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Aesthetic Proportion of Frontal Teeth in Dentoalveolar Class I, II and III Malocclusions.

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ABSTRACT

Golden proportion and golden percentage have been proposed as esthetic paradigms for evaluation and restoration of maxillary anterior teeth. The purpose of the present study was to evaluate the difference in prevalence of golden proportion and golden percentage between Class I, II/1, II/2 and III malocclusions and to identify potential factors that might have association with golden proportion and golden percentage values. Plaster casts from 160 subjects (78 male and 82 female subjects with Class I (26.3%), Class II/1 (25%), Class II/2 (22.5%), and Class III (26.3%) malocclusions were scanned with the ATOS II SO scanner (GOM mbH, Braunschweig, Germany) and measured with ATOS Viewer software (version 6.0.2; GOM mbH). Point-biserial correlation and logistic regression were performed to identify the association of sex, age, malocclusion type, arch form, dentoalveolar discrepancy (DAD), and Little's index of irregularity (LII) with golden proportion and percentage. Values of golden proportion and percentage did not differ significantly among malocclusion groups. Deviation from golden proportion was most frequently found in Class II/2 (64-69 % on incisors and 67% on canines), whereas rarest deviation was determined in Class I (45-52% on incisors and 48-55% on canines). Sex, age, malocclusion type, arch form, DAD and LII were not identified as significant predictors of deviation from golden proportion. Significant predictors of deviation from golden percentage rule was determined only for tooth 11 and included Class II/1 and Class II/2 malocclusion, male sex and higher age.

Keywords: frontal teeth, malocclusion

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INTRODUCTION

Golden proportion concept has been proposed as an esthetic paradigm for evaluation and restoration of maxillary anterior teeth.Levin[1] and Lombardi[2] advocated the application of golden proportion to optimize the dentofacial composition of maxillary anterior segment. The term golden proportion in smile design theory presumes mathematically constant ratio that defines the dimension between width of maxillary anterior teeth. In this matter the ratio calculated for maxillary lateral incisors and the canines in reference to that of the central incisors are 0.62 and 0.38 respectively. Golden proportion concept presumes that dental esthetics is optimized if those suggested ratios are repeated when patient smile is viewed from front [1,2]. Although various authors[3,4] have advocated usage of golden proportion concept as a means for evaluation of symmetry, dominance, and proportion in the smile design there are studies that denote its use as an esthetic guideline rule[5-8] or its prevalence in the majority of the population[4,9].

Because golden proportion presents unilateral calculation with no meaningful assessment of symmetry[10], Snow[11] has proposed simplified rule of golden proportion - the golden percentage. The golden percentage concept presumes recommended proportional width of each maxillary central incisor as 25%, maxillary lateral incisors as 15 % and maxillary canine as 10% of the total maxillary anterior sextant width. Snow found this approach as more useful in analyzing the esthetic properties of smile: asymmetry is clearly identifiable and quantifiable combined with individual evaluation of each tooth for its contribution to symmetry and proportion to maxillary anterior segment[11].

Studies from the literature mainly reported of golden proportion prevalence in various population or they evaluated the relation of golden percentage with dental attractiveness. According to our knowledge, this is the first study that evaluates the possible relations and significance of various malocclusion features in terms of golden proportion and golden percentage prevalence.

The purpose of this study was 1) to evaluate the difference in the prevalence of golden proportion and golden percentage concepts between Angle Class I, Class II/1, Class II/2, and Class III malocclusion groups; and 2) to identify the possible relation between golden proportion and golden percentage and sex, age, malocclusion type, dental arch form, Little's index of irregularity (LII), and dentoalveolar discrepancy (DAD) respectively.

MATERIALS AND METHODS

Plaster dental cast were collected from randomly pre-treatment 160 subjects (78 male and 82 female participants) aged between 10 and 42 years (median 15.5; interquartile range; 13.5-18) with Angle Class I (26.3%), Class II/1 (25%), Class II/2 (22.5%) and Class III (26.3%)malocclusions . Records were recorded from the Department of Orthodontics, School of Dental Medicine, University of Zagreb.

Inclusion criteria were as follows: permanent dentition; no missing teeth; and absence of: periodontal disease, mesiodistal restoration, partially erupted teeth, tooth anomalies and interproximal tooth wear.

