyelid commonly found in East Asian populations is associated with both cosmetic and functional issues.

Key Words: East Asian, single eyelid, double eyelid, ptosis, superior visual field, blepharoplasty, Goldmann perimetry

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The single eyelid, representing an upper eyelid without a crease, is a common feature in East Asian populations, in addition to the presence of a narrow palpebral fissure and epicanthal fold. The prevalence of single eyelid among East Asian varies from 16.9% to 63.9%,^{1–6} compared with only 2% among White patients.⁵ Single eyelid is not considered a disorder, but double eyelid is often seen as more attractive than single eyelid. As a result, creation of a supratarsal crease in double-eyelid surgery is the most commonly performed cosmetic surgery in East Asia.^{7,8} Various methods have been applied, including suture ligation, full-incision, and partial-incision blepharoplasty, and preoperative conditions and surgical outcomes have been assessed in several studies.^{9–12} Considering the purpose of double-eyelid surgery, most assessments have understandably been anthropometric or based on the degree of patient satisfaction. However, in addition to cosmetic improvements, we have empirically observed that not a few patients who have undergone

double-eyelid surgery have subsequently perceived an expanded range of view after the operation.

To the best of our knowledge, no previous reports have undertaken functional evaluations of the effects of double-eyelid surgery. The present study therefore measured the superior visual field (SVF) before and after double-eyelid surgery in patients with single eyelid. We then compared preoperative and postoperative results to quantify the functional impact of single eyelid and to demonstrate the potential functional effects of surgery.

PATIENTS AND METHODS

This prospective cohort study compared the preoperative and postoperative SVF measured by Goldmann perimetry (GP) in patients with single eyelid who underwent blepharoplasty between January 2015 and August 2020 at Matsunami General Hospital. Subjects were limited to teenagers and those in their 20s with normal levator function, because changes causative of ptosis by aging were considered negligible. None of the patients had any previous history of ophthalmic surgery, injury, or neurologic disorders.

Preoperative measurements included edge reflex distance (ERD) as a marker of palpebral fissure height (PFH), brow reflex distance (BRD) as a surrogate marker of frontalis muscle activity, and levator function. Edge reflex distance was measured from the central corneal light reflex to either the inferior edge of the skin fold or the upper lid margin (whichever was lower) in subjects when performing a primary gaze. Brow reflex distance was defined as the perpendicular distance from the central corneal light reflex to the inferior margin of the eyebrow (Fig. 1). At 3 months postoperatively, ERD and BRD were measured again. Because the skin fold was cleared and the true lid margin was revealed by the operation, postoperative ERD was synonymous with margin reflex distance (MRD). Measurements were made to the nearest 0.1 mm based on digital photographs with a square, 10 × 10-mm scale sticker (Casmatch; Bear Medic, Tokyo, Japan) that was attached to the skin of the glabella. Images were evaluated using Photoshop image editing software (Adobe Systems, San Jose, CA). Levator function was measured as the excursion of the upper lid margin when moving from the full downward gaze to the full upward gaze, with the brow manually held in position. Skin overhanging the single eyelid during upward gaze was gently elevated to expose the lid margin.

Goldmann perimetry was performed preoperatively and at 3 months postoperatively by certified orthoptists. All subjects were examined using the same perimeter. For the preoperative evaluations, the first measurement was made with the eyelid in the natural (untaped) position. The measurement was then repeated with the palpebral skin taped up (taped position) to confirm the absence of any causative factors for visual field impairment other than that associated with the eyelid. Postoperative measurements were performed with the eyelid in the natural resting position.

Area of the SVF (aSVF) was defined as the area of the hemiellipse bordered by the horizontal line running from 0 to 180 degrees and the upper half of the V4e isopter of the GP. As an approximation of the hemiellipse, we adopted the area of a polygon inscribed in the V4e isopter, comprising the 12 triangles divided by each meridian line (from 0 to 180 degrees). The area of each triangle was calculated in units of degrees squared using the following equation:

