

Golden Standard and Golden Proportion of Maxillary Anterior Teeth Among Saudi Population in Makkah

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ABSTRACT **Background:** Maxillary anterior teeth are important in achieving optimum aesthetics, Different methods are used to calculate their dimension: as golden standard (GS) to measure Width/Height (W/H) of anterior teeth and Golden Proportion (GP) to measure their perceived widths. Researchers had reported on GS and GP in different populations. **Objectives:** The aim of the present study is to evaluate the occurrence of GS and GP of maxillary anterior teeth among the Saudi population in Makkah. **Materials and Methods:** A total of 384 participants (2304 teeth) were included in this study; photographs were taken by using a digital camera at a fixed distance and saved on a personal computer; the perceived mesio-distal widths and occluso-gingival heights of the maxillary anterior teeth were measured; GS was calculated from W/H of upper central incisors (W11/H11 and W21/H21); and GP was calculated from width of canines/laterals (W13/W12 and W23/W22) and laterals/centrals (W12/W11 and W22/W21). The normal range of GS was considered between 75% and 85%, whereas the normal range of GP was considered between 55% and 65%. Data were analyzed by using suitable statistical tests, and p-value ≤ 0.05 was considered statistically significant. Both GS and GP were compared in relation to gender, race, and shape of the face. **Results:** There were 43% of GS ratios, 14% of GP of canines/laterals, and 34% of GP ratios of laterals/centrals that were within the normal range. There were no significant differences between GS of males and females ($p=0.512$) as well as among different races (0.137), whereas there were significant differences among different face shapes ($p=0.001$). For GP of canines/laterals, there were significant differences between males and females ($p=0.000$), different races ($p=0.000$), and different face shapes ($p=0.001$). For GP of laterals/centrals; there were no significant differences between males and females ($p=0.216$) whereas there were significant differences among different races ($p=0.000$) and different face shapes ($p=0.007$). **Conclusion:** The GS was 85% among the Saudi population in Makkah and it was more prevalent than other golden measures. The GP was 77.5 for canines/laterals and 65.8 for laterals/centrals, and their frequencies were very low. Personal characteristics and dento-facial specifications should be considered to obtain maximum aesthetics.

KEYWORDS: Anterior teeth, aesthetics, golden proportion, golden standard

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INTRODUCTION

Dimensions of anterior teeth are important during prosthodontics treatment planning to achieve ideal

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aesthetic results.^[1] Many guidelines were introduced to achieve maximum aesthetics in the maxillary anterior region as GP. Lombardi was the first to introduce the GP; Lombardi and Levin^[2] stated that the width of the upper central incisor can be measured by using GP to the width of the upper lateral incisor; also, the width of the upper lateral incisor can be calculated by the width of the canine, respectively, by using the GP. As per the GP rule, “Visible mesio-distal width of upper canine is approximately sixty two percent (0.618) of upper lateral incisor and the visible width of upper lateral incisor is approximately sixty two percent (0.618) of upper central incisor.”^[3] Many studies were carried out to assess GP in different populations. Aldegeishem *et al.*^[4] studied GP in the Saudi population living in Riyadh; they found a significant difference between W/H and GP, except in the case of the upper right lateral incisor in male samples, where no significant width comparison was available for upper anterior teeth to the ideal GP of 0.618–1.618. Swelem and Al-Rafah^[5] found highly significant differences between ideal GP and the calculated golden ratio in the Jeddah population in Saudi Arabia and the males in their study had a broader perceived mesio-distal width of upper anterior teeth than the females. Also, Mahajan V. found that GP did not present in most cases of the Himachal Pradesh population in north India.^[6] Similarly, Hegde and Malhotra^[7] found that GP was not prevalent in the south Indian population where the ratio of central incisor and lateral incisor on both sides was 1.23 and 1.18, respectively. Al-marzouk *et al.*^[8] evaluated GP and GS of maxillary central incisors in three different races living in Malaysia. They found no significant differences between the studied races for GP and GS. The ratio of upper lateral to central incisors was 73.8% in China, 71% in India, and 77% in Malaysia; however, the canine to lateral ratio was 75% in China, 79% in Malaysia, and 80% in India. Many other researchers studied GP in different populations.^[8]

The concept of “recurring aesthetic dental proportion” (RED) was introduced in 2001 by Ward,^[9] who suggested that dentists can use their own proportion in a constant ratio proceeding distally according to the relationship between teeth and facial proportion. In the year 2007, he reported that most dentists in North America are using the RED concept to create aesthetic smiles.^[10]

However, Ali Fayyad *et al.*^[11] and Murthy and Ramani^[12] found that the RED proportion was unsuccessful when applied to upper anterior dentition.

GS value is “the relation between width and height of maxillary anterior teeth”; it had been studied for

different populations of different origins.^[13-24] The optimum W/H proportion of upper central incisors should be approximately 80%^[25]; increasing the W/H ratio will lead to squarer looking teeth, whereas decreasing it will give a longer tooth appearance.^[26]

Williams^[27] and Cesário^[28] proved that a great correlation exists between the face shape and dimensions of the anterior teeth. However, Sellen *et al.*^[29] mentioned that there is not necessarily any relationship between face shape and anterior teeth, and accurate aesthetic analysis must be taken into consideration to establish the final dimensions of the teeth to be restored.

Due to limited available research that evaluated GP and GS in the KSA population and special characteristics of the Makkah population as there are diverse population, their origin was from different races, the aim of the current study was to investigate the GP and GS in Makkah population and to evaluate whether there is a consistent relationships of GP and GS values with the gender, race, and face shape.

MATERIALS AND METHODS

STUDY DESIGN AND ETHICAL APPROVAL

This cross-sectional study was carried out at the Faculty of Dentistry, Umm Al-Qura University, Makkah city. Acceptance was obtained from the ethical committee (IRB number: 147-19). All participants signed a consent form after illustration of the study objectives.

SUBJECTS AND SAMPLE SIZE CALCULATION

This study was carried out for the Makkah population who had been seeking dental treatment at UQUDENT teaching hospital and accepted to participate in the study. Sample size was determined according to the formula used for the whole population ($No. = Z^2 (pq)/e^2$), where $q = 1 - p$, with a 95% level of confidence and sample error $\pm 5\%$; we considered $q = 0.5$ to obtain maximum sample size. The sample for this study consists of 384 (196 males and 188 females) Saudi nationals.

SUBJECTS' INCLUSION CRITERIA

Certain criteria were met in all participants; these criteria were: (1) Makkah origin and resident, (2) No significant gingivitis or periodontitis, (3) No missed teeth in both arches (except the third molar), (4) No anterior defects or restorations, (5) No anterior crowding or history of orthodontic treatment, (6) No developmental anomalies such as hypoplasia, dense indent, or peg-shaped laterals.

