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The golden proportion in facial soft-tissues of Vietnamese females

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SUMMARY

Objective of the current study was to evaluate proportions of frontal facial soft-tissues of Vietnamese females correspond to the golden proportion (GP).

Material and Methods. Sixty frontal facial photographs of Vietnamese female students aged 19 years were selected. The selected participants had symmetrical face, a Class I relationship occlusion, complete lip closure, and no history of trauma and orthodontic treatment. The photographic record was set-up with a white backdrop, fill light, a reflector, a camera Canon 650D and subjects were asked to sit in a standard position. Trichion (TR), Temporal soft tissue (TS), Lateral canthus (LC), Lateral nasal (LN), Chilion (CH), and Menton (ME) point were used for photometric measurements on CorelDRAW Graphic X3 software.

Results. The vertical facial proportions (mean, percentage compared with GP) were significantly higher than the GP including: LC-CH:CH-ME (1.661, 102%), LN-ME:LC-LN(1.729, 106%), TR-ME:LC-ME (1.739, 107%), TR-LN:LN-ME(1.759, 108%). Whereas TR-ME:LN-ME; CH-ME:LN-CH; LC-LN:LN-CH had ratios of 84% – 92% and were significantly smaller in comparison with GP. The horizontal facial proportions of CHR-L:LNR-L, LCR-L:CHR-L and TSR-L:LCR-L deviated from the GP with mean values of 1.221, 1.922 and 1.229, respectively. The new mean values of TR-ME:LC-ME (1.733), TR-LN:LN-ME (1.732), LC-ME:TR-LC (1.374), CH-ME:LN-CH (1.524), which were predictable changes in proportions, can be significantly converged to the GP if LC-CH:CH-ME is equal to the GP.

Conclusions. Soft-tissue facial proportions of Vietnamese females did not correspond to the GP. Changing the lower third face may create harmony vertical facial proportions.

Key words: aesthetic, golden proportion, facial, photograph.

INTRODUCTION

In term of Mathematics, the ratio of two quantities which is the same as the ratio of their sum to the larger of the two quantities, is always the constant Phi number (φ=1.618). It is called the golden proportion (GP) was discovered by the mathematician Euclid. The GP has been observed and applied in fields such as architecture, design, and natural sciences (1, 2).

As the first finding of Rickett's study (3) about the association between the ratios of facial tissue and the GP in orthodontics, many investigations have been reported in application of the GP for detailed analyses of facial features. For example, the GP was not found to exist between perceived maxillary anterior teeth widths with aesthetic smile (4) while Condon et al (5) showed that the GP could be applied to the ratio of lateral incisor and central incisor widths. Moreover, Ferring and Pancherz (6) used the GP as an index number for evaluation of the growing face in their longitudinal studies.

The assessment of facial attractiveness has still been under discussion. Bashour (7) claimed that the most important determinants of facial attractiveness were averageness, sexual dimorphism, youthfulness, and symmetry; whereas, aesthetic face was determined based on the analysis of soft-tissue profiles (8,9). While in another studies, the role of the posed smile in overall facial aesthetics was considered (10,11) .

Regarding the special attractiveness of the face, several authors used the GP tool to measure and analyse facial features in their countries such as Brazil (12), Japan (13), and India (14). Some of these studies found the GP in the ratio of the distance between the

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Trichion-Menton and Lateral canthus-Menton. On the other hand, the establishment of average values of facial soft tissue measurement plays an important role to set up the plan for orthodontic diagnosis and treatment.

Since the GP was considered as an important factor for facial aesthetics, no data was available for evaluation frontal facial proportions among Vietnamese females. Therefore, the aim of present study was to evaluate frontal facial soft-tissue proportions of Vietnamese females correspond to the GP.

MATERIALS AND METHODS

Sample of study

A total of 60 frontal facial photographs of volunteer participants, who were Vietnamese female students aged 19 years, were selected for this study. The main objective in selecting was that they came from different regions and might present for a sample of Vietnamese female population. This study had been approved by the Human Research Ethics Committee of the Danang University of Medical Technology & Pharmacy, Protocol No. 524/CN/DHKTYDDN.

The selected participants who satisfied the requirements of symmetrical face, a Class I relationship occlusion, normal overbite and overjet, complete lip closure, no previous orthodontic treatment or plastic surgery, and non-traumatic face were asked to have dental examination before the snapshots.

The facial measurements on photographs were performed by the first author. Twenty photographs would be randomly selected after one week to evaluate the reliability according to Dahlberg's formula $ME=\sqrt{d^2/2n}$, where *d* is the difference between duplicated measurements and n as the number of replications.