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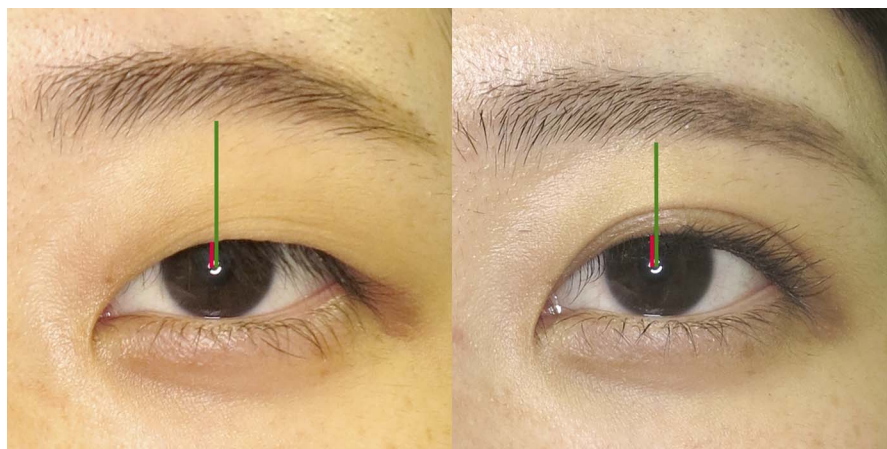


FIGURE 1. Assessment of palpebral parameters for a 22-year-old woman. Red lines indicate palpebral edge to corneal light reflex distance (ERD), and green lines indicate the lower border of the eyebrow to light reflex distance (BRD). Left, Preoperative photograph of the left eye. Right, Photograph of the left eye at 3 months postoperatively.

$$\text{Area of triangle } A_1 = 1/2 \times \sin 15^\circ \times d_1 \times d_2$$

The aSVF was defined as follows:

$$aSVF = A_1 + A_2 + A_3 + \dots + A_{12} = 1/2 \times \sin 15^\circ (d_1d_2 + d_2d_3 + d_3d_4 \dots + d_{12}d_{13}; \text{ Fig. 2}).$$

Because the important value is not the absolute value of aSVF, but rather the comparison between preoperative and postoperative aSVF, the value of $1/2 \sin 15^\circ$ (which can be assumed to represent a coefficient) was omitted from our calculation. We then compared variables, that is, the sum of the product of both sides of triangles ($d_1d_2 + d_2d_3 + d_3d_4 \dots + d_{12}d_{13}$), which we subsequently defined as aSVF.

After defining the visual field of the upper 90-degree meridian on the GP as the superior visual angle (SVA), we inspected differences in ERD, BRD, aSVF, and SVA between preoperatively and postoperatively. To evaluate the difference in SVF between single and double eyelids with an equivalent ERD range, we compared preoperative and postoperative aSVF among patients with ERD, which ranged between 2.0 and 4.0 mm. We then evaluated the correlation both between ERD and aSVF and between ERD and SVA.

This study was approved by our institutional review board (approval no. #424) and adhered to the tenets of the Declaration of Helsinki. Written informed consent for participation was obtained before patient inclusion in the study.

Statistical Analysis

Comparisons between preoperative and postoperative ERD and BRD, and comparisons for SVA and aSVF between preoperative natural, taped, and postoperative values were performed using the Friedman test and Wilcoxon signed-rank test. Correlations between ERD and aSVF and between ERD and SVA were estimated using Spearman correlation coefficient rank test. *P* values less than 0.01 were considered significant in all statistical tests. All statistical analyses were performed using JMP 10 software (SAS Institute, Cary, NC).

Surgical Procedures

All operations were performed by the senior author under local anesthesia using a 2- to 4-mL injection of 1% lidocaine containing 1:100,000 epinephrine in the orbicularis oculi muscles of both eyelids. Before anesthesia, double-eyelid lines were drawn 10 to 12 mm away from the gray line of the lid margin, and an incision was then made along this line. Although the skin was not excised, some amount of

orbicularis muscle and retro-orbicularis oculi fat were removed, as necessary, to facilitate creation of the supratarsal crease. After incising the orbital septum horizontally to open the preaponeurotic fat pad, the caudal end of the septum was turned over the tarsus. As the preaponeurotic fat pad frequently protruded into the anterior surface of the tarsus in single eyelids, this fat pad was partially removed to expose the levator aponeurosis as necessary. The reflected orbital septum, which can be considered an expansion of the levator aponeurosis, was secured to the upper one third of the tarsal plate with 1 or 2 stiches of 6/0 polypropylene without penetrating the conjunctiva. Fixation of the supratarsal crease was performed in a skin-aponeurosis-skin fashion at 3 points on each side (Fig. 3).