DATA COLLECTION

The participants were asked face to face about their origin and age. Face shape was divided into six forms: (1) *Round*: Face has equal width and length; (2) *Oval*: Forehead is wide and bones of the cheeks are wide, whereas there is tapering toward chin; (3) *Long*: Face height is obvious and there is tapering toward chin; (4) *Heart*: Also, face tapers toward chin, which is pointy; (5) *Square*: Width of the forehead, bones of the cheeks, and jawline are equal, and jawline is bony and square; (6) *Diamond*: Bony face with high angles and widest part is at the temple.

A frontal photograph of the mouth was taken while the participant was smiling to expose all anterior teeth. All photographs were taken while the participant was sitting in an upright position at a dental chair; a special head holder device was used to stabilize the participant's head position by supporting chin and forehead and the standardization of the distance between the camera and teeth was 50 cm [Figure 1].

Photos were taken in standard daylight while maxillary teeth were parallel to the floor by using a digital camera (Canon EOS D700, Canon Inc, Ota, Tokyo, Japan). The photos were transferred to a personal computer and opened by using Photoshop program (Adobe



Figure 1: A special device was constructed to standardize the distance from the camera to the teeth

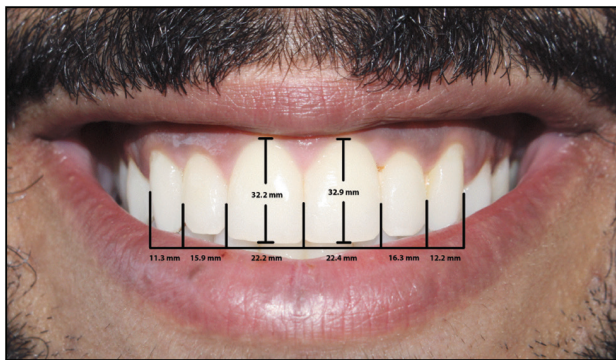


Figure 2: Measurements of teeth dimensions using imaging software

Photoshop CS 6, Adobe system Inc. San Jose, CA, USA) [Figure 2]. Special calibration tools were used in the program to change pixels to mm. Anterior teeth width (W) was measured from mesial to distal surfaces of upper anterior teeth, whereas height (H) was measured from the cervical margin to the incisal edge on a line to the long access of the tooth as described by Hasanreisoglu *et al.*^[15] and Janiszewska-Olszowska *et al.*^[30] The following values were recorded: (1) Width of upper centrals, laterals, and canines (W11, W21, W12, W22, W13, W23) was recorded. (2) Calculating the W/H ratio of upper right and left centrals (W11/H11, W21/H21) to determine GS. (3) Calculating the ratio between canines and laterals (W13/W12, W23/W22), laterals and centrals (W12/W11, W22/W21) to determine GP. All readings and calculations were checked thrice.

The normal range of GS was considered between 75% and 85%, whereas the normal range of GP was considered between 55% and 65%.

STATISTICAL ANALYSIS

Data were collected and analyzed by using statistical program (SPSS, version 22, IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). Quantitative data were interpreted as mean \pm SD. Independent *t*-test was used to compare between males and females. One-way ANOVA and post hoc Tukey tests were used to compare among different races and different face shapes. Qualitative data were presented as frequency, and a comparison was done by the Chi-square test. The level of significance was considered statistically significant at $P \leq 0.05$.

RESULTS

This study was carried out on 384 participants (196 males + 188 females) with a mean age of 23.47 ± 2.78 years. The sample contained 165 Saudis, 84 Middle Easterners, 57 South Asians, 30 Eastern Asians, 29 Caucasians, and 19 Africans. In relation to face shape, there were 55 square, 98 rounded, 100 oval, 67 long, 26 heart, and 38 diamond face shapes [Table 1].

Regarding GS, there were no significant differences between males and females ($P = 0.512$) as well as different races (0.137) whereas there were significant differences among different face shapes ($P = 0.001$): The differences were between oval faces and long, heart, and diamond faces [Table 1]. All GS measures were within the normal range except for African and Eastern Asian races as well as between square and oval face shapes, which were above the normal range [Table 1 and Figure 3].

Table 1: Golden standards measurements in relation to gender, race, and face shape

Variables (No.)		W11/H11, mean ± SD	W21/H21, mean ± SD	Total mean ± SD
Gender	Male (196)	0.853 ± 0.088	0.852 ± 0.088	0.852 ± 0.088
	Female (188)	0.847 ± 0.091	0.848 ± 0.102	0.848 ± 0.097
	p	0.549	0.738	0.512
Race	Saudi (165)	0.850 ± 0.089	0.845 ± 0.090	0.848 ± 0.089
	Middle Easterner (84)	0.855 ± 0.084	0.848 ± 0.079	0.851 ± 0.082
	South Asian (57)	0.849 ± 0.099	0.852 ± 0.112	0.850 ± 0.105
	Eastern Asian (30)	0.859 ± 0.093	0.865 ± 0.093	0.862 ± 0.092
	Caucasian (29)	0.820 ± 0.089	0.838 ± 0.081	0.829 ± 0.085
	African (19)	0.867 ± 0.089	0.893 ± 0.157	0.880 ± 0.126
	p1	0.357	0.483	0.137
	Face shape	Square (55)	0.856 ± 0.089	0.867 ± 0.124
Round (98)	0.856 ± 0.097	0.849 ± 0.89	0.853 ± 0.093	
Oval (100)	0.865 ± 0.097	0.868 ± 0.092@	0.867 ± 0.094 ^{S&#}	
Long (67)	0.836 ± 0.080	0.837 ± 0.087	0.837 ± 0.084 ^S	
Heart (26)	0.819 ± 0.076	0.820 ± 0.084	0.820 ± 0.079 ^o	
Diamond (38)	0.831 ± 0.065	0.822 ± 0.082@	0.827 ± 0.074 [#]	
p1	0.079	0.030	0.001	
Total of the sample (384)		0.850 ± 0.089	0.850 ± 0.096	0.850 ± 0.093

No = number, p = P-value calculated by unpaired Student t-test. p1 = P-value calculated by one-way ANOVA test

@,S,&# = Similar symbols mean significant differences between corresponding groups in the same column according to Tukey's test, P ≤ 0.05 considered statistically significant value