Classification for Class II/1 and Class II/2 included the following: bilateral half Class II or great canine and molar relation combined with proclination of the maxillary anterior teeth with an overjet not more than 4 mm for patients with Class II/1 and retroinclination of two or more maxillary anterior teeth combined with deep bite for patients with Class II/2.Class III was classified as bilateral Class III canine and molar relation (the mesiobuccal cusp tip of the maxillary first molar occluded within 1 mm of the distal marginal ridge of the mandibular first molar).

Casts were scanned using an ATOS II SO (small objects) scanner (GOM mbH, Braunschweig, Germany). The scanner has point spacing in the range of 0.02 to 0.17mm, a measuring area of 30 x 324 to 250 x 200 mm^2,and measured pointsof 1,400,000. Fringe patterns were projected into the object's surface with a white lightand recorded by 2 cameras. The 3D coordinates for each camera pixel were calculated, and a polygonmesh of the object's surface was generated. Models were measured and analyzed using ATOS Viewer software (version 6.0.2; GOM mbH).

ATOS Viewer version 6.0.2.software was used to digitally mark landmark points on each virtual 3D model. Each point was automatically defined by software in a 3D coordinate system with associated values (x, y, z).

Landmark points were made by principal investigator at two different time points. Pearson correlation coefficients between first and second measurements ranged from 0.96 to 0.99. Student t-test did not show any significant differences for interaexaminer error.

From these landmarks, further measurements were made:

1)The widths measurements of maxillary incisors and canines were measured from its mesial contact point to its distal contact point at its greatest interproximal distance on a line perpendicular to the long axis according to the method described by Jensen et al. (12).

2) Perceived mesiodistal widths of maxillary incisors and canines (the widest distance between the mesial and distal sides of the tooth as viewed from the front).

3) Dental arch measurements:

- maxillary intercanine width: the distance between canine clinical bracket point
- maxillary intermolar width: the distance between first molar clinical bracket point
- anterior arch depth: the length perpendicular from the midpoint of the intercentral width to the intercanine width
- posterior arch depth: the length perpendicular from the midpoint of the intercentral width to the intermolar width

From mentioned measurements canine width and anterior arch dept ratio along with molar width and posterior arch depth ratio were calculated.

4) LII was estimated according to the method described by Little[13].

5) DAD measurements for intercanine segment(arch length discrepancy was calculated as the difference between available and required space for the alignment of the upper frontal teeth) was calculated according to the method by Van der Linden[14].

6) Golden proportion of maxillary anterior segment was calculated according to the method described by Levin[1].

7) Golden percentage of maxillary anterior segment was calculated according to the method described by Snow[11].

Statistical analysis

For the assessment of normality of data, Kolmogorov-Smirnov and Shapiro-Wilk tests were used. Data were analyzed using Kruskal-Wallis and Mann-Whitney tests with Bonferroni corrections for multiple comparisons, Spearman and point-biserial correlations. Chi-square test was used in frequency analysis, whereas the effect size was tested with Cramer's V test. To classify subjects in those who deviate significantly from the golden proportion and percentage rule, the z-score for each subject was calculated according to the formula: z=[individual(r-φ)- mean (r-φ)]/SD of the sample.φ presented value of golden proportion/percentage value for each tooth, AS – mean, and SD - standard deviation. The z-scores were dichotomized (Dz - dichotomized z-scores) to reduce the effects of outliers and to classify the proportions in 2 groups as follows: Group 1(within a range of 1 SD of the z-score, the ratio was supposed to be close to the golden proportion/percentage rule): Dz= 0 if $-0.5 \leq z \leq 0.5$ and Group 2 (the ratio was supposed to be away from the golden proportion/percentage rule): Dz=1 if $z < -0.5$ or $z > 0.5$(15). All individual Dz scores for each ratio were used as input for a subsequent point-biserial correlation and logistic regression to determine the association between them with sex, age, intercanine width/anterior arch depth ratio, intermolar width/posterior arch depth ratio, malocclusion type, DAD and LII. Commercial softwares Statistica 10 (StatSoft, Tulsa, USA) and SPSS 11.5 (SPSS Inc., Chicago, USA) were used.