RESULTS

The 20 patients (40 eyes) enrolled in this study comprised 5 male and 15 female patients, with a median age of 21 years. Median levator function was 15 mm.

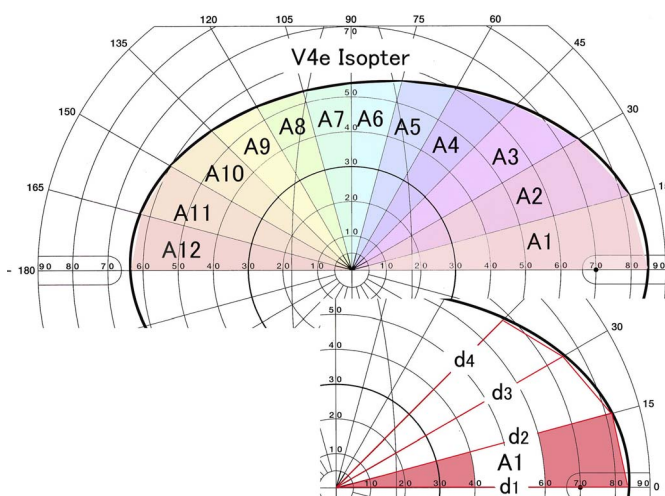


FIGURE 2. Calculation of the SVF. Based on the lengths of the 2 sides “*d*₁” and “*d*₂” of triangle A1, with an angle of 15 degrees formed at the apex between “*d*₁” and “*d*₂,” the area of the triangle can be determined as “ $1/2 \sin 15^\circ \times d_1 \times d_2$.” Area of SVF can be approximated as the sum of the area of the 12 triangles.

The inferior edge of the skin fold was located below the lid margin (in other words, the lid margin was veiled by overhanging skin) at the primary gaze position in 35 eyelids. In contrast, the lid margin was natively exposed in 5 eyelids. Postoperatively, the lid margin was exposed in all subjects. Fourteen patients had complained of chronic headache preoperatively, symptoms of which were ameliorated to a greater or lesser degree postoperatively in all 14 cases (Table 1).

The median ERD values preoperatively and postoperatively were 1.45 mm (range, -1.1 to 4.2 mm; interquartile range [IQR], 0 to 2.7 mm) and 3.4 mm (range, 1.0 to 4.9; IQR, 2.8 to 3.7 mm), respectively. The median preoperative and postoperative BRD values were 15.1 mm (range, 9.3 to 21.0 mm; IQR, 13.4 to 16.4 mm) and 14.4 mm (range, 8.8 to 19.5 mm; IQR, 12.4 to 15.9 mm). The median aSVF for natural, taped, and postoperative values were 34,443 degrees² (range, 9827 to 47,956 degrees²; IQR, 27,207 to 38,563 degrees²), 49,975 degrees² (range, 29,070 to 58,485 degrees²; IQR, 47,569 to 53,199 degrees²), and 50,796 degrees² (range, 25,831 to 58,260 degrees²; IQR, 47,628 to 53,504 degrees²), respectively. The median SVA for the natural, taped, and postoperative values were 38.5 degrees (range 13 to 55 degrees; IQR, 32 to 44.5 degrees), 57.5 degrees (range, 44–63 degrees; IQR, 53 to 59.5 degrees), and 56 degrees (range, 37 to 62 degrees, IQR, 52 to 59 degrees), respectively. A significant difference was seen between preoperative and postoperative ERD and between preoperative and postoperative BRD, respectively ($P < 0.01$). Significant differences were also identified between natural and taped aSVF and between natural and postoperative aSVF ($P < 0.01$ each). However, no significant differences were observed between preoperative taped and postoperative aSVF or between preoperative taped and postoperative SVA (Table 2).

A significant positive correlation was found between preoperative ERD and preoperative natural aSVF ($r = 0.57$, $P < 0.01$). However, no significant correlation was observed between postoperative ERD and postoperative aSVF ($r = 0.09$, $P = 0.6$). Similarly, although a positive correlation was apparent between preoperative ERD and natural SVA ($r = 0.68$, $P < 0.01$), no correlation was observed between postoperative ERD and postoperative SVA ($r = 0.01$, $P = 0.97$; Fig. 4).