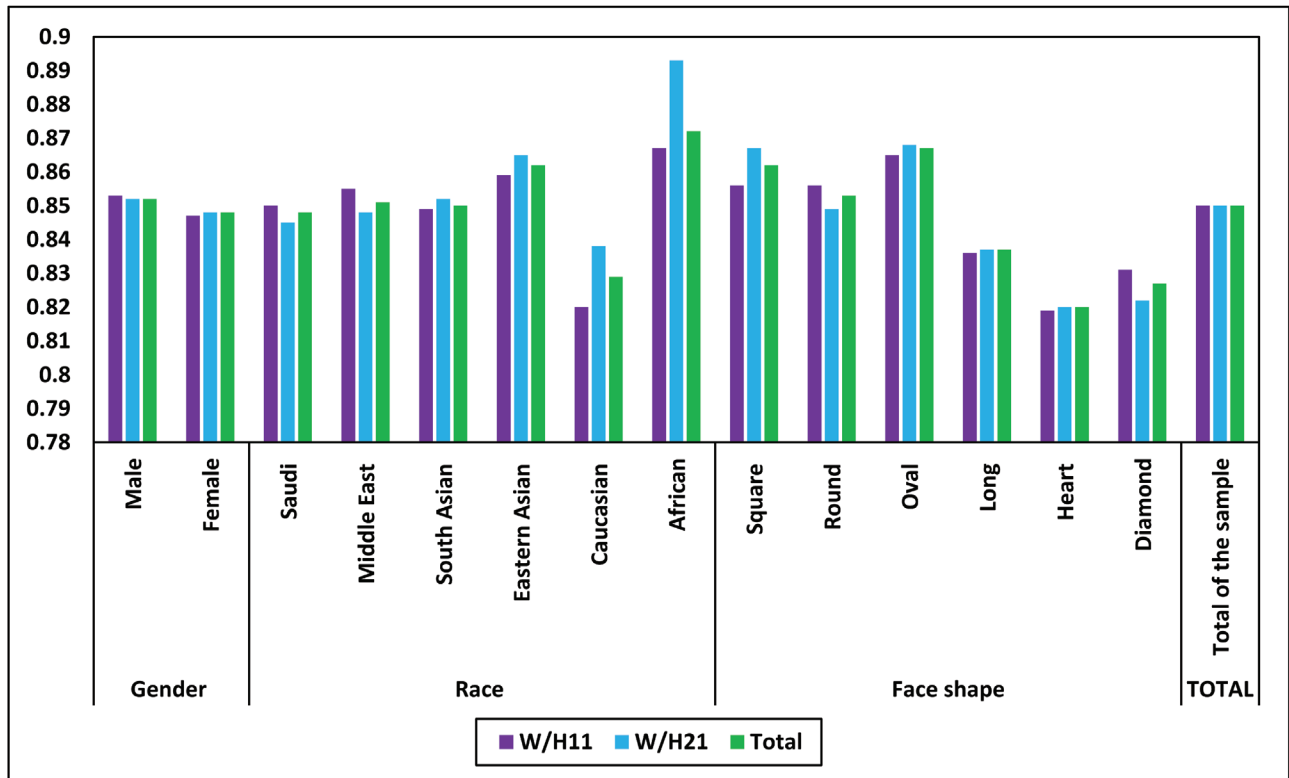


Figure 3: The mean of GS (W/H11 and W/H21) in relation to gender, race, and face shape

Regarding the GP of canines/laterals, there were significant differences between males and females ($P = 0.000$), different races ($P = 0.000$), and different face shapes ($P = 0.001$). In relation to race, the differences

were between Caucasian and Saudi, Middle East, South Asian, and African; they were also between South Asian and Eastern Asian. In relation to face shape; the differences were between oval and square, rounded and

diamond face shapes. All GP measures obtained from canines/laterals were above the normal range regardless of gender, race, and face shape [Table 2 and Figure 4].

For the GP of laterals/centrals, there were no significant differences between males and females ($P = 0.216$). On the other hand, there were significant differences

Table 2: Canines/laterals golden proportion in relation to gender, race, and face shape

Variables		W13/W12, mean ± SD	W23/W22, mean ± SD	Total mean ± SD
Gender	Male	0.798 ± 0.135	0.812 ± 0.152	0.805 ± 0.144
	Female	0.745 ± 0.118	0.743 ± 0.131	0.744 ± 0.125
	p	0.000	0.000	0.000
Race	Saudi	0.772 ± 0.113	0.761 ± 0.125 ^A	0.766 ± 0.119 ^A
	Middle Easterner	0.767 ± 0.152	0.783 ± 0.135 ^B	0.755 ± 0.144 ^B
	South Asian	0.735 ± 0.136 ^A	0.747 ± 0.136 ^C	0.741 ± 0.136 ^{DE}
	Eastern Asian	0.793 ± 0.093	0.833 ± 0.234	0.813 ± 0.178 ^E
	Caucasian	0.844 ± 0.134 ^A	0.874 ± 0.144 ^{ABCD}	0.859 ± 0.139 ^{ABCD}
	African	0.762 ± 0.138	0.761 ± 0.154 ^D	0.761 ± 0.145 ^C
	p1	0.010	0.000	0.000
	Face shape	Square	0.771 ± 0.116	0.807 ± 0.184 [#]
Round	0.783 ± 0.154	0.799 ± 0.155 ^S	0.792 ± 0.155 ^S	
Oval	0.746 ± 0.126	0.733 ± 0.113 ^{#S}	0.739 ± 0.120 ^{&S#}	
Long	0.776 ± 0.099	0.775 ± 0.136	0.776 ± 0.119	
Heart	0.772 ± 0.173	0.788 ± 0.177	0.780 ± 0.174	
Diamond	0.803 ± 0.085	0.795 ± 0.112	0.799 ± 0.099 [#]	
p1	0.213	0.012	0.001	
Total of the sample		0.772 ± 0.130	0.778 ± 0.146	0.775 ± 0.138

No. = number, p = P-value calculated by unpaired Student t-test. p1 = P value calculated by one-way ANOVA test

^{A-E,#&S} Similar letters/symbols mean significant difference between corresponding groups in the same column according to Tukey's test, $P \leq 0.05$ = statistically significant value