Photographic records

The photographic set-up consisted of as follows:

- Backdrop was a white screen with a ruler to provide referential distance on the photograph.
- The fill light was placed close to the camera and in eyes level of the subjects while the reflector was used to bounce backlight and reduce shadow from the fill light into the shaded side of the subject's face.
- Camera Canon (EOS 650D, Japan) and lens (EF-S 18-135 mm f/3.5-5.6 IS STM, Japan) were used.

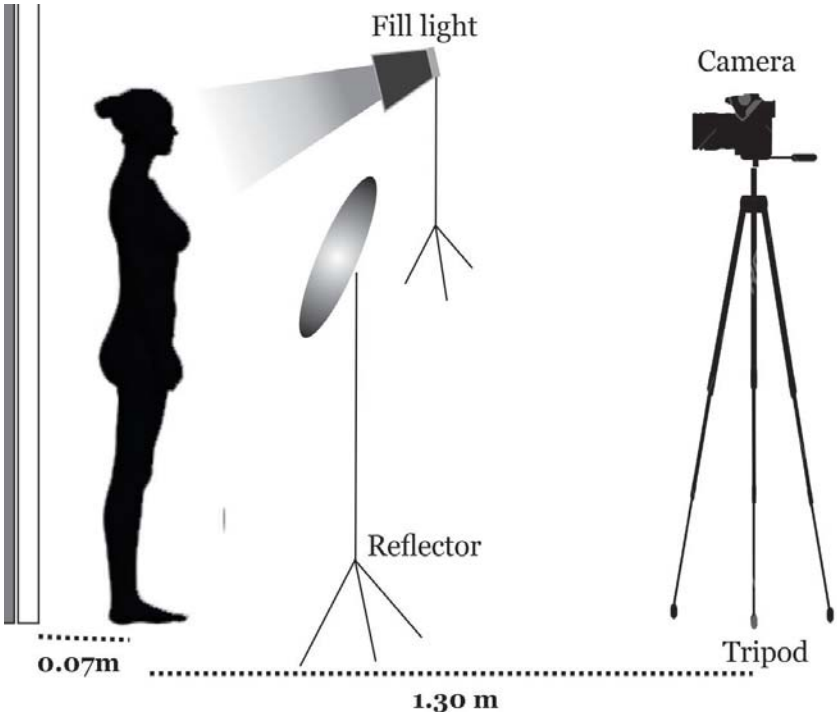

Fig. 1. Method for taking a frontal photo of the subjects

In human optic system, the ratio of the eye's focal length to the diameter of the entrance pupil (f-number of the human eye) varies from about f/8.3 in brightly lit conditions, to about f/2.1 in dark conditions and the maximal physical aperture of the pupil can be as large as 6 mm wide open (15). Therefore, the maximal focal length of the human eye, which is estimated approximately 50 mm (Focal length = f-number × Diameter), will be equivalent with a 110 mm focal length of full frame camera (35 mm format film, 50 mm sensor).

However, Canon EOS 650D was only designed with 31.3 mm Advanced Photo System type-C (APS-C) crop sensor; in this case; lens focal length of Canon 650D in the present study was adjusted to use at 70 mm focal length (≈31.3/50×110 mm) to avoid distortion and kept the angle of view as human optic system.

The camera was set manually to a shutter speed of 1/200 per second and the aperture of f/5.6 at 70 mm focal length. The real frame picture of subject's face was estimated 40 cm; therefore, the distance 1.3m between subject and camera was calculated, and 0.07 m for subject and backdrop. The frame of the camera had to parallel inter-pupillary line and the centre of the frame had to be focused on the nose tip of the subject.

Tripod (Benro, USA) was used to hold the camera in a precise position and correct camera in relation to a subject's body height.