RESULTS

Both sexes were equally distributed among malocclusion groups. Class III subjects were statistically significantly older than other malocclusion groups (median 18; $p<0.05$), but without significant difference among them (median 14.5-16).Mesiodistal widths of maxillary incisors and canines when comparing Class I, Class II/1, ClassII/2 and Class III malocclusion groups did not show any difference. LII was 7.4mm (interquartile range of 5.1-13.2 mm) whereas DAD was -0.5mm (interquartile range -2.3-0.8mm).There is no difference in LII and DAD among malocclusion groups (data not shown).

Statistically significant difference in perceived tooth widths was determined among 13, 23 and 12 teeth ($p<0.05$, Figure 1.). There was a tendency for subjects with Class I and III malocclusion to have wider perceived widths of canines than subjects with Class II/1 and II/2 malocclusions, whereas perceived widths of lateral incisors were higher in Class I and II/2 than in subjects with Class II/1 and Class III. Arch forms differ significantly among malocclusion groups with Class II/1 malocclusion group having significantly narrower and deeper maxillary arches (in both canine and molar segment)($p<0.001$).Other malocclusion groups did not differ significantly in canine segment, but class III group had significantly wider and shallower molar segment than Class II/2 and Class I ($p<0,001$)(data not shown).

Golden proportion

Dichotomized values of deviation from the golden proportion concept (ratio calculated for maxillary lateral incisor (0.62) and the canine (0.38) in reference to that of the central incisor)are shown in Figure 2.There were no significant differences between malocclusion groups in prevalence of deviation from golden proportion concept. However, subjects with Class II/2 malocclusion tend to deviate more frequently from the golden proportion concept, and those with Class I tend to deviate less frequently. Deviation from golden percentage was most frequently found in Class II/2 (64%-69% on incisors and 67% on canines) malocclusion group, whereas rarest deviation was determined in Class I (45%-52% on incisors and 48%-55% on canines) malocclusion group. Point-biserial correlation and logistic regression did not identify any of the tested variables as significant predictors of golden proportion deviation (at cut-off $r>0.25$) (Table 1.)

Golden percentage

Dichotomized values of deviation from the golden percentage concept are presented in Figure 3. Significant difference between malocclusion groups was determined at teeth 11 and 12 ($p=0.013$, Cramer $V=0.260$, and $p=0.024$, $V=0.243$, Figure 3.). Subjects with Class I malocclusion had less frequent deviation from the golden percentage concept for 11 and 21 than subjects with Class II/2 and Class II/1. In Class III malocclusion group deviation is less frequent than in Class II/2 malocclusion group only for tooth 11 ($p<0.05$).

Point-biserial correlations did not identify any of the tested variables as significant predictors of golden percentage concept deviation (at cut-off point $r>0.25$) (Table 2.).Using multiple logistic regression we have tested potential predictors of deviation from golden percentage concept for each tooth in the anterior maxillary segment. Statistically significant predictors for golden percentage deviation were indentify only for tooth 11 and included Class II/1 and Class II/2 malocclusion, male sex and higher age producing 4.7, 5.3, 2.1, and 1.1 odds ratio, respectively (Table 3).This model correctly classified 65% of the subjects 49.3% insignificantly deviate from the golden percentage rule, and 77.4% of those subjects deviate significantly from the golden percentage rule.