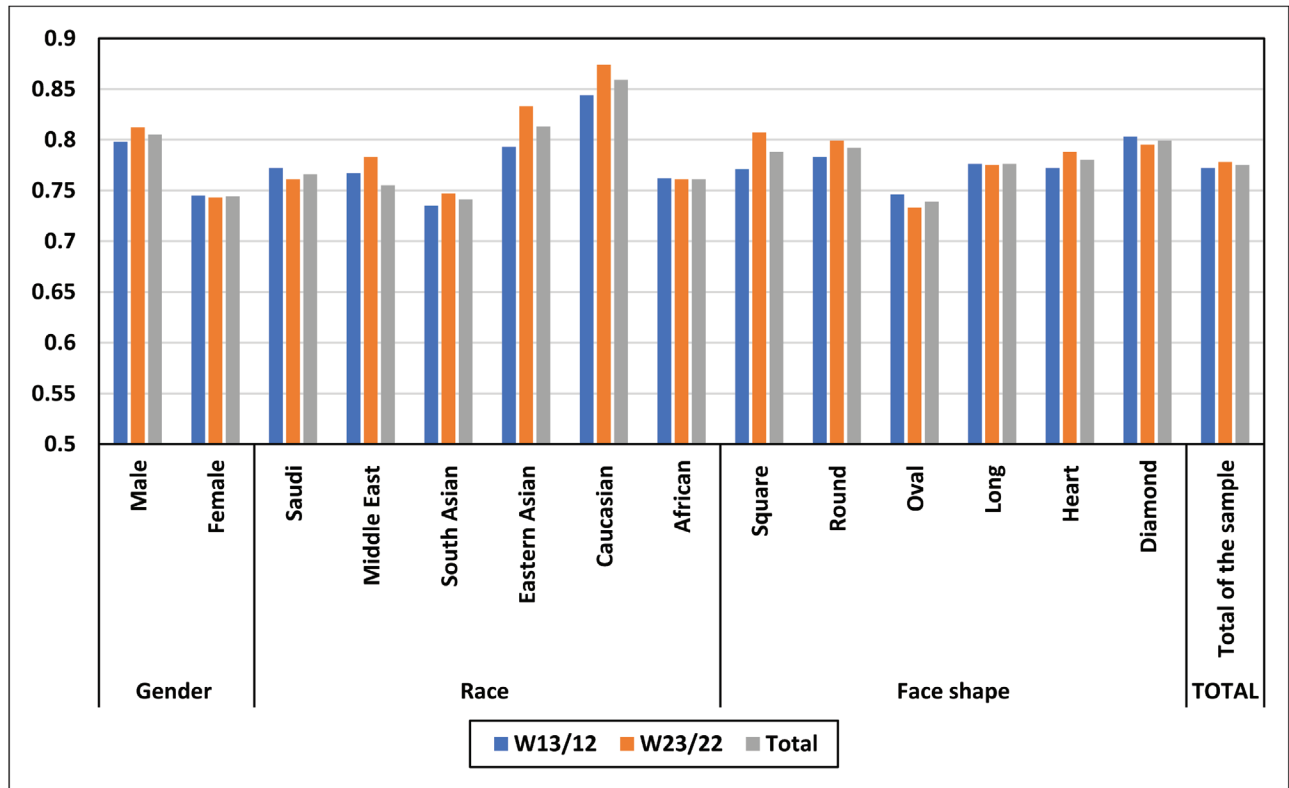


Figure 4: The mean of GP (W13/12 and W23/22) in relation to gender, race, and face shape

among different races ($P = 0.000$) and different face shapes ($P = 0.007$). In relation to race, the differences were between Eastern Asian and Saudi, Middle Eastern and Caucasian, and also between African

and Saudi, Middle Eastern and Caucasian. In relation to face shape, the differences were between oval and heart face shape. The GP measures obtained from laterals/centrals were close to the normal range, except

Table 3: Laterals/centrals golden proportion in relation to gender, race, and face shape

Variables		W12/W11, mean ± SD	W22/W21, mean ± SD	Total mean ± SD
Gender	Male	0.661 ± 0.069	0.661 ± 0.065	0.661 ± 0.067
	Female	0.653 ± 0.079	0.655 ± 0.083	0.654 ± 0.081
	p	0.332	0.449	0.216
Race	Saudi	0.647 ± 0.073 ^A	0.651 ± 0.078	0.647 ± 0.076 ^{AD}
	Middle Easterner	0.653 ± 0.079	0.650 ± 0.069	0.652 ± 0.074 ^{BE}
	South Asian	0.662 ± 0.068	0.670 ± 0.071	0.666 ± 0.069
	Eastern Asian	0.698 ± 0.083 ^A	0.690 ± 0.078	0.694 ± 0.080 ^{ABC}
	Caucasian	0.649 ± 0.063	0.641 ± 0.067 ^A	0.645 ± 0.065 ^{CF}
	African	0.697 ± 0.051	0.696 ± 0.075 ^A	0.696 ± 0.065 ^{DEF}
	p1	0.002	0.007	0.000
Face shape	Square	0.667 ± 0.058	0.662 ± 0.056	0.665 ± 0.057
	Round	0.650 ± 0.084	0.651 ± 0.078	0.651 ± 0.080
	Oval	0.644 ± 0.083	0.651 ± 0.077	0.648 ± 0.080 ^S
	Long	0.658 ± 0.063	0.657 ± 0.076	0.658 ± 0.070
	Heart	0.679 ± 0.069	0.683 ± 0.077	0.681 ± 0.072 ^S
	Diamond	0.677 ± 0.064	0.675 ± 0.081	0.676 ± 0.072
	p1	0.080	0.244	0.007
	Total	0.657 ± 0.075	0.658 ± 0.075	0.658 ± 0.075

p = *P* value calculated by unpaired Student *t*-test. p1 = *P*-value calculated by one-way ANOVA test

^{A-DES} = Similar letters/symbols mean significant difference between corresponding groups in the same column according to Tukey's test, $P \leq 0.05$ = statistically significant value

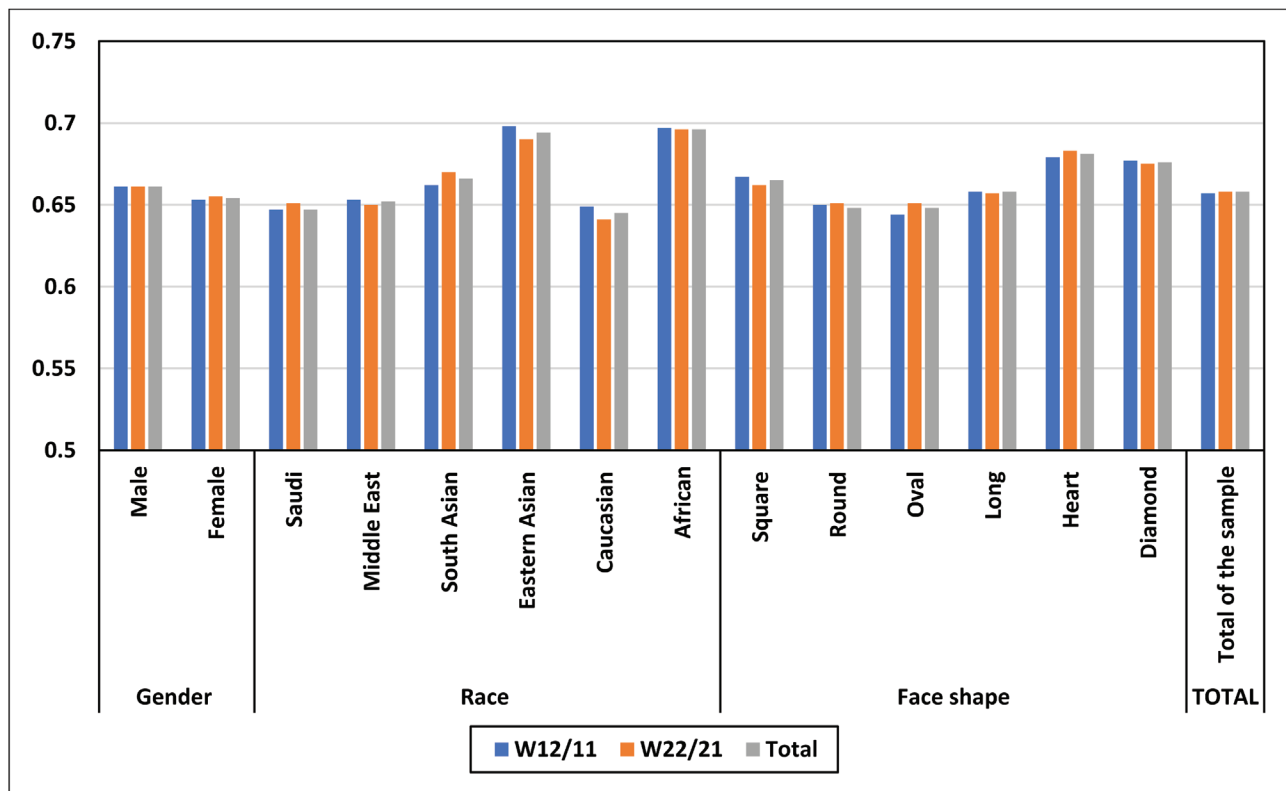


Figure 5: The mean of GP (W12/11 and W22/21) in relation to gender, race, and face shape

