



ISSN Print: 2394-7489  
ISSN Online: 2394-7497  
IJADS 2020; 6(1): 161-166  
© 2020 IJADS  
[www.oraljournal.com](http://www.oraljournal.com)  
Received: 10-11-2019  
Accepted: 14-12-2019

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## Evaluation of the golden proportion in facial soft-tissues of class I and II malocclusion patients

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### Abstract

**Aims:** The purpose of this study was to assessment facial soft tissue proportions of class I and II malocclusion patients (18-25) years comparing with the golden proportion using digital photographic images and study the effect of malocclusion on facial aesthetics.

**Materials and methods:** Forty- eight frontal photographic images were performed using a (Canon EOS 600D, Japan) digital imaging camera of patients aged (18-25) years were selected with symmetrical face, no history of trauma, no orthodontic treatment or cleft lip or palate divided in three groups (class I, class II div 1, class II div 2 malocclusion), each group consisted of 16 patients. 6 landmarks, 13 measures, 13 ratios were used for photographic measurements on Micro Dicom Viewer software.

**Results:** This study shows statistically significant differences between the 3 groups in the vertical proportions (TR-LN: LN-ME), (LN-ME:LC-LN) and (LC-LN: LN-CH) ( $P < 0.05$ ), also in the horizontal proportions (CH r-l: LN r-l), (LC r-l:CH r-l)  $P < (0.05)$  between the 3 groups.

Out of the 13 ratios, only 3 of class 1 malocclusion ratios were similar to the golden proportion (TR-ME:LC-ME, LC-ME:TR-LC, CH-ME:LN-CH), whilst two of class ii division 1 ratios were similar (TR-ME:LC-ME, LC-ME: TR-LC) and of 13 ratios in class ii division 2 were similar (TR-ME:LC-ME, LC-ME:TR-LC, TR-LN:LN-ME, LC-CH:CH-ME).

**Conclusion:** Based on this study, we found that it should not be considered every patient with Angle molar class I and a straight profile that is attractive and should be all facial proportions identical to the golden proportion.

Facial proportions of the class I, class II div 1 and class II div 2 were significantly different from the golden proportion, but the vertical proportion in class II div 2 (LC-ME:TR-LC) 1.613 (99.6%) MD (0.005) was the closest to the GP between 3 groups.

**Keywords:** Golden proportion, photography, class II malocclusion, facial soft tissue, aesthetic

### Introduction

The aim of orthodontics treatment is to produce ideal occlusion and therefore achieve facial aesthetics <sup>[1]</sup>, facial aesthetics is a complex issue that must be evaluated during an oral examination. Gugino and Dus emphasized that the anatomical and aesthetic human face is one of the most complex areas of the human body <sup>[11]</sup>. Facial attractiveness has been thought to be based on individual taste, culture, popular trend, and sex difference <sup>[23, 34]</sup>, also many factors, including eyes, hair, skin, lips, teeth, nose, chin and jaws, play an important role in the formation of facial beauty.

Although the face is considered beautiful or not by cultural and ethnic factors, the disproportionate face remains a psychological and social problem and creates aesthetic problems <sup>[5]</sup>.

The attention of orthodontists is often directed towards improving the appearance of their patients and also Researchers turned to study facial aesthetics as a therapeutic goal <sup>[3]</sup>.

Many authors have discovered that faces with aligned teeth were significantly more attractive than those which did not possess this feature <sup>[27]</sup>, whilst some authors didn't find this result in their researches. Angel also relied on the Apollo Belvedere sculpture as a law of facial and physical beauty <sup>[2, 18, 9]</sup>.

