Aesth Plast Surg (2019) 43:1547–1552
https://doi.org/10.1007/s00266-019-01478-3

ORIGINAL ARTICLE FACIAL SURGERY

Difference in Midface Rejuvenation Strategy Between East Asians and Caucasians Based on Analysis of Age-related Changes in the Orbit and Midcheek Using Computed Tomography

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Received: 25 April 2019 / Accepted: 3 August 2019 / Published online: 29 August 2019

Abstract

Background The differences between Caucasian and East Asian faces could lead to different age-related bony changes. We analyzed computed tomography (CT) scan images of East Asians to find objective differences in midface rejuvenation strategy between East Asians and Caucasians.

Methods We reviewed 54 East Asian individuals' charts and facial CT images ranging in age-group: Group A (21–30 years), Group B (41–50 years), and Group C (61–70 years). No patients had congenital or acquired facial deformity and history of facial trauma. The antero-posterior length of the orbital roof and floor (LOR, LOF) and the angle of the anterior wall of the maxilla were recorded on parasagittal images through the midline of the orbit.

Results The LORs at their midpoints showed significant differences between Groups A and B ($p < 0.01$). The LOFs were also significantly different between Groups A and B ($p < 0.001$). The difference in the angle between the anterior maxillary wall and the orbital floor was not significant between Groups A and B. The lengths between Groups B and C showed no significant differences.

Conclusion Our study demonstrated that the aging process in East Asians differs considerably from that in Caucasians, with characteristic significant changes in LOF and LOR. Since the aging process is different, the strategies to cope with aging should also differ. Volume restoration of the inferior orbital rim in the midface is one of the most important rejuvenation methods in East Asians.

Level of Evidence V This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Midface rejuvenation strategy · Age-related changes · East asians · Caucasians · Computed tomography

Introduction

In the field of plastic surgery, there has been continuing interest in facial aging. Since skin aging was discussed by Gonzales-Ulloa et al. [1] in 1965, numerous studies have covered aging of not only the skin and soft tissues, but also the facial skeleton. Several researchers, including Lambros [2], Pessa [3], Bartlett et al. [4], and Yaremchuk [5], have clearly demonstrated that the bones of the face, like other bones in our bodies, show a loss of volume with aging. In particular, changes in the inferior orbital rim and anterior maxilla, which provide a crucial foundation, have been found to result in changes to the overlying soft tissue, ultimately acting as a key vector causing facial aging.

The bones of the face are broadly divided into the maxilla and mandible, and while there has been active research on both parts of the face, most of the data are restricted to Caucasians. Thus, there is a lack of understanding about facial aging in East Asians [2–4]. Caucasians and East Asians show different cranial shapes (dolichocephaly and mesocephaly, respectively) and

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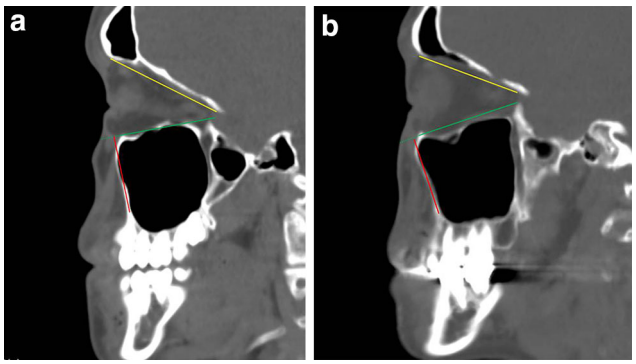

Fig. 1 Measurements of the superior (yellow line) and inferior orbital lengths (green line) and the maxilla angle between the extension of the orbital floor (green dots line) and the anterior wall of the maxilla (red line). **a** A 24-year-old man from Group A. The measured values on facial CT were LOR: 49.12 mm, LOF: 53.43 mm, and MA: 90.42°. **b** A 45-year-old man from Group B. The measured values on facial CT were LOR: 46.41 mm, LOF: 48.62 mm, and MA: 89.44°. These measurements were slightly different from the average of our data; however, they were within the standard deviation, showing that there is a significant difference between LOR and LOF. *LOR* length of orbital roof, *LOF* length of orbital floor, *MA* maxilla angle

Table 1 Differences between Groups A (21–30 years) and B (41–50 years) in LOR, LOF, and MA

Age	Mean ± SD	*T*	*p* value
LOR (cm)			
21–30	48.09 ± 2.50	3.10**	0.004
41–50	45.48 ± 2.53		
LOF (cm)			
21–30	52.40 ± 3.55	3.99***	0.000
41–50	48.58 ± 1.93		
MA (°)			
21–30	91.94 ± 4.94	0.6	0.552
41–50	91.17 ± 2.29		

Data represented as mean ± SD

SD standard deviation, *LOR* length of orbital roof, *LOF* length of orbital floor, *MA* maxilla angle

$^{**}p < 0.01$, $^{***}p < 0.001$

differences in skull base growth leading to differences in midface and mandible growth. With this evidence, we surmised that aging of East Asians would also differ from Caucasians and hypothesized that ethnic differences in aging between Caucasians and East Asians could be demonstrated by analyzing East Asians using the same methods as previous studies of Caucasian data and identifying discrepancies.