for South Asians, Eastern Asians, and Africans; apart from this, square, heart, and diamond face shapes were above the normal range [Table 3 and Figure 5].

Regarding the frequency of GS, there were no significant differences between male and female participants ($P = 0.523$), different races ($P = 0.066$), and different face shapes ($P = 0.144$) [Table 4].

Table 4: Frequency of golden standard in relation to gender, race, and face shape

Variables			W11/H11	W21/H21	Total	
Gender	Male	With G.S.	82	85	167	
		Above G.S.	93	90	183	
		Below G.S.	21	21	42	
	Female	With G.S.	82	81	163	
		Above G.S.	82	82	164	
		Below G.S.	24	25	49	
P		0.696	0.723	0.523		
Race	Saudi	With G.S.	77	79	156	
		Above G.S.	70	66	136	
		Below G.S.	18	20	38	
	Middle Easterner	With G.S.	35	37	72	
		Above G.S.	40	38	78	
		Below G.S.	9	9	18	
	South Asian	With G.S.	21	16	37	
		Above G.S.	29	31	60	
		Below G.S.	7	10	17	
	Eastern Asian	With G.S.	15	14	29	
		Above G.S.	13	14	27	
		Below G.S.	2	2	4	
	Caucasian	With G.S.	11	16	27	
		Above G.S.	11	11	22	
		Below G.S.	7	2	9	
	African	With G.S.	5	4	9	
		Above G.S.	12	12	24	
		Below G.S.	2	3	5	
	P		0.444	0.173	0.066	
	Face shape	Square	With G.S.	24	25	49
			Above G.S.	25	26	51
Below G.S.			6	4	10	
Round		With G.S.	33	39	72	
		Above G.S.	52	48	100	
		Below G.S.	13	11	24	
Oval		With G.S.	44	46	90	
		Above G.S.	47	48	95	
		Below G.S.	9	6	15	
Long		With G.S.	29	31	60	
		Above G.S.	29	24	53	
		Below G.S.	9	12	21	
Heart		With G.S.	13	11	24	
		Above G.S.	9	10	19	
		Below G.S.	4	5	9	
Diamond		With G.S.	21	14	35	
		Above G.S.	13	16	29	
		Below G.S.	4	8	12	
P			0.617	0.225	0.144	
Total of the sample		With G.S.	164	166	330 (43%)	
		Above G.S.	175	172	347 (45.2)	
	Below G.S.	45	46	91(11.8)		

p = P value calculated by χ^2 test

For the GP frequency of canines/laterals, there were significant differences between males and females (0.000), different races ($P = 0.017$), and different face shapes ($P = 0.009$) [Table 5 and Figure 6].

For the GP frequency of laterals/centrals, there were no significant differences between males and females (0.233). On the other hand, there were significant differences among different races ($P = 0.005$) and different face shapes ($P = 0.016$) [Table 5 and Figure 7].

For the total sample, the mean GS was 0.850 ± 0.093 with 43% of the measurements being within the normal range. The mean GP of canines/laterals was 0.775 ± 0.138 and for laterals/centrals it was 0.658 ± 0.075 with 14% and 34% of the measurements being within the normal GP range [Tables 1–3 and Figure 8].

DISCUSSION

Patients' speech as well as their aesthetics will be improved and this will be reflected in their public communications, which will, in turn, improve their quality of life.^[20] The GS and GP are important mathematical calculations used by prosthodontists, orthodontists, or lab technicians to design restorations and set up teeth in the most aesthetic positions. They are affected by different variables such as gender, facial characteristics, races, and geographical location. An

aesthetic smile was not one of the factors of selection for the participants; rather we chose a natural smile, as previous studies^[4,31] reported that GS and GP were not affected by aesthetic smiles.

For each case, frontal standardized photographs were taken at a fixed distance by using a digital camera; then, they were analyzed by a computer program. This method has many advantages, such as accurate and repeatable measurements, simplicity, and the ability to manipulate (as magnification) the photographs by using the computer program.^[21]

The upper central incisors greatly affect a patient's smile; their W/H ratio plays an important role in aesthetic appearance. When W/H equals 0.62 or 62%, the central incisor is identified to be in GS.^[32] However the most attractive aesthetic appearance can be achieved when W/H equals 75–85%^[9]. If W/H values are decreased, they will result in a tall narrow tooth; if they are increased, they will lead to a short broad tooth. The results of the present study concluded that the Saudi population in Makkah have more square central incisors (0.850 ± 0.093); most of the different races (Saudi, Middle East, South Asian, and Caucasian) have a more attractive appearance than Eastern Asians and Africans, and rounded, long, heart, and diamond faces are more attractive than square and oval faces.