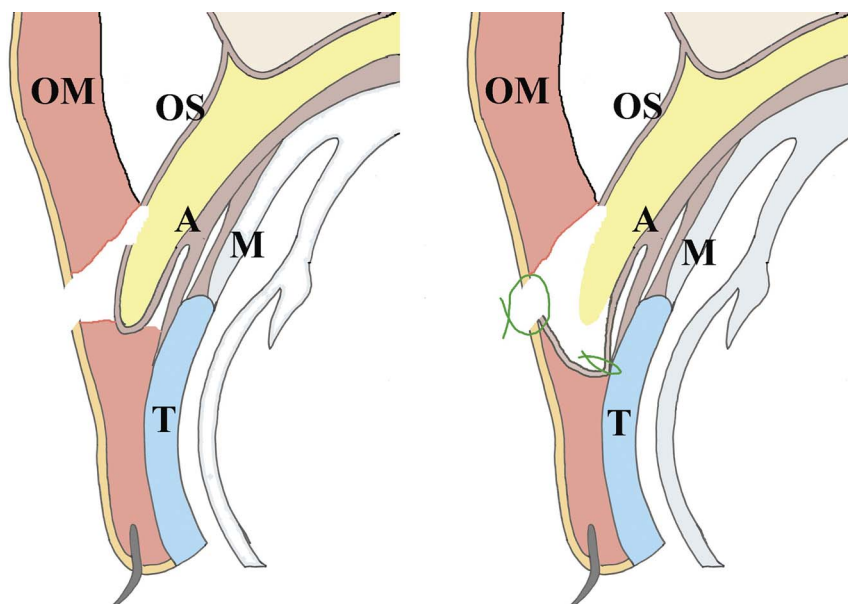


FIGURE 3. Sagittal schematics of the operation. Left, The orbicularis oculi muscle is partially removed and the orbital septum is cut. Right, The levator aponeurosis is secured to the tarsus with a polypropylene suture, with the wound closed together using the turned-over septum, which can be considered as an extension of the aponeurosis. A, levator aponeurosis; M, Müller's muscle; OM, orbicularis oculi muscle; OS, orbital septum; and T, tarsus.

TABLE 1. Demographic Characteristics of the Patients

Sex		
Female	15	
Male	5	
Symptoms		
Headache	14	
		Median (range)
Age, y		21 (13–27)
Levator function, mm		15 (14–16)
Veiled lid margin, eyes	35	
Exposed lid margin, eyes	5	

Edge reflex distance was within the range of 2 and 4 mm in 15 single eyelids preoperatively (median, 2.7 mm). In contrast, 30 postoperative double eyelids were included in the same range of ERD. From the postoperative group, we extracted 17 subjects to achieve a median ERD of 2.7 mm. Although no significant difference in ERD was present between the 15 preoperative and 17 postoperatively extracted subjects ($P = 0.15$), aSVF was significantly smaller in the preoperative group than in the postoperatively extracted group ($P < 0.01$; Table 3).

Figure 5 presents preoperative and postoperative aSVF of GP for the case shown in Figure 1.

DISCUSSION

Puffy single eyelids with a narrow palpebral fissure are commonly observed in East Asian populations. Extension fibers from the levator aponeurosis penetrating the orbicular muscle toward the skin conduct levator muscle contraction and form the eyelid crease in double eyelid. However, because extending fibers are absent or insert very low into the skin because of the protruding preaponeurotic fat pad, the

TABLE 2. Preoperative and Postoperative ERD, BRD, and Goldmann Visual Field Testing

	Preop Natural	Preop Taped	Postop	Difference Between Preop Natural and Postop
	Median (Range)	Median (Range)	Median (Range)	P
ERD, mm	1.45 (−1.1–4.2)		3.4 (1.0–4.9)	<0.01
BRD, mm	15.1 (9.3–21.0)		14.4 (8.8–19.5)	<0.01
aSVF, degrees ²	34,443 (9827–47,956)	49,975 (29,070–58,485)	50,796 (25,831–58,260)	<0.01
SVA, degrees	38.5 (13–55)	57.5 (44–63)	56 (37–62)	<0.01

eyelid skin is not drawn backward in single eyelid.¹³ The unretracted and unfolded skin often hangs over the lid margin to reduce PFH.