Of the many studies that have been conducted, the study of orbit and midcheek aging by Mendelson et al. [6] is methodologically clear and simple and was well suited to our intentions. Therefore, we used sagittal reconstruction

Table 2 Differences between Groups B (41–50 years) and C (61–70 years) in LOR, LOF, and MA

Age	Mean ± SD	*T*	*p* value
LOR (cm)			
41–50	45.48 ± 2.53	1.805**	0.08
61–70	44.10 ± 2.11		
LOF (cm)			
41–50	48.58 ± 1.93	1.256***	0.217
61–70	47.72 ± 2.24		
MA (°)			
41–50	91.17 ± 2.29	− 0.512	0.612
61–70	92.27 ± 8.84		

Data represented as mean ± SD

SD standard deviation, *LOR* length of orbital roof, *LOF* length of orbital floor, *MA* maxilla angle

$^{**}p < 0.01$, $^{***}p < 0.001$

of facial computed tomography (CT) by the same method as Mendelson et al. to compare the length of the orbital floor with the length of the orbital roof at different ages and to measure the angles of the maxilla.

Materials and Methods

We studied 54 East Asian participants who had undergone facial CT at Inje University Busan Paik Hospital between January 2008 and February 2009. There were 18 participants in Group A aged 21–30 years (nine men, nine women), 18 patients in Group B aged 41–50 years (nine men, nine women), and 18 patients in Group C aged 61–70 years (nine men, nine women). The patients did not have any facial malformation, congenital anomaly, facial trauma, or other facial diseases. The CT device was a Toshiba Aquilion and the image viewer was a Maro-View.

We fundamentally used the same experimental method as Mendelson et al. [6], which can be summarized as follows. We measured the length of the orbital roof (LOR), length of the orbital floor (LOF), and the maxillary angle (MA) from two-dimensional sagittal reconstructions. The sagittal images were reconstructed from existing data through the midaxis of each right orbit based on the optic nerve. The LOR was measured as the distance from the apex of the superior orbital rim to the optic nerve root. The LOF was measured as the distance from the apex of the inferior orbital rim to the optic nerve root. The MA formed between the anterior wall of the maxilla and the orbital floor. An independent t test was performed using the different datasets for statistical analysis. For empirical analysis in this study, we tested at significance levels of

Table 3 Summary statistics of our data and Mendelson's data

	Mendelson et al. (mean ± SD)	This study (mean ± SD)
LOR (cm)		
21–30 years	5.32 ± 0.44	4.81 ± 0.25
41–50 years	5.16 ± 0.43	4.54 ± 0.25
61–70 years	5.40 ± 0.40	4.41 ± 0.21
LOF (cm)		
21–30 years	5.30 ± 0.50	5.24 ± 0.35
41–50 years	5.16 ± 0.41	4.86 ± 0.19
61–70 years	5.37 ± 0.40	4.77 ± 0.12
MA (°)		
21–30 years	90.3 ± 3.1	91.94 ± 4.9
41–50 years	86.8 ± 4.0	91.17 ± 2.3
61–70 years	84.4 ± 3.4	92.17 ± 8.8

