Differences Between Single and Double Eyelid Anatomy in Asians Using Ultrasound Biomicroscopy

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Purpose: The aim of this study was to clarify the differences between single and double eyelid structures quantitatively using an ultrasound biomicroscopy.

Design: A single-center observational study.

Methods: Upper eyelids of Asian volunteers were evaluated with a 50-MHz ultrasound biomicroscopy. The skin–orbicularis oculi complex (SOOC), levator aponeurosis, Mueller muscle–conjunctival complex, and tarsus were imaged at the eyelid crease in the double eyelid group and 7 mm above the eyelid margin in the single eyelid group. The SOOC was also measured 2 mm above the eyelid margin and 5 mm above the eyelid crease.

Results: Forty-two upper eyelids of 42 subjects were studied. Mean SOOC thickness at the eyelid crease was 0.62 ± 0.12 mm in single eyelids and 0.57 ± 0.08 mm in double eyelids ($P = 0.03$). Mean SOOC thickness at 2 mm above the eyelid margin and 5 mm above the crease was not significantly different between single and double eyelids (P = 0.004 and P = 0.62, respectively). The levator aponeurosis, Mueller muscle–conjunctival complex, and tarsus measured 0.38 ± 0.12 mm, 0.86 ± 0.28 mm, and 10.84 ± 1.10 mm in single eyelids and 0.39 ± 0.14 mm, 0.88 ± 0.34 mm, and 10.61 ± 1.36 mm in double eyelids (P = 0.75, P = 0.81, and P = 0.54, respectively).

Conclusions: Single eyelids showed slightly thicker SOOC in the pretarsal area and at the eyelid crease but not 5 mm above the eyelid crease. The levator aponeurosis, Mueller muscle–conjunctival complex, and tarsus showed no differences in thickness.

Key Words: double eyelid, single eyelid, orbicularis oculi, ultrasound biomicroscopy, eyelid crease

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The uniqueness of East and Southeast Asian upper eyelid anatomy has been studied by researchers. The Asian eyelid is broadly categorized into 3 types: single eyelid, low/incomplete eyelid crease, and double eyelid. Double eyelid can then be subcategorized based on eyelid crease morphology. Eyelid crease formation or the differences between single and double eyelid anatomy remain an unsolved question. Many theories on eyelid crease formation have been postulated, but none are scientifically proven. Thicker tissue layers, especially the orbicularis oculi in single eyelid, have been observed anecdotally, and excision of such tissues is recommended during double eyelid procedures by many surgeons.[1,2] However, no study has been performed to quantify these differences in vivo.

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Ultrasound biomicroscopy (UBM) is a high-frequency ultrasound that allows easy, noninvasive visualization of living tissues at microscopic resolution. Even though UBM is designed for in vivo imaging of the anterior segment of the eye, good image correlation with anatomical structure can also be achieved in the eyelid area.[3–5]

The purpose of this study was to utilize UBM in measuring and comparing the thickness of each tissue layer of the upper eyelid between single and double eyelids including the skin–orbicularis oculi complex (SOOC), levator aponeurosis, Mueller muscle–conjunctival complex, and tarsus.

MATERIALS AND METHODS

After institutional review board approval, 42 healthy volunteers underwent UBM evaluation of the upper eyelid at King Chulalongkorn Memorial Hospital. Study subjects were between 20 and 29 years old with no history or clinical evidence of previous eyelid surgery, periocular trauma, or tumor. Subjects with partial or incomplete eyelid crease were excluded from the study.

After informed consent was obtained, eyelid examinations were performed and digital photographs were taken. Subject characteristic data collected included age, sex, visual acuity, type of eyelid, eyelid crease height, marginal reflex distance 1 (MRD1), MRD2, and levator function. The MRD1 measurements were performed with gentle upper eyelid skin lift. The eyelid was imaged with UBM (Aviso; Quantel Medical, France) using a 50-MHz contact probe in B scan mode by a single operator (P.T.). The scanner produced a 4 × 4-mm field with 512 image lines at a scan rate of 5 frames per second. The UBM probe was placed perpendicular to the area of interest with a vertical midpupillary line as a reference point. The image showing the SOOC, levator aponeurosis, Mueller muscle–conjunctival complex, and tarsal height and thickness was used for analysis (Figs. 1, 2). The SOOC and Mueller muscle–conjunctival complex appeared as echo-dense structures with highly reflective properties. The levator aponeurosis appeared as hypoechoic structures. Both SOOC and Mueller muscle–conjunctival complex were evaluated as a single unit because it was not possible to distinguish the different layers on UBM. The thickness of each layer was measured at the eyelid crease level in the double eyelid group and at 7 mm above the eyelid margin in the single eyelid group. The SOOC was also measured at 2 mm above the eyelid margin to represent pretarsal orbicularis oculi and 5 mm above the eyelid crease to represent preseptal orbicularis oculi. The levator aponeurosis and the Mueller muscle–conjunctival complex were measured just above the upper tarsal border.