A review of the previous literature to find a way to evaluate the dental facial aesthetically has found reliable variables, one of that is Golden ratio. The golden ratio is defined mathematically as the ratio of two quantities which is the same as the ratio of their sum to the larger of the two quantities and is the constant number ( $\Phi = 1.618$ ) <sup>[25]</sup> or this proportion is identified when

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$AB/AC=AC/CB$  which point C divide a straight line AB [24]. Lombardi was the first to introduce the concept of "Golden Ratio" in dentistry, after which Levin discussed the presence of golden ratio in the anterior-posterior teeth. Ricketts RM (1982) analyzed the ratio between different facial components and suggested that the golden divine ratio ( $\Phi=1.618$ ) between the parts of the face [8].

'Phi' became relevant to the aspects of beauty and was a matter of curiosity for artists, mathematicians and philosophers where there is a connection between the Fibonacci sequence - the divine ratio and the beautiful art in nature, such as intersecting spirals in sunflowers or pine cones, butterfly wings, leaves, peacock feather and Snails [33]. Baker and Woods and Shell and Woods stated that there was a little or no relationship between the divine and esthetic proportions [6, 31].

However, as there is great interest in the divine proportion as a measure of facial esthetics in general, there is still a need to evaluate the relationship between facial esthetics and divine proportions [13, 17]. Amoric also showed a golden ratio in many head measurements at different stages of Facial growth. Although some authors have suggested that esthetic appreciation of the face is linked to the skeletal structure of the face using the golden ratio, it remains a controversial topic [8]. This has led to the creation "Golden masks" to evaluate the degree of subjects' facial beauty and all this depends on the golden ratio [19].

The relationship between attractive female faces and the golden proportion has also been studied by Marquardt, who created an "ideal" mask, deriving from fashion models, using the golden ratio [20]. However, this has been found to be an inaccurate and biased method to predict attractiveness [12].

Moreover, studies that assess the extent of the golden ratio in the general population rather than attractive faces only have found that some elevation ratios that resemble the golden proportions; therefore, this ratio may actually be part of the face that appears [4].

Proffit and Fields wrote that the vertical height of the midface, from the supraorbital ridges to the base of the nose, should equal the height of the lower face, and in the lower face, the mouth should be about one third of the way between the base of the nose and the chin [22].

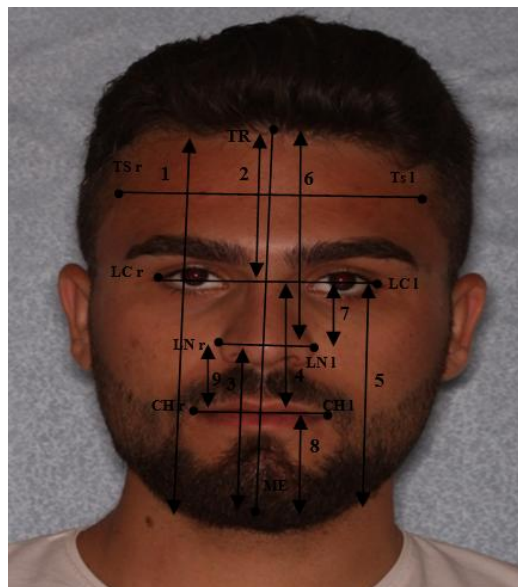
**Materials & methods**

The study sample consisted of 48 patients with the mean age was (20.17) years. They were divided into 3 groups (class I, class II div 1, class II div 2 skeletal malocclusion) according to ANB, U1-SN angles. All had symmetrical face with no history of trauma, no previous orthodontic treatment and no cleft lip or palate each group consisted of 16 patients.