SD Standard deviation

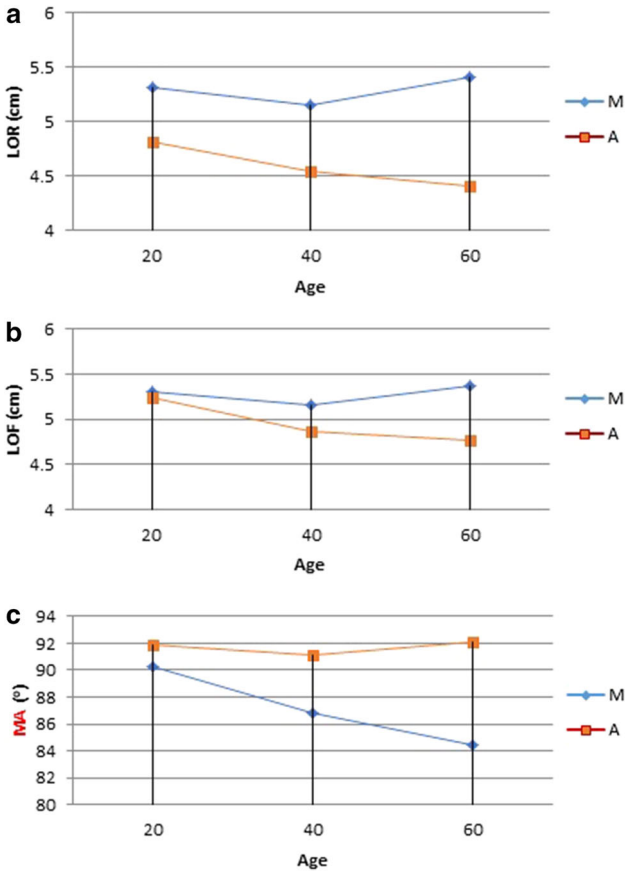

Fig. 2 Graphs of summary statistics. **a** Summary statistics of our data and Mendelson's data in LOR. **b** Summary statistics of our data and Mendelson's data in LOF. **c** Summary statistics of author's data and Mendelson's data in MA. M: Mendelson' data, A: our data

$p < 0.05$, $p < 0.01$, and $p < 0.001$. We used SPSSWIN 12.0 for statistical processing.

Results

There were significant differences between Groups A and B in LOR and LOF. LOR was significantly higher in Group A (48.09 mm) than in Group B (45.48 mm) ($p < 0.01$). LOF was significantly higher in Group A, at 52.40 mm, than in Group B, at 48.58 mm ($p < 0.001$). Meanwhile, MA was similar for Group A, at 91.94°, and Group B, at 91.17° ($p > 0.05$) (Fig. 1).

There were no significant differences between Groups B and C. LOR was higher in Group B, at 45.58 mm, than Group C, at 44.10 mm, but this was not significant ($p < 0.01$). LOF was higher for Group B, at 48.58 mm, than for Group C, at 47.72 mm, but this was not significant difference ($p < 0.001$). MA was 91.17° for Group B and 92.27° for Group C, but not significantly different ($p > 0.05$) (Tables 1 and 2).

We were unable to perform statistical analysis since there were no data on all measurements by Mendelson et al., but overall differences are summarized in the data for East Asians and Caucasians in (Table 3 and Fig. 2). Comparing our data with Mendelson et al.'s data, we showed a relatively continuous decrease in LOF and LOR as aging progressed, especially with significant changes in LORs in the 20s and 40s. However, there was no significant difference in MA. In Mendelson et al.'s data, there was no significant difference in LOR and LOF as aging progressed, but MA showed a significant continuous decrease.

Discussion

There were differences in the measurements of LOR, LOF, and MA between East Asians and Westerners compared to the participants in Mendelson et al.'s study. The most