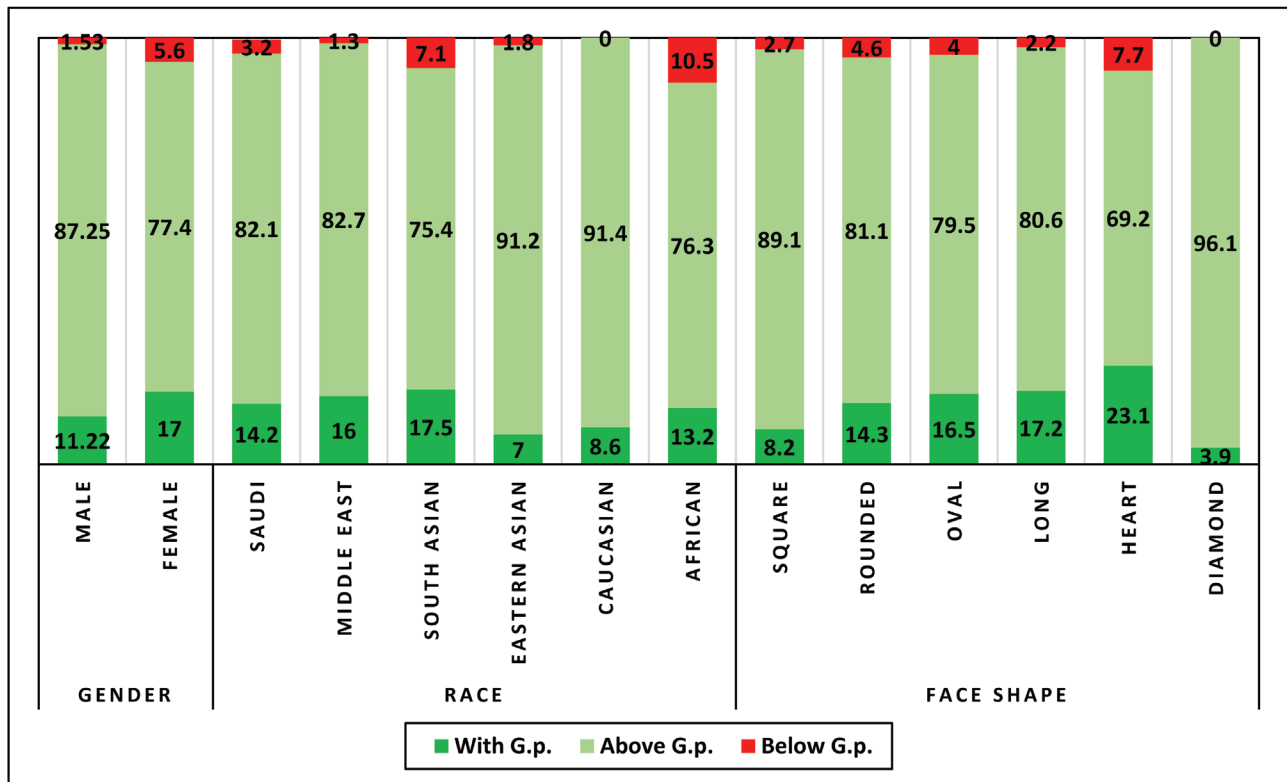


Figure 6: The percentage of GP (W13/12 and W23/22 in relation to gender, race, and face shape

The results of the current study indicated nonsignificant difference in mean GS values between right and left upper central incisors; there were no significant differences between male and female groups. Similar results were reported by different researchers.^[13,25]

Also, there were no significant differences between different face shape groups. On the other hand, the differences among different races were statistically significant [Table 1]. The percent of measurements within the normal GS range was comparable for males

Table 5: Frequency of the golden proportion in relation to gender, race, and face shape

Variables			W13/W12	W23/W22	Total	W12/W11	W22/W21	Total	
Gender	Male	With G.P.	22	22	44	70	65	135	
		Above G.P.	170	172	342	115	120	235	
		Below G.P.	4	2	6	11	11	22	
	Female	With G.P.	28	36	64	64	63	127	
		Above G.P.	149	142	291	105	111	216	
		Below G.P.	11	10	21	19	14	33	
p			0.074	0.003	0.000	0.260	0.750	0.233	
Race	Saudi	With G.P.	23	24	47	62	58	120	
		Above G.P.	138	133	271	85	94	179	
		Below G.P.	4	8	12	18	13	31	
	Middle Easterner	With G.P.	15	12	27	28	29	57	
		Above G.P.	67	72	139	48	48	96	
		Below G.P.	2	0	2	8	7	15	
	South Asian	With G.P.	8	12	20	22	17	39	
		Above G.P.	43	43	86	34	38	72	
		Below G.P.	6	2	8	1	2	3	
	Eastern Asian	With G.P.	0	4	4	6	5	11	
		Above G.P.	29	26	52	22	24	46	
		Below G.P.	1	0	1	2	1	3	
	Caucasian	With G.P.	3	2	5	13	13	26	
		Above G.P.	26	27	53	15	14	29	
		Below G.P.	0	0	0	1	2	3	
	African	With G.P.	1	4	5	3	6	9	
		Above G.P.	16	13	29	16	13	29	
		Below G.P.	2	2	4	0	0	0	
	p			0.040	0.172	0.017	0.064	0.346	0.005
	Face shape	Square	With G.P.	4	5	9	15	15	30
			Above G.P.	49	49	98	37	39	76
Below G.P.			2	1	3	3	1	4	
Round		With G.P.	13	15	28	41	37	78	
		Above G.P.	78	81	159	48	54	102	
		Below G.P.	7	2	9	9	7	16	
Oval		With G.P.	17	16	33	38	38	76	
		Above G.P.	79	80	159	50	54	104	
		Below G.P.	4	4	8	12	8	20	
Long		With G.P.	8	15	23	26	21	47	
		Above G.P.	59	49	108	39	41	80	
		Below G.P.	0	3	3	2	5	7	
Heart		With G.P.	7	5	12	7	7	14	
		Above G.P.	17	19	36	18	18	36	
		Below G.P.	2	2	4	1	1	2	
Diamond		With G.P.	1	2	3	7	10	17	
		Above G.P.	37	36	73	28	25	53	
		Below G.P.	0	0	0	3	3	6	
p				0.029	0.239	0.009	0.071	0.608	0.016
Total of the sample		With G.P.	50	58	108 (14%)	134	128	262 (34%)	
		Above G.P.	319	314	633 (82.4)	220	231	451 (58.7)	
	Below G.P.	15	12	27 (3.5)	30	25	55 (7.2)		

p = P value calculated by χ^2 test, $P \leq 0.05$ = statistically significant value.

and females (42.6% vs 43.3%). Eastern Asian has the highest GS percentage (48.3%) followed by Saudi (47.3%), Caucasian (46.5%), Middle East (42.9%), and South Asian (32.5%) and the least was the African (23.7%) [Figure 9].

In the current study, the W/H of upper centrals was close to the ideal 75–85% ratio, as the calculated ratios ranged from 82% to 88%. This range was comparable with previous studies that gave ranges from 76% to 86%. Hasanreisoglu *et al.*^[15] found it to be 82%, Wolfart *et al.*^[25] reported it to be 82%, and Parnia *et al.*^[33] stated that it

was 83%. The present results were not in agreement with those of Al-Marzok *et al.*,^[8] who found a great variation between the recorded and ideal W/H of anterior teeth, explaining that different complex factors may affect GS. Rosenstiel *et al.*^[14] suggested that GS can be used only with apparently long teeth and not normal or short ones.