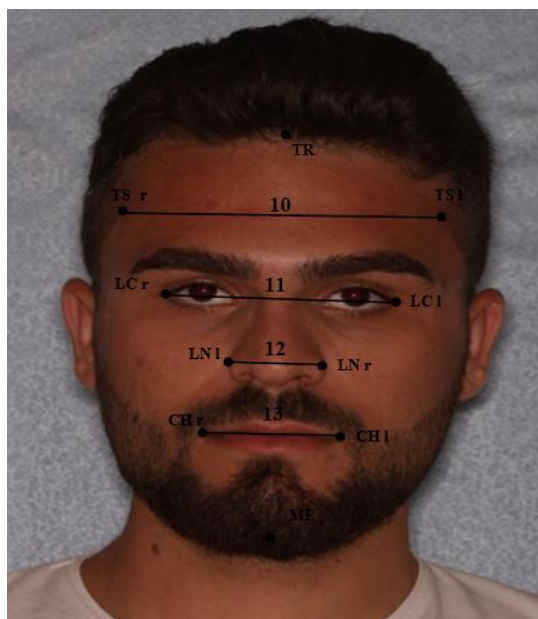
Frontal Photographs were taken with a blue background and the patients in natural head position (NHP), their eyes looking straight into the camera lens and the lips were held in a resting position by using digital imaging camera(Canon EOS 600D, Japan).

Photographs were digitized for analysis in an image processing program (Micro Dicom Viewer) software on a computer (ASUS, X52F, China).

The following landmarks were determined on photo: (TR) The midline point at the junction of the hairline and forehead, (TS) Most lateral borders of the face in the temporal region, (LC) The most lateral point where the superior and inferior eyelids meet, (LN) The most lateral points on the rims of the wings of the nose, (CH) The point located at each lateral oral commissure, i.e. the angle of the mouth, (ME) The most inferior midline point of the soft tissue chin [19]. Fig 1.



**Fig 1:** Landmarks and measurements for facial vertical analysis: 1, TR-ME; 2, TR-LC; 3, LN-ME; 4, LC-CH; 5, LC-ME; 6, TR-LN; 7, LC-LN; 8, CH-ME; 9, LN-CH. The vertical facial proportions were including: 1,TR-ME:TR-LC; 2,TR-ME: LN-ME; 3, TR-ME:LC-CH; 4, TR-ME:LC-ME; 5, LC-ME:TR-LC; 6, TR-LN:LN-ME; 7, LN-ME:LC-LN; 8, LC-CH:CH-ME; 9, CH-ME:LN-CH; 10, LC-LN:LN-CH.



**Fig 2:** Landmarks and measurements for facial width analysis: 10, TS r-l; 11, LC r-l; 12, LN r-l and 13, CH r-l. Three measurements of facial width components: 11. CH r-l: LN r-l, 12. LC r-l: CH r-l, 13. TS r-l: LC r-l.

**Vertical facial proportions were studied including (Fig 1)**

1. Trichion–Menton: Trichion–Lateral canthus TR-ME:TR-LC
2. Trichion–Menton: Lateral nasal–Menton. TR-ME:LN-ME
3. Trichion–Menton: Lateral canthus-Chilion. TR-ME:LC-CH
4. Trichion–Menton: Lateral canthus–Menton TR-ME:LC-Me
5. Lateral canthus–Menton: Trichion–Lateral canthus LC-ME:TR-LC
6. Trichion–Lateral nasal: Lateral nasal-Menton. TR-LN:LN-ME

7. Lateral nasal–Menton: Lateral canthus–Lateral nasal. LN-ME:LC-LN
8. Lateral canthus–Chilion: Chilion- Menton. LC-CH:CH-ME
9. Chilion–Menton: Lateral nasal–Chilion. CH-ME:LN-CH
10. Lateral canthus–Lateral nasal: Lateral nasal–Chilion. LC-LN:LN-CH

**Horizontal facial proportions were studied including (Fig2)**

11. Chilion right-left: Lateral nasal right –left. CHR-l: LNR-l
12. Lateral canthus right–left: Chilion right-left. LCr-l: CHR-l
13. Temporal soft tissue right–left: Lateral canthus right–left. Tsr-l: LCr-l

**Results**

The statistical analysis was done using SPSS (statistical package for social sciences) version 20.0. One-Way ANOVA was applied to study the effect of malocclusion on measurements in the 3 groups, and the one-sample T-test was used to test whether the facial proportions were similar to the GP at the confidence level at 95% and p-value of 0.05 for

significant difference. Mean measurements of proportions were converted to percentages, assuming that the divine proportion was 100%.