Uchida¹⁴ called this entity “pseudoblepharoptosis” and differentiated it from the pathological condition of blepharoptosis. He described single eyelid as being caused by ptosis of the eyelid skin, but because the levator muscle remains intact, the condition does not interfere with either the movements of the eyelid or vision. Li et al¹⁵ discriminated ptosis in young Asians with single eyelid from blepharoptosis on the basis of good or excellent levator function and a normal upper eyelid margin position. On the other hand, some authors consider single eyelid as a form of congenital blepharoptosis.^{16,17} In any case, single eyelid has been considered as a matter of cosmesis and functional evaluations have not been taken into account.

As shown in Figure 4, the present study offers the first demonstration that the SVA of single eyelid as included in this study was typically below the normal range, which has been determined to be approximately 55 to 60 degrees,¹⁸ despite being examined only in younger subjects. Second, SVF limitations of preoperative single eyelid in proportion to the ERD declination have been exhibited. A similar relationship between MRD and SVF has already been reported in blepharoptosis and dermatochalasis although the etiologies are different from those of

single eyelid.^{19–24} Single eyelid can thus result in functional problems as well as those maladies.

A postoperative increase in aSVF and SVA indicated expansion of SVF. This could simply be the result of an increase in ERD. The aponeurosis-securing procedure we adopted in the study might enhance postoperative levator function. The concept that a greater PFH is associated with a larger SVF is fairly clear. However, under the equivalent range of ERD (2 mm < ERD < 4 mm; in other words, under conditions of equivalent PFH), aSVF of the single eyelid was still smaller than that observed for the double eyelid (Table 3). As mentioned previously, the edge of the single eyelid is often not the lower tarsal border, but rather the edge of the overhung skin existing anterior to the tarsus. We hypothesized that the eyelid plays a role as a visor, and although the height of the visor may be comparable, a more anteriorly placed visor will result in greater obstruction of the SVF in single eyelid (Fig. 6). This means that eliminating overhanging skin from the single eyelid has considerable importance beyond simply increasing ERD in expanding SVF. It seems logical that elimination was achieved not by excision of the skin but by creation of the lid fold in the present study, because the eyelid skin of younger subjects shows little redundancy.

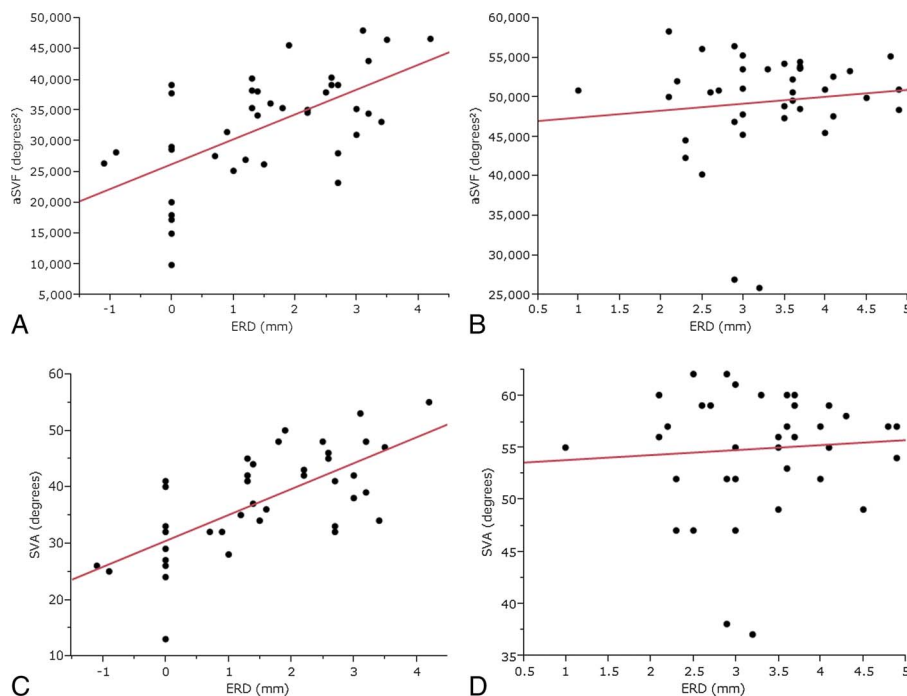


FIGURE 4. Relationships between each measurement. A, Preoperative ERD compared with aSVF. B, Postoperative ERD compared with aSVF. C, Preoperative ERD compared with SVA. D, Postoperative ERD compared with SVA.