The present results showed a very low prevalence of the ideal GP value (61.8%) among all participants from Makkah. The GP of canines/laterals and laterals/centrals was found only in nine (2.34% all participants) out of 384, fulfilling the ideal (1.618:1:0.618) rule. Similar results

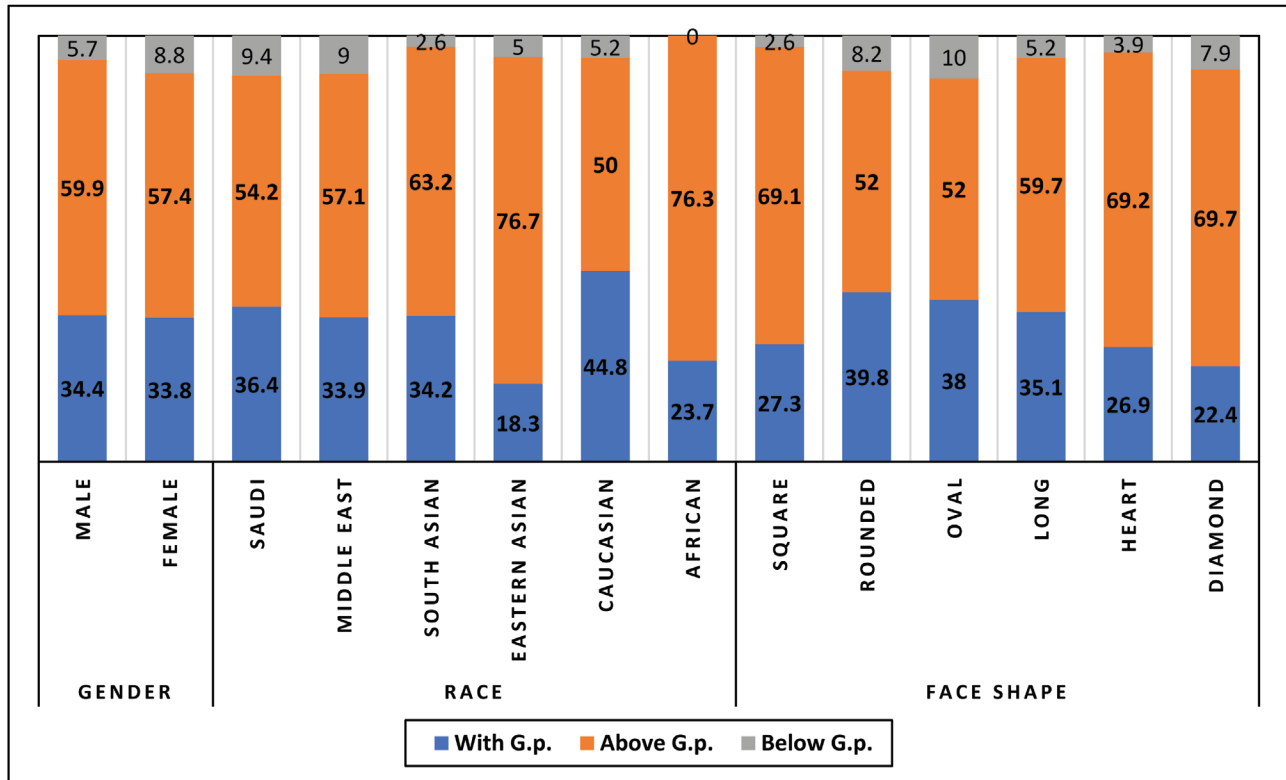


Figure 7: The percentage of GP (W12/11 and W22/21 in relation to gender, race, and face shape

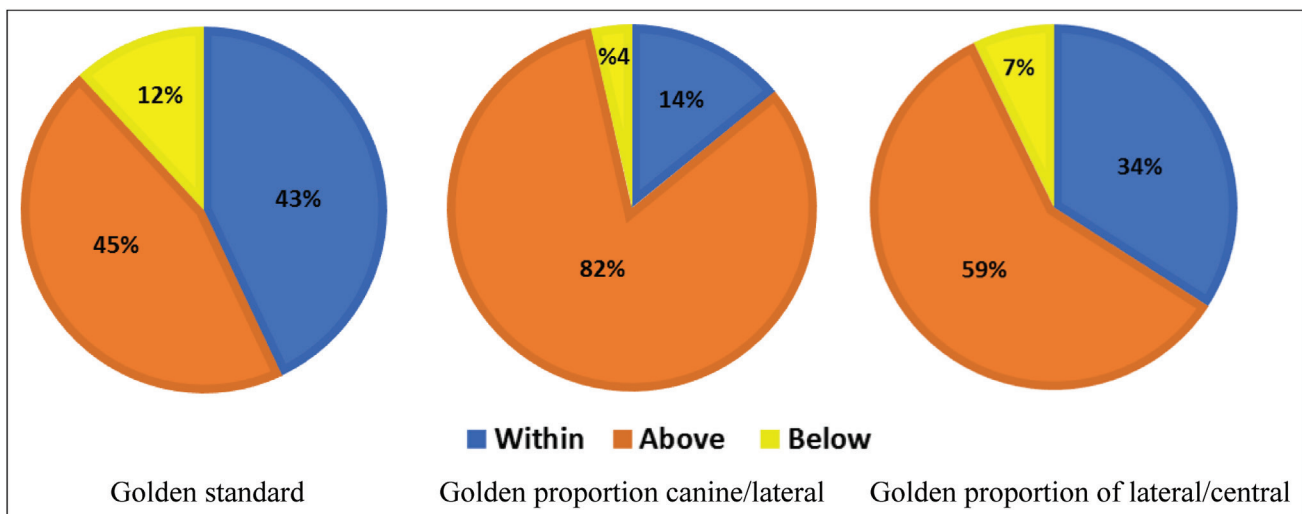


Figure 8: Pie chart showing the percentage of measurements within, above, and below the golden range

were obtained by other researchers^[5,8,10-12,31,33] studying different populations with age ranges such as that of the present study. Thus, GP might not be considered in dental treatment as many articles found that it did not exist. These results contrast previous studies carried out on Iraqi,^[13] Pakistani,^[34] and Indian participants.^[35] Also, the present results disagreed with the results reported by Kanaparthi *et al.*,^[36] who showed that GP is present between canines and laterals ratio in both male and female Saudi participants; these differences may be due to different methodologies and measurement methods. The current study and other research^[19,33] have proved that there is no golden ratio present but the ideal GS using W/H of maxillary central incisors is a dominating factor in aesthetic appearance.

When the GP was broadened in the present study to be 55% to 65% rather than a fixed value of approximately 62%, valuable results were obtained where 14% (11.2% males and 17% females) of the examined canine to lateral ratio was found to be within this new range [Figures 6 and 8]. Also, 34% (34.4% males and 33.8% females) of the lateral to central ratio was found to be within this range [Figures 7 and 8].

In relation to the GP frequency of canines/laterals, females have a higher percent than males (17% vs 11.22%); the South Asians have the highest GP

percentage (17.5%) followed by Middle Easterners (16%), Saudis (14.2%), Africans (13.2%), Caucasians (8.6%) and the least were the Eastern Asians (7%). This result may be due to the higher hairline in the south Asian race, as stated by Packiriswamy *et al.*^[37] The heart face has the highest GP percentage (23.1%), followed by long (17.2%), oval (16.5%), rounded (14.3%), square (8.2%) and the least was the diamond face shape (3.9%), as shown in Figure 6.