The subjects were taken a photograph in standard position with their heads in a natural position, eyes looking straight into the camera lens, teeth and jaws were held in a resting position (with lips relaxed but in

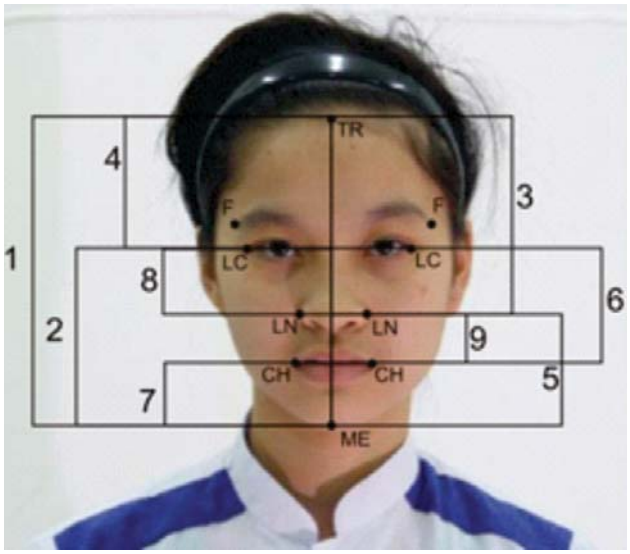

Fig. 2. Distance between landmarks of vertical face: 1) TR-ME; 2) LC-ME; 3) TR-LN; 4) TR-LC; 5) LN-ME; 6) LC-CH; 7) CH-ME; 8) LC-LN; 9) LN-CH. The vertical facial proportions were including: ϕ1 TR-ME:TR-LC; ϕ2 TR-ME:LN-ME; ϕ3 TR-ME:LC-CH, ϕ4 TR-ME:LC-ME; ϕ5 LC-ME:TR-LC; ϕ6 TR-LN:LN-ME, ϕ7 LN-ME:LC-LN; ϕ8 LC-CH:CH-ME; ϕ9 CH-ME:LN-CH; ϕ10 LC-LN:LN-CH.

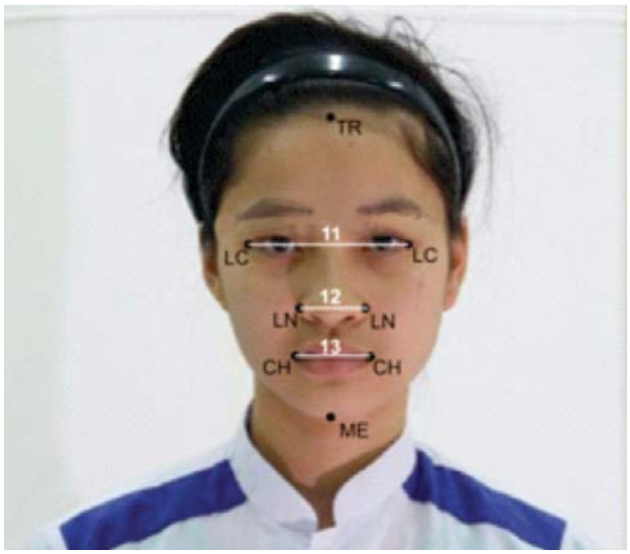

Fig. 3. Distance between landmarks of vertical face: 10) TSR-TSL; 11) LCR-LCL; 12) LNR-LNL; 13) CHR-CHL. The horizontal facial proportions were including: ϕ11 CHR-L:LNR-L, ϕ12 LCR-L:CHR-L, ϕ13 TSR-L:LCR-L.

contact), and ears exposed. In order to view all points of reference for the facial analysis, each subject wore a hair band to keep their hair off their face and their jewelleries should be removed (Figure 1).

Photometric measurement

Soft tissue landmarks of face were used including:

- **TR** (Trichion): point of the hairline on the forehead midpoint in subject.
- **TS_R** (Temporal soft tissue right): point of the right temporal soft tissue above the ear at the level of supraorbital ridge (eyebrow).
- **TS_L** (Temporal soft tissue left): point of the left temporal soft tissue above the ear at the level of supraorbital ridge (eyebrow).
- **LC_R** (Lateral canthus right): point located at the left corner of the right eye;
- **LC_L** (Lateral canthus left): point located at the right corner of the left eye;
- **LN_R** (Lateral nasal right): point located at the external portion of the right wing of the nose;
- **LN_L** (Lateral nasal left): point located at the external portion of the left wing of the nose;
- **CH_R** (Chilion right): point located in the outermost portion of the labial commissure, at the right angle of the mouth;
- **CH_L** (Chilion left): point located in the outermost portion of the labial commissure, at the left angle of the mouth;
- **ME** (Menton): the lowest and the most inferior point on the soft tissue of chin.

In the computer program used, all points for the vertical frontal facial analysis were orthogonally projected over the true vertical line and measurements of the face taken using point to point distances.