TABLE 3. Preoperative and Postoperative aSVF for ERD >2 but <4 mm

	Preop (n = 15)	Postop (n = 17)	P
	Median (Range)	Median (Range)	
ERD, mm	2.7 (2.2–3.5)	2.7 (2.1–3.0)	0.15
aSVF for ERD > 2 mm, <4 mm, degrees ²	35,079 (23,156–47,956)	50,563 (26,920–58,260)	<0.01

In contrast to the single eyelid, no correlation was evident between the ERD of the postoperative double eyelid (ie, MRD) and either aSVF or SVA. This means that to secure a sufficient SVF, the magnitude of PFH is the decisive factor for individuals with single eyelid, as well as for those with ptosis and chalasis, whereas this factor is irrelevant for people with double eyelid without ptosis. We speculate that because the PFH is large enough without overhanging skin, the results of postoperative GP may not depend on PFH but may instead be affected by visual acuity, astigmatism, or the dexterity in pushing the button when the examinee notices the moving light of the GP.

For SVA and aSVF, no significant difference was seen between preoperative taped and postoperative values. This suggests that postoperative SVF can be predicted by taping the eyelids up. Taping may thus offer a simple method for demonstrating the potential sight the patient is likely to achieve postoperatively.

Individuals with single eyelid may be able to maintain an adequate SVF through contraction of the frontalis muscle to elevate the overhanging skin. However, continuous frontalis contraction may potentially cause chronic headache. Actually, 14 of the 20 patients in this study complained of chronic headache preoperatively. Patients with ptosis or chalasis, who raise their brows to compensate for inadequate levator activity, reportedly often complain of tension-type headache that is improved by ptosis repair or blepharoplasty.^{25–28}

Kim et al²⁹ measured eyebrow height and frontalis muscle tonicity using needle electrography in 13 women before and after blepharoplasty. They demonstrated that despite no significant descent of postoperative brow height, tonicity of the frontalis muscle was significantly decreased compared with that preoperatively. In contrast to that report, although median postoperative eyebrow descent was only 0.7 mm in our study, the difference in eyebrow height between preoperative and postoperative was statistically significant. We speculate that because the compensatory contraction has become unnecessary, although postoperative descent of the eyebrow was minimal, tonicity of the frontalis muscle in our patients might have been reduced to a sufficient extent to ameliorate their headache.

Several limitations to the present study need to be acknowledged. Only a small number of subjects were examined in this study, and these evaluations were limited to Japanese subjects. Examination was limited to individuals complaining of some sort of symptoms who desired and underwent surgery, so it remains uncertain whether