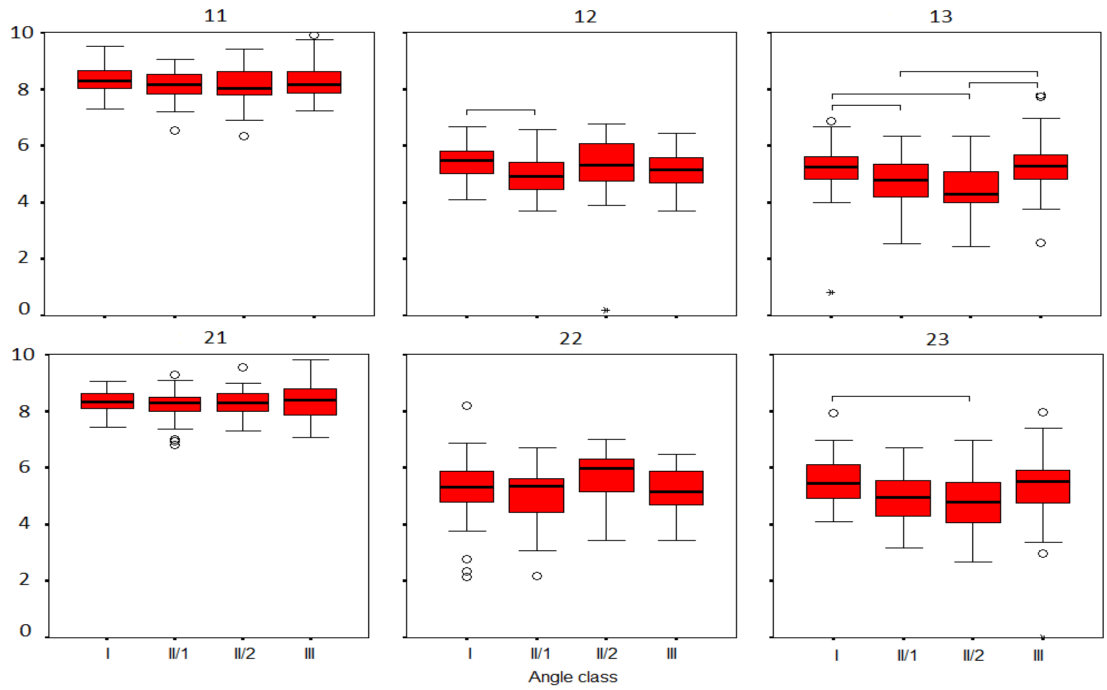

Figure 1. Percieved widths of central incisors and canines in Class I, Class II/1, Class II/2 and Class III malocclusions. Statistically significant difference in perceived tooth widths among malocclusions groups are shown using horizontal lines.

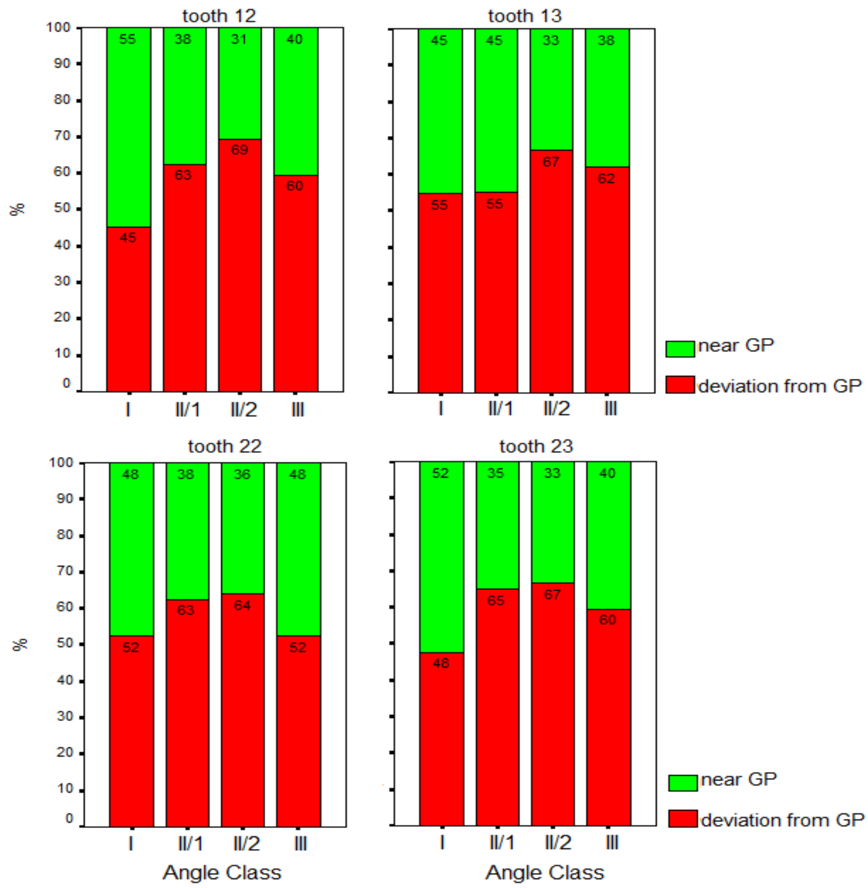

Figure 2. Prevalence of deviation from golden proportion concept for maxillary anterior teeth among Class I, Class II/1, Class II/2 and Class III malocclusion groups.

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Table 1. Relationship of dichotomized z-scores how significantly deviate from golden proportion with intermolar width/posterior arch depth ratio, intercanine width/anterior arch depth ratio, DAD, LII, sex, age and malocclusion groups.