Vertical facial proportions were analysed including (Figure 2):

- ϕ1 Trichion – Menton / Trichion – Lateral canthus (TR-ME:TR-LC).
- ϕ2 Trichion – Menton / Lateral nasal – Menton (TR-ME:LN-ME).
- ϕ3 Trichion – Menton / Lateral canthus – Chilion (TR-ME:LC-CH).
- ϕ4 Trichion – Menton / Lateral canthus – Menton (TR-ME:LC-ME).
- ϕ5 Lateral canthus – Menton / Trichion – Lateral canthus (LC-ME:TR-LC).
- ϕ6 Trichion – Lateral nasal / Lateral nasal – Menton (TR-LN:LN-ME).
- ϕ7 Lateral nasal – Menton / Lateral canthus – Lateral nasal (LN-ME:LC-LN).
- ϕ8 Lateral canthus – Chilion / Chilion – Menton (LC-CH:CH-ME).
- ϕ9 Chilion – Menton / Lateral nasal - Chilion (CH-ME:LN-CH).
- ϕ10 Lateral canthus – Lateral nasal / Lateral nasal – Chilion (LC-LN:LN-CH).

Horizontal facial proportions were analysed including (Figure 3):

- ϕ11 Chilion right – Chilion left / Lateral nasal right – Lateral nasal left (CH_{R-L}:LN_{R-L}).
- ϕ12 Lateral canthus right–Lateral canthus left / Chilion right–Chilion left (LC_{R-L}:CH_{R-L}).
- ϕ13 Temporal soft tissue right – Temporal

soft tissue left / Lateral canthus right – Lateral canthus left (TS_{R-L}:LC_{R-L}).

Statistical analysis

Photographs were measured by CorelDRAW Graphic X3 software (Corel, Canada). Data entry and statistical analysis were performed on version 17.0 of Statistical Package for Social Sciences (SPSS Inc., Chicago, Illinois, USA). The one-sample t-test was used to test whether value of facial proportions were similar to the GP. The confidence level at 95% and p-value of 0.05 were used for significant difference.

RESULTS

The measurement error ranged from 0.42 mm to 0.75 mm. Percentage according to the GP of vertical facial proportions ranged 84.1% to 172.4%. Among of these values, the highest percentage of proportions, which were found at TR-ME:LC-CH (172.4%), TR-ME:LN-ME (170.5%), and TR-ME:TR-LC (145.8%), were related to the total face height.

In comparison with the GP by using the one sample t-test, the significantly higher values (mean±SD) were observed in proportions of LC-CH:CH-ME (1.661±0.122), LN-ME:LC-LN (1.729±0.206), TR-ME:LC-ME (1.739±0.606), TR-LN:LN-ME (1.759±0.163); whereas, the value of CH-ME:LN-CH (1.484±0.140), LC-LN:LN-CH (1.458±0.204) and LC-ME:TR-LC (1.360±0.113) were significantly lower in comparison with GP.

The mean (%) values of horizontal facial proportion of CH_{R-L}:LN_{R-L}, LC_{R-L}:CH_{R-L} and TS_{R-L}:LC_{R-L} were 1.221 (75.5), 1.922 (118.8) and 1.229 (76.0), respectively. All vertical and horizontal facial proportion values were significantly different from the GP (Table 1).

Table 1 showed proportion of LC-CH:CH-ME (1.661±0.122) was closest with the GP. If LC-CH:CH-ME in the present study is equal to the GP, CH-ME will change length 1.027 (±0.073) times as much as the original therefore Menton point would have been possible to be adjusted. In this case, Table 2 showed result of predictable changes of proportion since LC-CH:CH-ME had been become GP; the new mean value of TR-ME:LC-ME (1.733), TR-LN:LN-ME (1.732) were decreased and LC-ME:TR-LC (1.374), CH-ME:LN-CH (1.524) were significantly increased to converge GP. Whereas, only LN-ME:LC-LN was deviated from GP. The difference between old and new values of proportions were statistically significant ($p<0.001$) (Table 2).

DISCUSSION

Modern dentistry aims to achieve the perfect facial aesthetics. The female facial attractiveness is assigned by visual perception of age, health, skin and appearance (16). The facial appearance can be analysed by

Table 1. Analysis and comparison of facial proportions and with the golden proportion