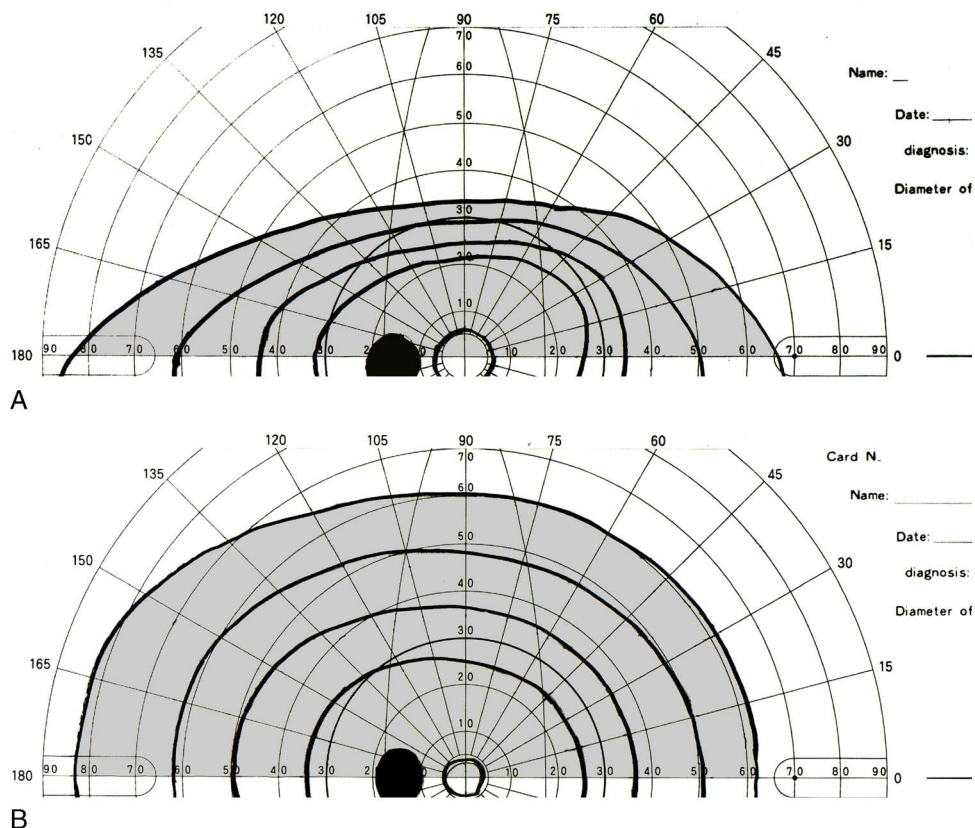


FIGURE 5. Results from GP of the left eye for the 22-year-old woman presented in Figure 1. Shaded area represents aSVF. A, Preoperative results. B, Postoperative results.

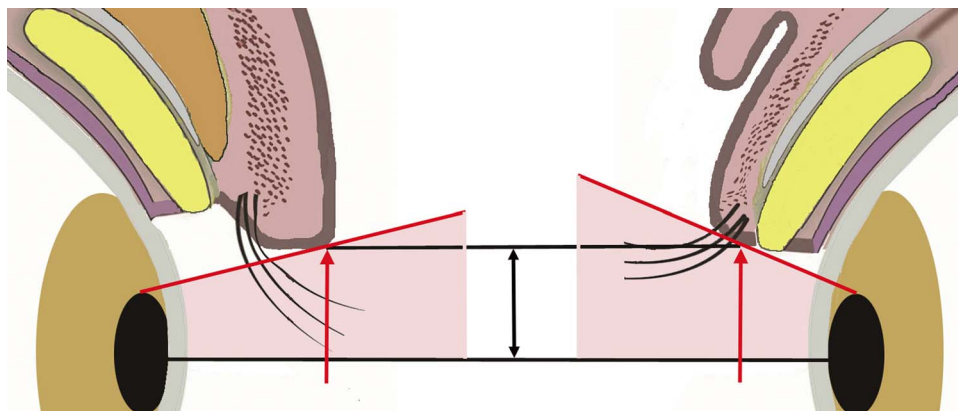


FIGURE 6. Difference in extent of aSVF between single and double eyelids under equivalent ERD. Left, Single eyelid. Right, Double eyelid. Black 2-directional arrow between the 2 black lines represents ERD. Red arrows indicate lowermost point of the palpebra. The lowermost point of the single eyelid exists more anterior to the cornea than the lowermost point of the double eyelid. Red lines represent SVA of each eyelid. Pink trapezoid areas represent aSVF of each eyelid.

all the individuals with single eyelid experience limitations to SVF. However, we surmise that a single eyelid with at least moderate to severe overhanging skin may manifest reduced SVF.

Last, because not all individuals with single eyelid or ptosis experience chronic headache, further studies on the relationship between eyelids and headache are needed.

CONCLUSIONS

The results of the present study showed impaired SVF in the single eyelid in proportion to the reduction of the ERD, and this impairment could be expanded by double-eyelid surgery without skin removal. Single eyelid is a natural feature that many people are born with, and many people with single eyelid are probably unaware of SVF limitations until surgery is actually performed. We believe that presence of the single eyelid in East Asians should not only be viewed as a subjective or cosmetic issue but also be viewed as a variation associated with objective and functional problems.

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