		13 DICH	12 DICH	22 DICH	23 DICH
13 dich	r	1.000	-0.021	0.190	0.067
	p	.	0.792	0.016	0.398
12 dich	r	-0.021	1.000	0.178	0.005
	p	0.792	.	0.024	0.951
22 dich	r	0.190	0.178	1.000	0.035
	p	0.016	0.024	.	0.657
23 dich	r	0.067	0.005	0.035	1.000
	p	0.398	0.951	0.657	.
Molar width/posterior arch depth ratio	r	0.099	-0.066	0.059	0.058
	p	0.213	0.406	0.458	0.466
Canine width/anterior arch depth ratio	r	0.024	-0.063	-0.002	-0.027
	p	0.765	0.425	0.975	0.735
DAD	r	0.094	0.035	0.125	0.044
	p	0.235	0.660	0.115	0.580
LII	r	-0.135	-0.041	-0.119	-0.122
	p	0.089	0.607	0.134	0.125
Sex	r	-0.036	0.145	-0.013	-0.113
	p	0.651	0.067	0.871	0.153
Age	r	0.068	0.081	0.156	0.043
	p	0.390	0.311	0.050	0.590
Class I (0=no, 1=yes)	r	0.056	0.164	0.062	0.143
	p	0.482	0.039	0.438	0.072
Class II/1 (0=no, 1=yes)	r	0.051	-0.044	-0.058	-0.066
	p	0.518	0.581	0.463	0.406
Class II/2 (0=no, 1=yes)	r	-0.080	-0.117	-0.070	-0.080
	p	0.315	0.140	0.382	0.315
Class III (0=no, 1=yes)	r	-0.031	-0.009	0.062	-0.002
	p	0.700	0.906	0.438	0.982

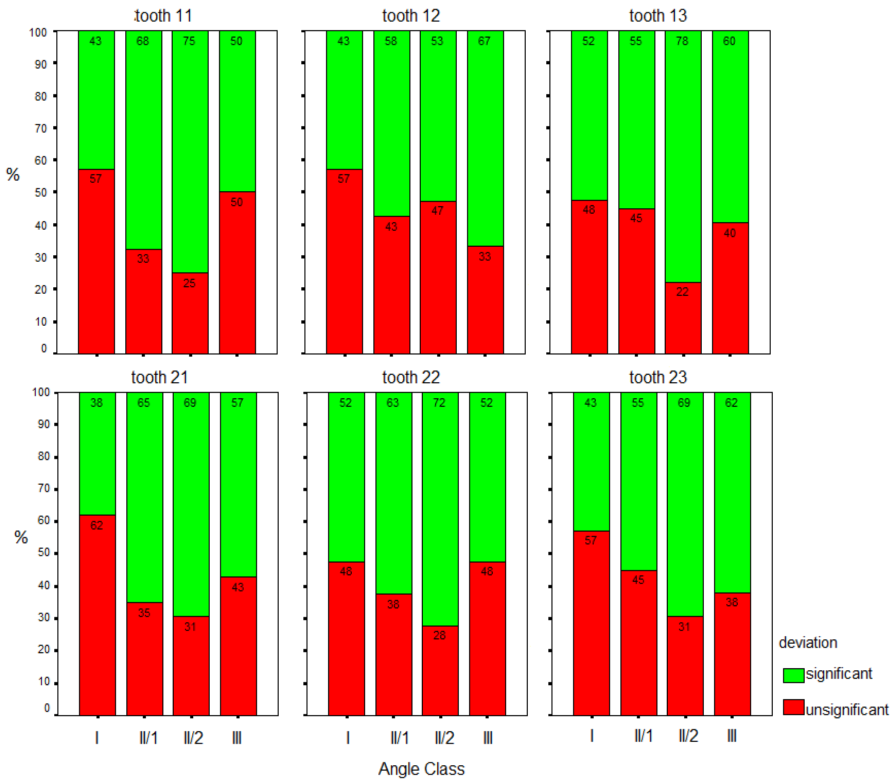

Figure 3. Prevalence of deviation from golden percentage concept for maxillary anterior teeth among Class I, Class II/1, Class II/2 and Class III malocclusion group

Table 2. Relationship of dichotomized z-scores how significantly deviate from golden percentage with intermolar width/posterior arch depth ratio, intercanine width/anterior arch depth ratio, DAD, LII, sex, age and malocclusion groups.