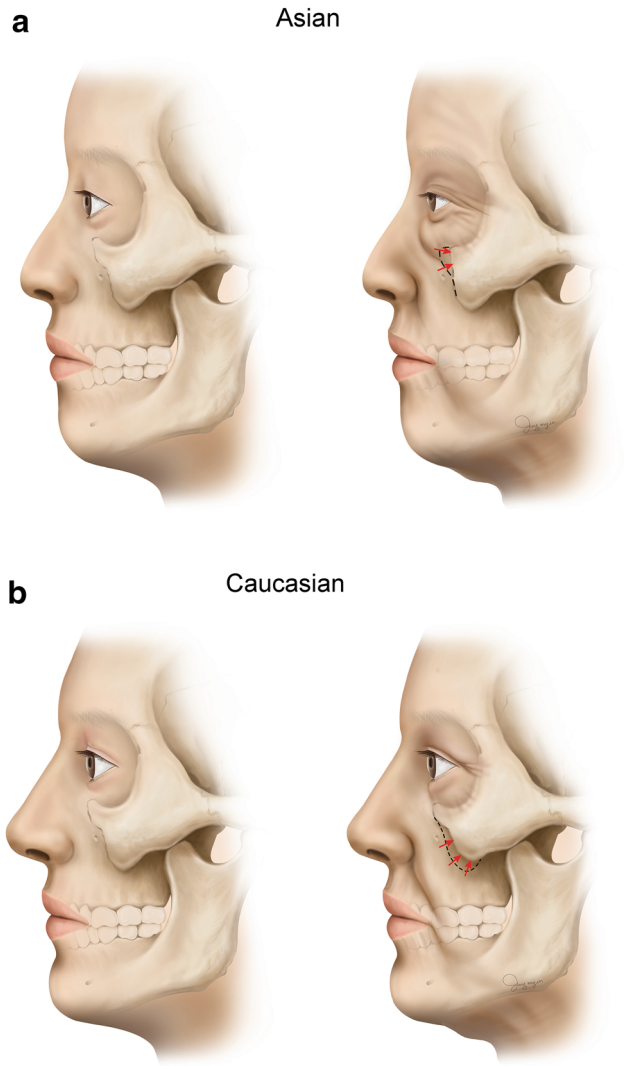

Fig. 3 Changes with age in Asian and Caucasians Faces. **a** In the case of East Asians, the inferior orbital rim retrudes with aging (red arrow). As a result, the laxity of the lower eyelid increases. **b** In the case of Caucasians, the anterior wall of the maxilla retracts with aging (red arrow). As a result, the laxity of the cheek increases

distinctive part of our study was that the changes in LOR and LOF were noticeable at the ages from 20 to 30 years and 40 to 50 years. These findings can considerably help in rejuvenating the midface according to age in the East Asian population.

The most debated part of the midface facial bones with regard to aging is the inferior orbital rim. This is because Bartlett et al. [4] reported that there was no change in the inferior orbital rim, while Pessa [3] reported shortening of the inferior orbital rim and counterclockwise rotation alongside changes in the maxillary anterior wall. Mendelson et al. [6] also analyzed this area using CT data and found that there was no change in the inferior orbital rim. Although we were also interested in this area, research results are limited to Caucasians. Since we considered that these results might be different in East Asians, we reasoned that by performing a study using the same methodology, we could not only examine the data for East Asians, but also explore their differences from Caucasians.

Even if the objective is the same, if the methods are different, the results may also differ. Bartlett et al. [4] measured the actual lengths of bones from cadavers stored at the Smithsonian Museum and described them all as European. Pessa [3] took measurements from 12 men using three-dimensional (3D) stereolithography, but only divided them into young and old groups and did not mention ethnicity. Shaw et al. [7] measured the glabellar angle and the MA using 3D CT, like Pessa, and obtained similar results, all from Caucasian individuals. Mendelson et al. [6] divided participants into three age-groups and took measurements using two-dimensional (2D) CT. Bartlett et al. [4] measured the bones from cadavers after the moisture and several elements had already been removed and the relations with soft tissue had been excluded; thus, this method was incompatible with our in vivo study model. The methods of Pessa [3] and Shaw et al. [7] have the drawback that it is impossible to exclude the possibility of error, and although the angles were measured, there were no measurements of length; therefore, we used the 2D method of Mendelson et al. [6]. Their study model is both clear and reproducible, and since it distinguishes between youth, middle age, and old age, it is better suited for observing the aging process.

When we compared our data with other anthropometric data, we observed several differences. First, there was significant bone resorption in the inferior orbital rim during middle and old age, while the MA showed no significant differences between individuals aged 20–30 years and 40–50 years, or between those aged 40–50 years and 60–70 years. In addition, East Asians showed a significant decrease in the LOR, and we deduced that this increases the prevalence of brow ptosis or pseudoptosis, for which forehead lift and forehead augmentation are appropriate treatments.

This is the first datum to objectively demonstrate differences in aging between East Asians and Caucasians, and based on these results, different strategies are required for midface rejuvenation. Among East Asians, the inferior orbital rim is already a negative vector even in many younger individuals, and because aging is associated with further bone resorption in the inferior orbital rim, volume augmentation is essential for rejuvenation of this area, and fat redistribution or fat graft should be performed to fill the amount of bone loss.

Resorption of the anterior wall of the maxilla occurs relatively late, and so there is little change in the MA. While there are clinically significant changes in the lower eyelid, malar fat and jowl drooping are infrequent. For

Table 4 Differences in upper and midface anti-aging strategy for East Asians and Caucasians

	East Asians	Caucasians
Group I		
Bony change	Congenitally short LOF and LOR	Relatively long LOF and LOR
Treatment	1. For short LOR, forehead lift for brow ptosis/fat graft or forehead implant for volume of forehead	LOF Tx
	2. For short LOF (negative vector)	– In positive vector cases: Septal reset/TCF removal
	TCFR/fat graft on arcus marginalis/implant on arcus marginalis	– In negative vector cases: TCFR
Groups II and III		
Bony change	1. Shortened LOF and LOR	1. No change in LOR and LOF
	2. Relatively less change in MA	2. Significant change in MA
Treatment	1. For shortened LOR, forehead lift and fat graft	Malar fat lifting or fat graft on malar and ant. Maxillary wall
	2. For shortened LOF, TCFR/fat graft on arcus marginalis/implant	