Statistical analysis of the proportions in class I and class II div 1 and div 2 groups revealed significant differences for the proportions (CH r-l:LN r-l), (LC r-l :CH r-l), (TR-LN:LN –ME), (LN-ME :LC-LN) and (LC-LN: LN-CH) between the 3 groups. On further analysis, to study the effect of malocclusion: The value of (TR-ME:LC-CH) showed there were statistically significant differences Comparison class I vs class II div 1 (Table 1).

The values of (TR-LN: LN-ME), (LN-ME:LC-LN),(CH r-l : LN r-l), (LC r-l: CH r-l) and (TS r-l: LC r-l) showed there were statistically significant differences. Comparison class I and class II div 2 (Table 1).

The values of (TR-LN:LN-ME),(LN-ME:LC-LN),(LC-LN:LN-CH) and (LC r-l :CH r-l) showed there were statistically significant differences Comparison class II div 1 vs class II div 2 (Table 1); whilst all the other measurements showed there were no statistically significant differences between the 3 groups.

**Table 1:** The Vertical and Horizontal Facial proportions in the three groups and comparison between them.

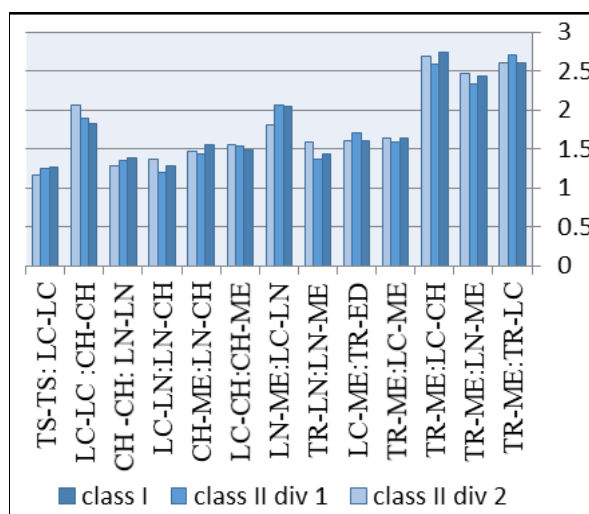
	Class I (n=16)		Class II div 1 (n=16)		Class II div 2 (n=16)		P-value		
	Mean	SD	Mean	SD	Mean	SD	G1vs G2	G1vs G3	G2vs G3
<b>Vertical proportions</b>									
TR-ME:TR-LC	2.60	0.08	2.71	0.27	2.61	0.19	**	**	**
TR-ME:LN-ME	2.43	0.10	2.34	0.20	2.47	0.26	**	**	**
TR-ME:LC-CH	2.73	0.10	2.59	0.24	2.69	0.13	*	**	**
TR-ME:LC-ME	1.63	0.04	1.59	0.08	1.63	0.07	**	**	**
LC-ME:TR-LC	1.60	0.08	1.71	0.27	1.61	0.19	**	**	**
TR-LN:LN-ME	1.43	0.09	1.37	0.15	1.59	0.11	**	*	*
LN-ME:LC-LN	2.04	0.27	2.06	0.25	1.81	0.08	**	*	*
LC-CH:CH-ME	1.48	0.12	1.53	0.12	1.56	0.21	**	**	**
CH-ME:LN-CH	1.55	0.16	1.43	0.06	1.47	0.24	**	**	**
LC-LN:LN-CH	1.28	0.21	1.19	0.15	1.37	0.15	**	**	*
<b>Horizontal proportions</b>									
CHR-l : LN r-l	1.38	0.09	1.35	0.08	1.28	0.13	**	*	**
LC r-l:CH r-l	1.83	0.18	1.90	0.14	2.06	0.14	**	*	*
TS r-l: LC r-l	1.26	0.15	1.24	0.11	1.17	0.05	**	*	**

\*P<0.05 (statistically significant)

\*\*P>0.05(no statistically significant)

The results of one-sample T-test shown in (Table 2) indicating the divergence or identical of facial proportions to the Golden Proportion (GP)  $\phi=1.618$ .