		13 dich	12 dich	11 dich	21 dich	22 dich	23 dich
13 dich	r	1	0.094	-0.01	-0.004	0.219	0.073
	p	.	0.238	0.901	0.956	0.005	0.358
12 dich	r	0.094	1	-0.004	-0.052	0.07	-0.027
	p	0.238	.	0.962	0.514	0.377	0.738
11 dich	r	-0.01	-0.004	1	0.361	0.252	0.156
	p	0.901	0.962	.	<0.001	0.001	0.049
21 dich	r	-0.004	-0.052	0.361	1	0.076	0.236
	p	0.956	0.514	<0.001	.	0.338	0.003
22 dich	r	0.219	0.07	0.252	0.076	1	0.179
	p	0.005	0.377	0.001	0.338	.	0.023
23 dich	r	0.073	-0.027	0.156	0.236	0.179	1
	p	0.358	0.738	0.049	0.003	0.023	.
Class I	r	-0.101	-0.146	-0.185	-0.226	-0.085	-0.169
	p	0.205	0.066	0.019	0.004	0.285	0.033
Class II/1	r	-0.066	0.029	0.11	0.095	0.037	-0.022
	p	0.404	0.716	0.167	0.233	0.645	0.784
Class II/2	r	0.189	-0.024	0.184	0.137	0.141	0.137
	p	0.017	0.763	0.02	0.085	0.075	0.085
Class III	r	-0.013	0.14	-0.098	0.003	-0.085	0.061
	p	0.866	0.078	0.216	0.968	0.285	0.447
Sex	r	-0.069	-0.028	-0.194	-0.041	-0.145	-0.092
	p	0.383	0.729	0.014	0.604	0.068	0.248
Age	r	-0.057	0.132	0.137	0.111	0.006	0.176
	p	0.473	0.097	0.084	0.164	0.938	0.026
Molar width/posterior arch depth ratio	r	-0.055	0.004	-0.024	-0.084	-0.139	-0.047
	p	0.494	0.963	0.762	0.293	0.079	0.558
Canine width/anterior arch depth ratio	r	-0.023	0	0.011	0.023	-0.077	-0.005
	p	0.774	0.999	0.892	0.773	0.335	0.948
DAD	r	-0.181	-0.013	-0.112	-0.129	-0.139	-0.002
	p	0.022	0.867	0.158	0.104	0.081	0.976
LII	r	0.229	0.083	0.107	0.168	0.14	0.134
	p	0.004	0.297	0.176	0.034	0.077	0.091

Table 3. Multiple linear regression for identifying predictors of deviation of tooth 11 from golden percentage

Tooth11	B	Std. error	Sig.	OR	95% CI OR	
Class I (1=yes)	0.407	0.524	0.438	1.502	0.538	4.194
Class II/1 (1=yes)	1.55	0.583	0.008	4.711	1.503	14.769
Class II/2 (1=yes)	1.668	0.57	0.003	5.302	1.736	16.195
Sex (1=men)	0.721	0.357	0.043	2.057	1.023	4.139
Age	0.116	0.055	0.034	1.123	1.009	1.249
Canine width/anterior arch depth ratio	0.097	0.225	0.664	1.102	0.71	1.712
DAD	-0.052	0.079	0.513	0.949	0.813	1.109
konstanta	-3.136	1.547	0.043	0.043		

Negelkerke pseudo R^2=0.185; p=0.001.
OR= odds ratio

DISCUSSION

Most golden proportion and golden percentage studies were done with measurements taken directly by calipers on plaster models or on photography. Reproducibility of these studies is questionable because of material defects on plaster models or omission of third dimension while using photography. In this survey we used 3D digital models and automatically calculated distance between landmark points to improve reproducibility and accuracy of the measurements. Various authors[1,7,11] have proposed different concepts (golden proportion, golden percentage, and recurring esthetic dental proportion) in smile design theory. The concept of golden proportion has been proposed as an esthetic guideline during evaluation and restoration of the maxillary anterior segment. From the literature, it is evident that there is a need for golden proportion concept revision because various authors have not been able to determine its presence in individuals with attractive smiles or in natural dentition respectively[4,6,8,16]. The present study also determined low prevalence of golden proportion among observed subjects. Although statistically significant difference of golden proportion prevalence among observed malocclusions was not determined; it is evident that subjects with Class II/2 malocclusion deviate more frequently from the golden proportion concept than other subjects in observed malocclusion groups.