Facial proportion	N=60	Compared with golden proportion		
	Mean (SD)	%	MD	95% CI
Vertical proportion				
TR-ME: TR-LC	2.360 (0.113)	145.8	0.742*	[0.713, 0.772]
TR-ME:LC-CH	2.791 (0.108)	172.4	1.173*	[1.145, 1.202]
TR-ME:LN-ME	2.759 (0.163)	170.5	1.141*	[1.098, 1.184]
TR-ME:LC-ME	1.739 (0.606)	107.5	0.121*	[0.105, 0.137]
LC-ME:TR-LC	1.360 (0.113)	84.1	-0.257*	[-0.286, -0.227]
TR-LN:LN-ME	1.759 (0.163)	108.7	0.141*	[0.098, 0.185]
LN-ME:LC-LN	1.729 (0.206)	106.9	0.111*	[0.056, 0.165]
LC-CH:CH-ME	1.661 (0.122)	102.7	0.043*	[0.011, 0.076]
CH-ME:LN-CH	1.484 (0.140)	91.7	-0.133*	[-0.170, -0.096]
LC-LN:LN-CH	1.458 (0.204)	90.1	-0.159*	[-0.213, -0.105]
Horizontal proportion				
CH_{R-L}:LN_{R-L}	1.221 (0.083)	75.5	-0.396*	[-0.418, -0.374]
LC_{R-L}:CH_{R-L}	1.922 (0.138)	118.8	0.304*	[0.268, 0.341]
TS_{R-L}:LC_{R-L}	1.229 (0.036)	76.0	-0.388*	[-0.398, -0.378]

Note. MD: mean difference; One-sample t-test with a test value =1.618 (i.e., the golden proportion), *p<0.01.

Table 2. The predictable changes of vertical facial proportions of Vietnamese females matching the Golden proportion after LC-CH:CH-ME was equal to Golden proportion

Vertical facial proportion	Mean		Sign with Golden proportion	p value
	Before	After		
LC-CH:CH-ME [a]	1.661	1.618	0	<0.001
TR-ME:LC-ME	1.739	1.733	+	<0.001
LC-ME:TR-LC	1.360	1.370	+	<0.001
TR-LN:LN-ME	1.759	1.732	+	<0.001
LN-ME:LC-LN	1.729	1.749	–	<0.001
CH-ME:LN-CH	1.484	1.519	+	<0.001

Note: The paired sample t-test, [a]: proportion was assumed equal to the golden proportion. +: converge golden proportion. –: deviate from golden proportion.

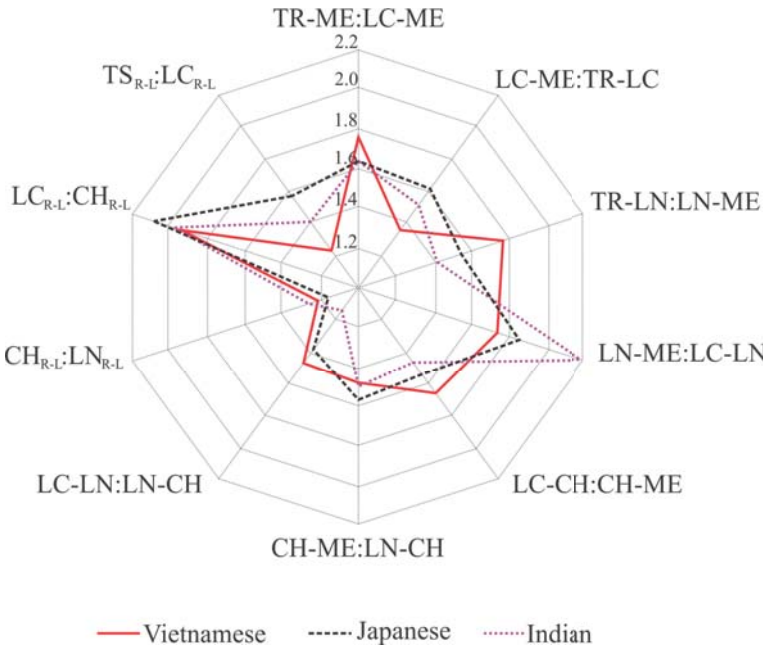

Fig. 4. Comparison of the facial proportions between Vietnamese (present study), Japanese (13) and Indian (14)

anthropometric measurement of soft-tissues. Moreover, female with golden proportion facial features are attractive and tend to be strong, physiologically healthy and fertile (17).

In general, the first facial analysis was performed with regard to the ratio between the upper third face: middle third: lower third face (18). Several studies indexed that this ratio which could be determined by ratio of TR-LC:LC-CH:LN-ME was approximate 1:1:1 (18, 19). However, in the present study, the ratio of TR-LC:LC-CH:LN-ME was 0.9:1:1; this meant the Trichion point had a trend to be closer to the Lateral canthus point in the facial Vietnamese females.