- In group 1 (class I) the values of Vertical proportion (CH-ME:LN-CH, LC-ME:TR-LC and TR-ME:LC-ME) were similar to the golden proportion (100%): 1.545 (95.5%), 1.599(98.8%), 1.63 (100.7%), respectively. However, the Vertical proportion TR-ME:LC-ME 1.630(100.7%) was closer to the golden proportion, whilst, the other measurements deviated more from the golden proportion.
- In group 2 (class II div 1) the Vertical proportion: LC-CH:CH-ME 1.532(94.6%) and TR-ME:LC-ME 1.594 (98.5%) were similar to the golden proportion, but all the other proportion were different from the golden proportion.
- In group 3 (class II div 2) the proportions were similar to GP : TR-ME:LC-ME 1.628 (100.6%), LC-ME:TR-LC 1.613 (99.6%), TR-LN:LN-ME 1.589(98.2%) and LC-CH:CH-ME 1.558 (96.2%), whereas the proportion LC-ME:TR-LC MD (0.005) was the closest to GP, the other proportions deviated from the golden proportion.



**Fig 3:** Comparison of means values of facial proportions between the 3 groups.

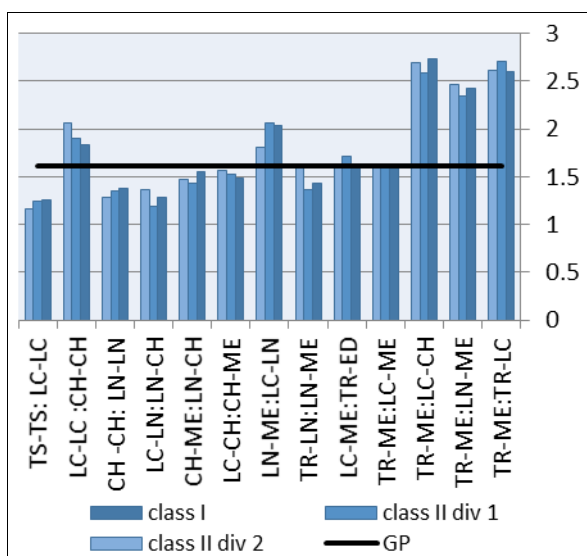
**Table 2:** Analysis and comparison of facial proportions with the golden proportion.

Proportions	Class I (n=16)			Class II div 1 (n=16)			Class II div 2 (n=16)		
	M±SD	%	MD	M ±SD	%	MD	M ±SD	%	MD
<b>Vertical proportions</b>									
1	2.604(0.081)	160.9	0.986*	2.705(0.273)	167.2	1.087*	2.613(0.193)	161.4	0.995*
2	2.430(0.103)	150.1	0.812*	2.335(0.197)	144.3	0.717*	2.466(0.263)	152.3	0.848*
3	2.733(0.100)	168.8	1.115*	2.590(0.243)	160.0	0.972*	2.689(0.128)	166.2	1.071*
4	1.630(0.035)	100.7	0.012	1.594(0.079)	98.5	0.024	1.628(0.070)	100.6	0.010
5	1.599(0.082)	98.8	0.019	1.709(0.269)	105.6	0.091	1.613(0.193)	99.6	0.005
6	1.427(0.093)	88.1	0.191*	1.366(0.149)	84.3	0.252*	1.589(0.109)	98.2	0.029
7	2.038(0.267)	125.9	0.420*	2.059(0.250)	127.2	0.441*	1.807(0.077)	111.7	0.189*
8	1.478(0.124)	91.3	0.140*	1.532(0.118)	94.6	0.086*	1.558(0.213)	96.2	0.060
9	1.545(0.157)	95.5	0.073	1.434(0.064)	88.6	0.184*	1.471(0.235)	90.9	0.147*
10	1.276(0.214)	78.8	0.342*	1.194(0.148)	73.7	0.424*	1.370(0.150)	84.6	0.248*
<b>Horizontal proportions</b>									
11	1.382(0.090)	85.4	0.236*	1.347(0.079)	83.2	0.271*	1.284(0.135)	79.3	0.334*
12	1.827(0.179)	112.8	0.209*	1.902(0.141)	117.5	0.284*	2.057(0.144)	127.1	0.439*
13	1.256(0.150)	77.6	0.362*	1.237(0.114)	76.4	0.381*	1.172(0.051)	72.4	0.446*