According to our knowledge, there are obvious deficiency of critical views of golden proportion and golden percentage application to the various malocclusion cases and their accompanying features in the literature. Although Hasanreisoglu et al.[17] findings have stated the difference among actual and perceived tooth widths when progressing distally in the dental arch, date, there has not been any survey in the literature regarding evaluation of influence of different arch forms on perceived tooth widths. One of the explanations could be that golden proportion/ percentage studies were mainly reported by prosthodontics[18] and restorative dentist how underestimate role of different arch forms and malocclusions on perceived tooth widths. Snow[11] hypothetically recognized the influence of the different arch forms on the perceived tooth widths but without presenting substantiated measurements (quantifiable arch form measurements and its relation to perceived tooth widths).

Results from this survey have indicated subjects with Class I and III malocclusion as those with wider perceived widths of canines than subjects with Class II/1 and II/2. Difference in perceived widths of canines among observed malocclusion groups can be explained by the presence of wider maxillary intercanine width in Class III and Class I patients than in patients with Class II/1 malocclusion. Gradual transition in the posterior segment of the dental arch through the lateral incisors and canines results in wider perceived widths of canines, whereas in patients with Class II/1 malocclusions, width transition in the posterior dental segment curve back rapidly through the lateral incisors and canines. Although results from present study have indicated correlation between narrower intercanine widths and smaller values of canine perceived widths, different arch forms have not been identified as significant predictors of golden proportion deviation. Possible explanation can be attributed to the relatively small number of tested subjects in each malocclusion group and to the insignificant influence of various arch forms on perceived width of central incisor which presented a reference point in golden proportion ratio.

Golden percentage concept has been proposed for the evaluation of widths of maxillary incisors and canines to evaluate its contribution to symmetry, dominance, and proportion of the entire maxillary anterior segment. The present study indicated that high percentage of subjects deviate from the golden percentage concept in all observed malocclusion groups. Statically significant deviation from the golden percentage concept is observed among tooth 11 and 21 in subjects with Class II/2 malocclusion whereas subjects with Class I showed the least deviation from the golden percentage concept. Results from this study have not identified any of the tested variables as significant predictor of the golden percentage deviation. Statistically significant deviation from the golden percentage concept observed in Class II/2 malocclusion among central incisors can be attribute to lingual inclination, morphological aspects of central incisors, or the crown-root angulation[19] characteristic of patients with Class II/2 malocclusion, although this remains to be tested in further research studies. Using multiple logistic regression, we have indicated statistically significant predictors of deviation from the golden percentage only for tooth 11 and those included: Class II/1, Class II/2 malocclusions, male gender, and older age. Because the Snow concept is suggested for the entire maxillary sextant to gain balance and symmetry, we found these results insignificant for clinical implication. Also, determined perceived widths of maxillary central incisors occupied slightly less than suggested 50% of the entire perceived maxillary anterior segment whereas perceived widths of canines are slightly higher (13% versus 10%) in all observed malocclusions which is similar to the reports from the literature[8,20].

Other studies demonstrated[11,21] the different forms of tooth alignment (rotation, spacing, and overlapping) as potential factors that might have negative influence on golden proportion and percentage values. Their claims were not substantiated in this survey; LII and DAD have not been identified as significant predictors of deviation from the golden proportion and percentage concept. Results from the present survey are supported by findings from the study by Mahshid et al.[6]; this study has not been able to determine the effect of maxillary anterior alignment on golden proportion existence. However, direct comparison of their data with the results of this study is not possible because Mashid et al. have not used objective inclusion criteria for the study participants, and the exact estimation of maxillary anterior alignment is lacking.

CONCLUSIONS

Statistically significant difference in prevalence of golden proportion and golden percentage concept could not be found among Class I, Class II/1, Class II/2 and Class III malocclusion groups.

Most frequent deviation from the golden proportion and golden percentage concept was determined in subjects with Class II/2 malocclusion whereas subjects with Class I deviate less frequently than the other observed malocclusions.

Sex, age, malocclusion type, intercanine width/anterior arch depth ratio, intermolar width/posterior arch depth ratio, LII and DAD were not identified as significant predictors of deviation from the golden proportion.

Predictors for golden percentage deviation were indentify only for tooth 11 and included Class II/1 and Class II/2 malocclusion, male sex and higher age.

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