LOR Length of roof, *LOF* length of floor, *MA* maxillary angle, *TCFR* transconjunctival fat redistribution

Caucasians, resorption of the anterior wall of the maxilla proceeds at a faster rate during aging, meaning that downward movement of the malar fat occurs readily, and this can cause changes in the cheek and jowl. On the other hand, since there is little change in the inferior orbital rim, compared to Asians, there is less need for volume augmentation of the inferior orbital rim, and rejuvenation can be achieved with relatively simple procedures, such as fat removal or septal reset (Fig. 3). In addition, our results show that changes in the facial skeleton of Asians differ depending on age, and this datum can be used to identify the rejuvenation strategies required for different ethnicities and age-groups.

At 20–39 years, compared to Caucasians, some East Asians may already show a shorter LOF and protrusion of the eyes leading to baggy eyelids. This is considered congenital, rather than the result of aging; therefore, early transconjunctival fat distribution surgery can be performed to prevent later discoloration. In 40–59-year-olds, previously absent baggy eyelids may develop due to aging, and lower eyelid skin excision with fat redistribution can be performed. Since there is not yet any significant change in the MA, which supports the malar fat, rejuvenation can be achieved by volume restoration, such as fat graft. The upper face shows significant bone loss; thus, forehead fat graft or endoscopic forehead lift can be performed if indicated. At 60–79 years, volume restoration is required in the midface, but since aging also occurs in the lower and upper face, to achieve a natural outcome, upper face-lifting needs to be accompanied by treatment to improve symptoms of aging in the lateral midface and lower face (bone and soft tissue resorption and drooping). However, 60–79-year-olds also show little change in the MA in the midface; thus, in patients showing less advanced aging, isolated neck lift and fat graft can be considered (Table 4). We applied our midface anti-aging strategy clinically and achieved good results (Fig. 4).

Our study had some limitations. First, since aging was examined by prospective observation on different patients, individual differences were not reflected in the study results, and, as mentioned in the paper by Mendelson et al. [6], long-term follow-up observation for the same patient is the best way to measure and analyze aging-related changes in the face. However, it is not easy to accomplish tracking the same patient for more than 40 years. Therefore, it was thought that the most effective method for the present study was to derive the results using the same experimental method as used by Mendelson et al. Second, as only one point was measured on the midaxis of orbit, aging of the individual bones constituting the maxilla could not be examined separately. However, the study was benefitted by the fact that, among East Asians, we only included Korean subjects, and since Koreans originate from a single ethnic group, there were relatively few individual differences in appearance.

Conclusion

Our results are quite different from those of Mendelson et al. [6]. In our results, bony aging was significantly advanced in East Asians aged 41–50 years, but there was little change at 61–70 years. Clinically, at 41–50 years, volume restoration can be performed using fat or a biocompatible prosthesis to account for the amount of bone loss. After the age of 60 years, if the patient underwent volume restoration in their 40s, lifting the skin and submuscular aponeurotic system face-lift can be beneficial.

Fig. 4 Cases with rejuvenation using anti-aging strategy for East Asians. **a** F/28, preoperative photograph and postoperative photograph (POD 6 m). Preoperative photograph shows the congenitally short LOF and LOR, characteristic of Asians in their 20s. To rejuvenate for this, endoscopic forehead lift and transconjunctival fat redistribution were implemented. **b** F/25, preoperative photograph and postoperative photograph (POD 6 m). Preoperative photograph shows the congenitally short LOF and LOR. To rejuvenate for this, fat injection (forehead, lower eyelid, cheek) and transconjunctival fat redistribution and upper blepharoplasty were implemented. **c** F/46, preoperative photograph and postoperative photograph (POD 6 m). Shortened LOR and LOF were further noticed, increasing the laxity of the upper and lower eyelids with slight ptosis. Due to the relatively less change in maxillary angle, the change in midcheek was not noticeable. To rejuvenate this, upper blepharoplasty, lower blepharoplasty were implemented

Our result can explain ethnic differences in bony aging. In particular, although lower blepharoplasty is a commonly performed procedure, there are several techniques that leave much room for choice. However, based on our data, we recommend the fat redistribution method, fat injection, and insertion of implant over the arcus marginalis area to increase volume in patients aged 20 years and above.

Acknowledgements This work was supported by 2019 inje University Busan paik hospital research grant.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed during this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study, informed consent is not required.

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