**Note:** MD: mean difference; One-sample t-test with a test value =1.618 (i.e., the golden proportion), \*: statistically significant differences.

Statistical analysis of the golden proportions in the class I, class ii div 1 and class ii div 2 groups revealed significant differences comparison with the golden proportion for the All the horizontal proportions. The vertical proportions TR-ME:TR-LC; TR-ME:LN-ME; TR-ME:LC-CH; LN-ME:LC-LN; LC-LN:LN-CH in the 3 groups show statistically significant differences comparison with the golden proportion, also the vertical proportions LC-CH:CH-ME and TR-LN:LN-ME in the two groups class I and class II div1 malocclusion and CH-ME:LN-CH in the two groups class II div 1 and 2 show statistically significant differences comparison with the golden proportion.

Out of the 13 ratios, only 3 of class 1 malocclusion ratios were similar to the golden proportion (TR-ME:LC-ME, LC-ME:TR-LC, CH-ME:LN-CH), whilst two of class ii division 1 ratios were similar (TR-ME:LC-ME, LC-ME: TR-LC) and of 13 ratios in class ii division 2 were similar (TR-ME:LC-ME, LC-ME:TR-LC, TR-LN:LN-ME, LC-CH:CH-ME).



**Fig 3:** Comparison of facial proportions in the 3 groups with the golden proportion (1.618).

**Discussion**

The present study conducted an evaluation of the facial soft tissues of class I and class II malocclusion with the mean age was (20.17) years which is the most frequently reviewed age of orthodontic clinics to study the effect of malocclusion on

facial beauty and to evaluate whether there was congruence between the studied proportions and the GP.

Many researchers have conducted studies on attractive females, normal occlusion, Caucasian populations and rare in a black population. However, our study focused on the aesthetics aspects of facial attractiveness in class I and II malocclusion and the golden proportion in a Syrian population.

The values ranged from 1.25 to 2.73 in class I malocclusion, 1.19 to 2.70 in class II div 1 and 1.17 to 2.68 in class II division 2 malocclusion. The proportions that included the forehead height (TR-LC), except (TR-LN/LN-ME) did not show statistically significant differences between groups. Therefore, the height of the forehead appeared to have a little effect on facial features among malocclusion groups. This result agree with Juhi and Rajiv [14].

Rossetti A *et al.* [30] and Proffit WR *et al.* [30] indexed that the ratio between upper third : middle third : lower third face was approximate 1:1:1, but in this study the ratio of TR-LC:LC-CH:LN-ME was 1:1:0.9 in the 3 groups this meant the menton point had a trend to be closer to the lateral nasal point and not agree with them and with Mizumoto *et al.* [22] and Nguyen *et al.* [25] wich studied GP of Vietnamese females.

This study show that the facial proportions of class I, class II division 1 and class II division 2 patients do not accurately fit the golden proportion and it is difficult to find one proportion for all faces. Thus, we can determine if any ratios are similar and closer to the golden proportions, also to be studied separately. This result agree with Mantelakis *et al.* [19], they noted that most of the facial ratios for attractive male and female black subjects do not correspond to the golden proportion.