One upper eyelid from each subject was randomly selected for analysis. Differences in all parameter measurements between single and double eyelids were recorded as mean ± SD. Significance of the differences between group means were determined by using the descriptive statistic unpaired *t* test. All statistical tests were 2-tailed, and statistical significance was defined as $P < 0.05$.

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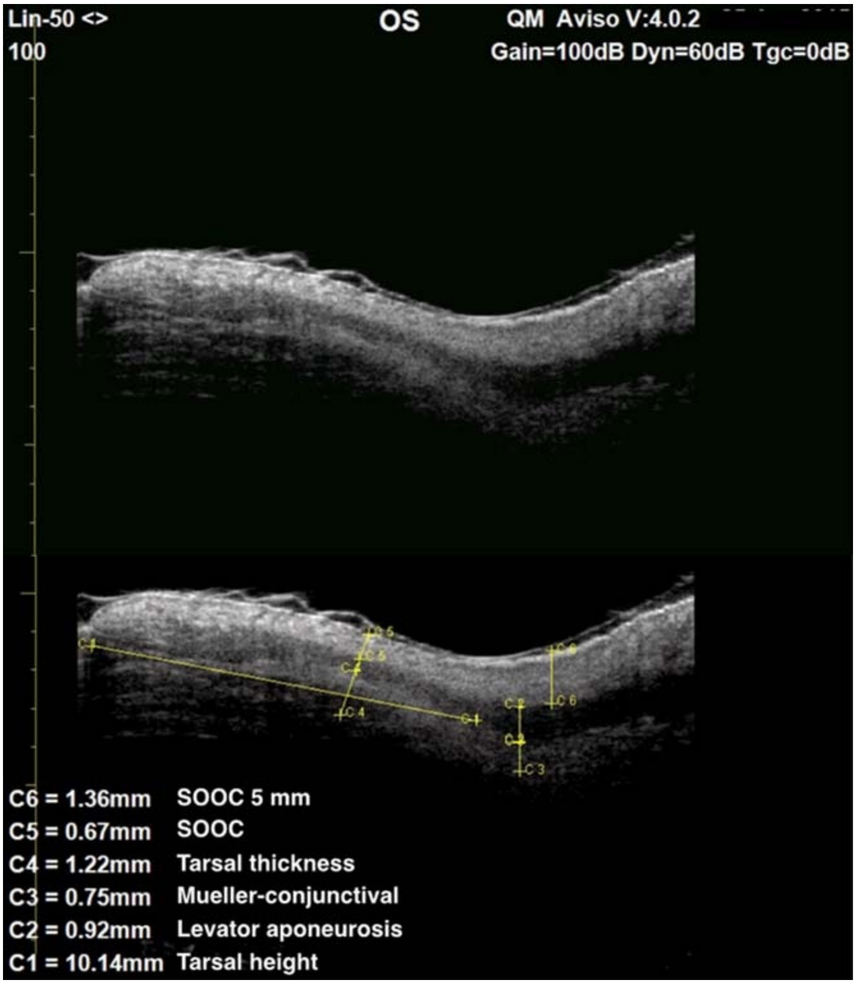

FIGURE 1. Ultrasound biomicroscopy image of a subject with a single eyelid. The SOOC and the tarsal thickness were measured at the reference point, 7 mm above the eyelid margin. The SOOC was also measured at 2 mm above the eyelid margin (not shown) and 5 mm above the main reference point. The levator aponeurosis and the Mueller muscle–conjunctival complex were measured just above the upper tarsal border.

All statistical analysis was carried out using SPSS for Windows version 17.0.

RESULTS

Forty-two eyelids of 42 subjects were studied. Of those, 18 were male and 24 were female with an average age of 23 years. Subject baseline characteristics are summarized in Table 1. The mean MRD1 in the single eyelid group was significantly lower than in the double eyelid group (3.04 ± 0.99 mm and 3.64 ± 0.96 mm, respectively; $P = 0.006$). The mean levator function in the single eyelid group was less than in the double eyelid group (11.50 ± 1.68 mm and 14.00 ± 1.62 mm, respectively; $P < 0.0001$).