Concerning anthropometric characteristics of facial structures ethnical differences have been described. In the present study, the mean proportion of TR-ME:LC-ME, TR-LN:LN-ME, LC-CH:CH-ME in which Chilion-Menton distance in denominator was the highest; on the contrary, the lowest mean values of LC-ME:TR-LC, LN-ME:LC-LN in which Chilion-Menton distance in numerator were found compared to vertical facial proportion of Japanese (13) and Indian groups (14). It is obvious that the Chilion-Menton distance located in the lower third face of Vietnamese female might be shorter than that of studies in the Japanese and Indians (Figure 4).

Moreover, facial attractiveness was influenced by lower face proportion. Rhee (20) showed that famous female entertainers in Korea owned short lower face. Layperson evaluated that the higher lower facial proportions were the less attractiveness happened (21, 22). While a slightly shorter lower facial profile was favoured with young females (23).

In the finding of the GP for facial proportions of Vietnamese females, the ideal horizontal facial proportion was recognized when the distance LN_{R-L} is estimated 1 unit, the distance CH_{R-L}, LC_{R-L}, TS_{R-L} should have to value 1.618, 2.617 (or 1.618^2), 4.235 (or 1.618^3) respectively (18). In simpler term, the proportions of TS_{R-L}:LC_{R-L}, LC_{R-L}:CH_{R-L}, CH_{R-L}:LN_{R-L} are always equivalent to the value of 1.618. However, in our sample, these horizontal proportions were 1.221, 1.922, 1.211 respectively; this meant that the ratios of LN_{R-L}:CH_{R-L}:LC_{R-L}:TS_{R-L} was 1:1.211:2.346:2.884. The similar ratios in the Japanese sample it was 1:1.183:2.422:3.786 (13) while in the Indian sample it was 1:1.261:2.466:3.448 (14). It was indicated that the GP did not appear in horizontal facial proportion for both groups. Moreover, with the average nose width, the Vietnamese had tendency of narrower eyes and temporal soft tissue width than the Indians and Japanese. However, there were still several limitations, which might be related to the characteristics of the compared samples. In Sunilkumar's study (14), the participants included males and females, while treated orthodontic group was selected for Mizumoto's study (13) and sample of present study was only young females.

Regarding the vertical facial proportion, we found that the ratios of LC-ME:TR-LC, LC-ME:TR-LC, LC-LN:LN-CH were significantly lower and TR-ME:LC-ME, TR-LN:LN-ME, LN-ME:LC-LN, LC-CH:CH-ME were significantly higher than GP. These findings were unexpected for our study.

Actually, the application of the GP had showed unexpected results in several studies. For example, the GP was not a predictor of facial attractiveness and malocclusion (24), or no finding of the GP existed between perceived maxillary anterior teeth widths with an aesthetic smile while Peron (12) and Rossetti (19) claimed that there was no correlation between perception of facial beauty and divine proportion. The GP has an uncertain impact about the context of attractive face analysis of the Caucasian. Therefore, some modified GP were suggested such as silver proportion (25) and "M" proportion (26) for analyses the face.

Based on the observation of treated orthodontic group in Mizumoto's study (13), we discovered that five out of seven vertical facial proportions which related to Menton point were similar to the GP and TR-ME:LC-ME was the closest with the GP, in the similar way, LC-CH:CH-ME was found in our study.

Moreover, some authors also indicated that facial proportions of patients could be changed by orthodontic intervention (27, 28). Therefore, any changes of any points on facial soft tissue are able to influence on proportion alteration.

In this case, for the purpose of finding the GP which could be appeared by orthodontic treatment for Vietnamese females, the present study was certainly assumed that the original value of LC-CH:CH-ME (1.661±0.122) of all participants would be equal to the GP (1.618), then the length of distance CH-ME would be changed 1.027 (±0.073) times as much as the original by the moving position of Menton point. It was worth noticing that the new mean value of TR-ME:LC-ME, TR-LN:LN-ME, LC-ME:TR-LC, CH-ME:LN-CH would be set up and significantly converged to the GP.

Although the GP was not found in facial proportion of Vietnamese females in present study; changing the CH-ME distance might create the harmony between the vertical facial proportions. However, a larger sample and more application points for measurement would be necessary for finding the true GP for Vietnamese population.

CONCLUSIONS

Soft-tissue facial proportions of Vietnamese females did not correspond to the golden proportion. Changing the lower third of the face may create the harmonious vertical facial proportions.

STATEMENT OF CONFLICTS OF INTEREST

The authors state no conflict of interest.

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