The most attractive vertical ratios that did not show statistical differences with the golden proportion were:

- In class I malocclusion: TR-ME :LC-ME 1.630(1.613-1.648), LC-ME: TR-LC 1.599(1.559-1.639) and CH-ME :LN-CH 1.545(1.468-1.622).
- In class II division 1 malocclusion: TR-ME: LC-ME 1.594 (1.556-1.633) and LC-ME: TR-LC 1.709(1.578-1.841)
- In class II division 2 malocclusion: TR-ME: LC-ME 1.628 (1.593-1.662) LC-ME: TR-LC 1.613 (1.518-1.707) TR-LN:LN-ME 1.589 (1.536-1.643) LC-CH:CH-ME 1.558 (1.453-1.663).

The results of the study showed that malocclusion didn't have any effect on the facial aesthetic, therefore it should not be considered every patient with Angle molar class I and a straight profile that is attractive and should be all facial proportions identical to the golden proportion. This result agree with Rodriguez *et al.* [29] and Pancherz *et al.* [10] which they found that attractive patients have an increased ANB and more convex profile than the non-attractive ones. But not agree with Mizumoto *et al.* [22] which the vertical proportions in group 1 skeletal class 1 (treated ortho) were similar to the golden proportion. We didn't find any similarity between the golden proportion and the horizontal ratios in class I, class II division 1 and class II division 2 malocclusion.

According to Medici *et al.* [21], Kawakami *et al.* [15], Mizumoto *et al.* [22] and Sunilkumar *et al.* [32] were found that the photographs with ratios closer to the golden proportion tended to be perceived as more attractive we can say class II division 2 malocclusion group the more attractive than the other two groups (class I, class II division 1) [19].

But this not agree with Rossetti *et al.* [30] and research conducted on Brazilian attractive women and no correlation was found between perception of beauty and the golden proportion [26].

The means of TR-ME: LN-ME, TR-LN:LN-ME and LC-CH:CH-ME were larger in group 3 than in group and group 2; this indicates a shorter length of LN-ME, CH-ME (lower interior face) and an hypodivergent growth pattern in group 3 class II division 2 this agree with group magazine Models Japanese [22, 32].

The proportion (TR-ME: LC-ME) was closer to the gp in class I (1.630) and class II div 1 (1.594), the proportion (LC-ME:TR-LC) in class II div 2 malocclusion was closer to the gp (1.613). According to Sunilkumar *et al.* [32] the horizontal proportions deviated from the gp in 3 groups. This indicate to wide nose width, small mouth width, wide eye width and small upper facial width and this not agree with Mizumoto *et al.* [22] which were normal eye width, average nose width and agree with them in small lip width and not agree with Filho *et al.* [21] which were the proportions closer to the gp.

Farkas *et al.* reported that American, Afro-American, Caucasian, Malaysian, Indian, Arabic and Chinese people have different facial characteristics, which is affected by race and ethnicity [16]. The deviations in this study than the gp indicated to a longer upper lip height in 3 groups and a shorter forehead height in class II div 1 group. This not agree with Burusapat and Lekdaeng [7] which determine modern facial proportions of the most beautiful women in the 21st century, also nose height was shorter in 3 groups this agree with Mizumoto *et al.* [22]

## Conclusions

### We found that

- Majority of the proportions of class I malocclusion were significantly different from the golden proportion, therefore it should not be considered every patient with Angle molar class I and a straight profile that is attractive.
- Comparing class II div 1 and div 2 with the gp. The proportions of class II div 2 were more similar to the gp. The vertical proportion (LC-ME: TR-LC) was close to gp than other proportions in the 3 groups.
- The horizontal proportions indicated to a wide nose width, small mouth width, wide eye width and small upper facial width.
- The vertical proportions indicated to a shorter lower

facial height and upper lip height in class II div 2 than other two groups, nose height was shorter in class II div 1 than other two groups with out statistically significant differences.

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