The UBM parameters are summarized in Table 2. The mean SOOC thickness at the eyelid crease was 0.62 ± 0.12 mm in the single eyelid group and 0.57 ± 0.08 mm in the double eyelid group. The single eyelid group showed a significantly thicker SOOC than the double eyelid group at the eyelid crease level ($P = 0.03$). The mean SOOC thickness at 2 mm above the eyelid margin in the single eyelid group was also thicker than in the double eyelid group (0.69 ± 0.18 mm and 0.60 ± 0.12 mm, respectively; $P = 0.004$). The mean SOOC thickness at 5 mm

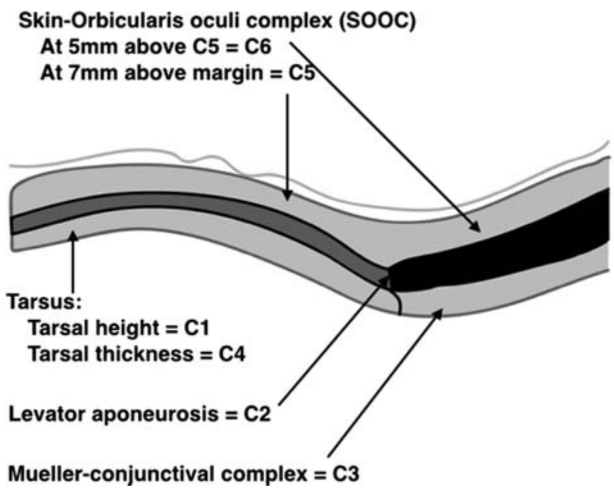

FIGURE 2. Schematic drawing of Figure 1, the UBM image of a subject with a single eyelid.

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TABLE 1. Demographic Data and Baseline Characteristics

	Single Eyelid	Double Eyelid	P
Age	24	18	0.93
Sex, male/female	10/14	8/10	0.69
Lid crease height, mm	None	7.22	
Levator function, mm	11.50 ± 1.68	14.00 ± 1.62	<0.0001
MRD1, mm	3.04 ± 0.99	3.64 ± 0.96	0.006
MRD2, mm	5.02 ± 0.51	5.22 ± 0.70	0.12

above the eyelid crease was not different between the single and double eyelid groups (0.71 ± 0.17 mm and 0.73 ± 0.21 mm, respectively; $P = 0.62$).

DISCUSSION

The prevalence of single eyelids in East and Southeast Asians varies from 50% to 90% by country and region. Culturally and aesthetically, those with single eyelids may be perceived as dull, lacking passion, and less attractive.[6] Therefore, the double eyelid procedure or upper blepharoplasty with eyelid crease fixation is the most common cosmetic procedure in Asia. Understanding eyelid crease formation and differences between single and double eyelids is crucial to creating a natural-looking double eyelid.[7] Many theories on eyelid crease formation have been postulated, and the levator expansion theory by Sayoc[8] is among the most popular: the posterior levator aponeurosis penetrating the orbital septum and orbicularis oculi muscle give rise to the dermal extension fiber creating an eyelid crease. However, a recent histological study in Japanese cadavers by Kakizaki et al[9] revealed levator extension in both single and double eyelids, finding only thinner orbicularis oculi and thinner skin at the eyelid crease in the double eyelid group as major causative factors.

Ultrasound biomicroscopy is an in vivo diagnostic tool for anterior segment imaging. It provides a resolution of 20 to 60 μm with a depth of penetration of up to 4 mm. In eyelid evaluation, UBM images correlated with anatomic structures both quantitatively and qualitatively. Using UBM imaging features, Kikkawa et al[3] analyzed tissue characteristics of patients with eyelid lesions and found a correlation with histopathological results. Ultrasound biomicroscopy has also been used in measuring tissue layers in normal eyelids and in blepharoptosis eyes.[4,5] We performed this study in vivo using UMB to find the difference in tissue layer thickness between single and double eyelids in younger subjects with no ageing change as a confounder.