In relation to the GP frequency of laterals/centrals, males and females have a comparable percentage (34.4% vs 33.8%); Caucasians have the highest GP percentage (44.8%), followed by Saudis (36.4%), South Asians (34.2%), Middle Easterners (33.9%), Africans (23.7%) and the least were the Eastern Asians (18.3%). The rounded face has the highest GP percentage (39.8%), followed by oval (38%), long (35.1%), square (27.3%), heart (26.9%) and the least is the diamond face shape (22.4%), as shown in Figure 7.

So, optimum aesthetics can be achieved by applying local measurements and racial characteristics rather than blindly calculating GP values, as stated by Forster *et al.*^[19] The results of the current study indicated that for the Saudi population in Makkah, the aesthetic proportion can be generalized as a canine to lateral ratio of 77.5% and a lateral to central ratio of 65.8%

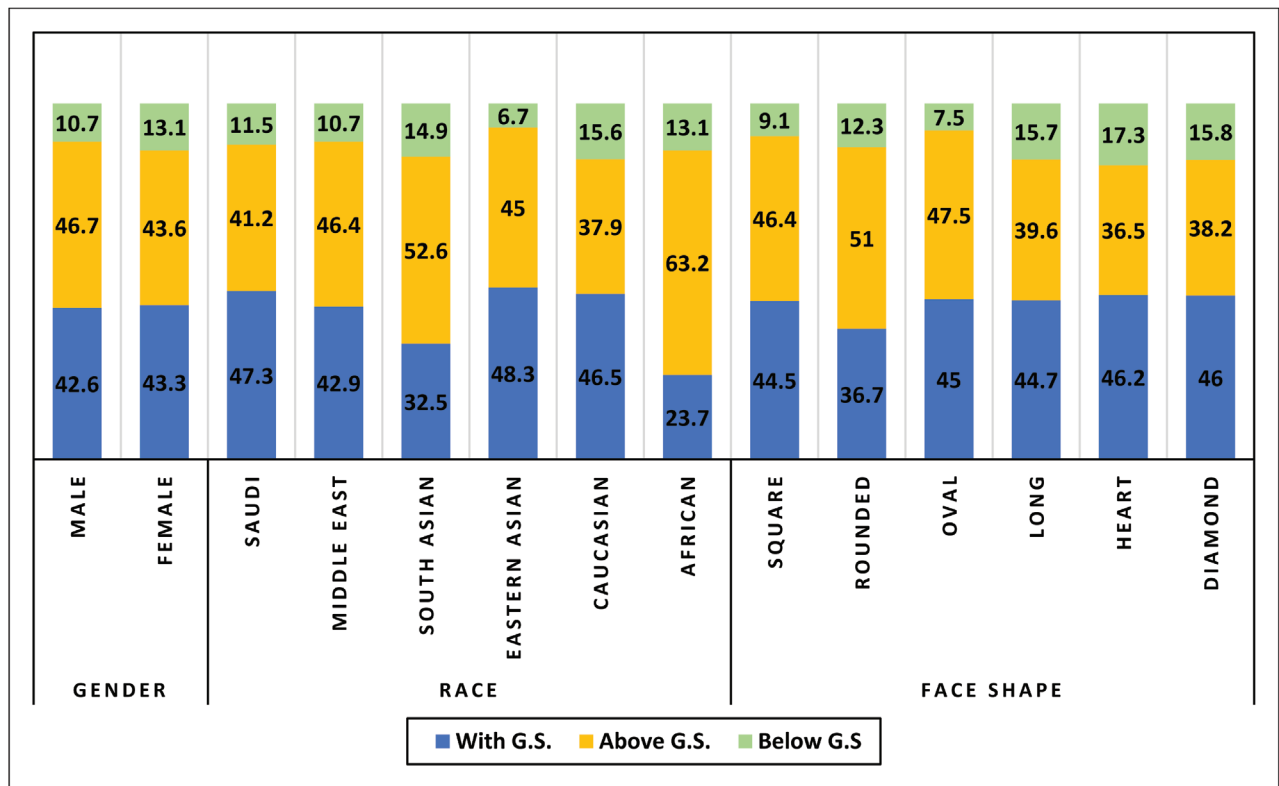


Figure 9: The percentage of GS in relation to gender, race, and face shape

and they considered ideal ratios for all races and face shapes.

The GS and GP of the total participants in the present study were different from those obtained in the most recent studies.^[38,39] The GS and GP were significantly different among different face shapes [Tables 1–3]. These findings were in disagreement with the results obtained by Rokaya *et al.*,^[38] who concluded that: GS was 90% for upper central incisors; GP was 66% for laterals/centrals, 70% for canines/laterals; and there were no differences among different face shapes in the Nepalese population. Melo *et al.*^[39] reported that the GS was 92.4% for centrals; GP was 61.6% for laterals/centrals and 83.2% for canines/laterals in the Spanish population. These differences may be attributed to the differences of the study population and study methodology. These previous findings support the results of the present study, as these golden ratios cannot be generalized as a standard for the different populations.

The variations in GS and GP may be due to genetic properties that are affected by race; thus, race may affect teeth dimensions, proportions, and face shapes. However, these results may be due to the special characteristics of the Makkah population: Different races had intermarried and stayed there due to the entire Muslim population considering Makkah a holy place.

According to these results, a patient who comes to a dental clinic seeking cosmetic dental rehabilitation should not be treated based on the mathematical calculation of GP values; rather, the patient should be treated based on his/ her facial and personal characteristics and preference to obtain an aesthetically attractive smile.

STUDY LIMITATION

There are some limitations of the present study, such as sample size, exclusion criteria, and measurements that were done only on a computer screen without any indirect measurements on the casts or directly on the patient's mouth.

CONCLUSION AND CLINICAL SIGNIFICANCE

Within the limitations of the current study, the following conclusions can be drawn:

1- The GS (W/H of upper central incisor teeth) was found to be the most prevalent among the Saudi population in Makkah and it was not affected by gender, race, or face shape. However, the frequency of the GP was very low and it differed among different races and face shapes.

2- The GS for the Saudi population was 85% (ranged from 82% to 88%); the GP was 65.8% (ranged from 64.5% to 69.6%) for the laterals/centrals ratio and 77.5 (ranged from 73.9% to 85.9%) for the canines/laterals ratio.

3- Although dentists should follow aesthetic principles during prosthodontics treatment, the GP should not be a regular mathematical calculated value, but personal characteristics and dento-facial specifications should be considered to obtain maximum aesthetics of anterior teeth.

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Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally, this included study design and conception, data retrieval and analysis as well as writing and reviewing the final paper.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

The study was approved by the Institutional Review Board (IRB), College of Dentistry, Umm AlQura University (registration number: 147-19) and all the procedures have been performed as per the ethical guidelines laid down by Declaration of Helsinki (2000).

PATIENT DECLARATION OF CONSENT

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/ have given his/ her/ their consent for his/ her/ their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

DATA AVAILABILITY STATEMENT

The collected data that support the findings of this study are available from the corresponding author upon request.

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