We found a thicker SOOC in single eyelids both at the eyelid crease level and 2 mm above the eyelid margin. These findings could be due to the thicker pretarsal orbicularis oculi. Many surgeons routinely excise pretarsal orbicularis oculi when performing double eyelid procedures to create a long-lasting eyelid crease and flatter pretarsal platform.[10] Some surgeons have even performed this operation without eyelid crease fixation suture placement, as it is believed that proper tissue thinning and scar formation are adequate for eyelid crease formation.[11] Even though we found a statistically significantly thicker pretarsal orbicularis oculi in single eyelids, there is still doubt in terms of the clinical significance of a less than 0.1 mm difference in mean thickness. The cause of eyelid crease formation should not be solely attributed to the difference in SOOC thickness, and current evidence suggests multiple factors are responsible.[7] On the other hand, the mean thickness of 0.62 ± 0.12 mm in single eyelids and 0.57 ± 0.08 mm in double eyelids should raise awareness for surgeons to not excessively remove the muscle but meticulously trim off an amount just enough to create a more permanent eyelid crease. There was no difference in preseptal orbicularis oculi thickness when comparing single and double eyelids. The preseptal part should only be excised in conjunction with skin removal when performing upper blepharoplasty, but no further than the skin incision line.

Tarsal height in single and double eyelids was not different. Previous studies showed a shorter average tarsal height in Asians compared with whites.[12] Microscopically, the average upper tarsal height was 11.3 ± 1.7 mm and 9.2 ± 0.8 mm in whites and Asians, respectively. Our findings of 10.84 ± 1.10 mm in single eyelids and 10.61 ± 1.36 mm in double eyelids are comparable with the previous published average Asian tarsal height. Tarsal height in Asians might be shorter, but we may not be able to conclude that it plays a role in eyelid crease formation or eyelid crease level. Tarsal thickness was also measured but was not statistically different when comparing between single and double eyelids.

We also found no difference in levator aponeurosis and Mueller muscle–conjunctival complex thickness. These tissue layers showed no histological difference in terms of size, length, shape, and thickness when comparing between Asians and whites.[13] However, when compared with double eyelids, single eyelids showed lesser MRD1 and levator function. A similar finding was also reported when comparing Asians and whites.[1] We might conclude that the muscles of eyelid elevation themselves are not responsible for the MRD1, but the surrounding soft tissue layers are. Either descended preaponeurotic fat or the existence of the lower-positioned transverse ligament in single eyelids might weaken the levator force and altogether result in no crease with smaller vertical palpebral fissure.[14,15] It is noteworthy that our levator aponeurosis was thinner and the Mueller muscle–conjunctival complex was thicker than previous UBM reports in normal white subjects because UBM was performed in the primary gaze position as opposed to over closed eyelids in this study.[5]

There are a few study limitations worth mentioning. First, we faced a measurement bias. Even though UBM has been used for eyelid evaluation both in normal and diseased subjects, it processes and shows good anatomical correlation. However, UBM itself is designed for anterior segment imaging. This means that the sound speed in the eyelid tissue is different from the preset value, resulting in an absolute value from this study that cannot be real. Second, although there was only 1 observer, intraobservation error could not be avoided in this measurement method. Third, as we excluded partial or incomplete eyelid crease subjects from our study, our results cannot be applied to these particular patient groups. A final limitation is due to the complexity of the eyelid anatomy itself. A difference in SOOC thickness between single and double eyelids was found, but we still believe that

TABLE 2. Thickness of the Tissue Layers in Single and Double Eyelids

	Single	Double	P
SOOC	0.62 ± 0.12	0.57 ± 0.08	0.03
SOOC 2 mm	0.69 ± 0.18	0.60 ± 0.12	0.004
SOOC 5 mm	0.71 ± 0.17	0.73 ± 0.21	0.62
Levator aponeurosis	0.38 ± 0.12	0.39 ± 0.14	0.75
Mueller muscle–conjunctival complex	0.86 ± 0.28	0.88 ± 0.34	0.81
Tarsal height	10.84 ± 1.10	10.61 ± 1.36	0.54
Tarsal thickness	0.99 ± 0.24	1.03 ± 0.34	0.64

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multiple factors apart from SOOC thickness are also responsible for eyelid crease formation.[7]

In conclusion, our in vivo study in young healthy volunteers confirms previous published anatomical differences between single and double eyelids in cadavers.[9] The single eyelid shows slightly thicker SOOC both in the pretarsal area and at the eyelid crease but not at 5 mm above the eyelid crease.

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Those who cling to perceptions and views wander the world offending people.
— Guatama Buddha

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