The assessment of Golden and Red Proportions among a North-African population

L'évaluation des proportions dorées et rouges au sein d'une population Nord-Africaine

Rim Kallala[1], Yosra Gassara[1], Behaeddine Garrach[2], Soumaya Touzi[1], Belhassen Harzallah[1]

1. Faculty of Dental Medicine, University of Monastir, Research Laboratory of Occlusodontics and Ceramic Prostheses LR16ES15, 5000 Monastir, Tunisia
2. Faculty of Medicine ,University of Monastir,Tunisia

ABSTRACT

Introduction: The constant increase of both esthetic demands and advancement in materials and technologies have led to the development of guidelines to achieve optimal aesthetic results. These tools are useful to predict the teeth proportion and dimensions. Golden and Red proportion are the most described theories.

Aim: of present study was to evaluate the existence of both Golden and Red proportion in the maxillary anterior teeth among a North-African population.

Methods: This was an observational study performed at the Fixed Prosthetic department of the dental clinic of Monastir, Tunisia. The study included participants with full intact anterior dentition. Those with diastema or teeth crowding were excluded. For each one, an alginate impression was done. Measures were, including the perceived width and length, have been taken on casts using digital caliper. Width ratios of maxillary lateral incisor to maxillary central incisor and lateral incisor to canine were calculated.

Results: The study included 100 Tunisian participants including 97 females and 21 males. The maxillary central incisors were the largest (8.60±0.58mm) and the longest (99.71±1.14mm). The ratio was 0.89±0.09mm. Anterior teeth dimensions were not statistically not different between males and females. Significant differences were observed between calculated ratios with GP and to each other's. (p=0).

Conclusions: Either GP nor RP is applicable amongst the Tunisian Population.

Key words: Dental esthetic, Incisor, Teeth, Tunisia,

RÉSUMÉ

Introduction: Les dents antérieures maxillaires sont les dents les plus impliquées dans l'attractivité du sourire grâce à leurs positions frontales par leur taille, leur forme et ainsi aux leurs arrangements. Les chercheurs ont suggéré les proportions dorées et rouges qui constituent des théories mathématiques permettant de déterminer les dimensions des dents antérieures afin d'établir des lignes directrices et de créer un sourire naturellement agréable.

Objectifs: L'objectif de la présente étude était d'évaluer l'existence de la proportion d'or et de rouge pour les dents antérieures maxillaires au sein de la population tunisienne.

Méthodes: Il s'agit d'une étude transversale réalisée au service de prothèse fixe de la clinique dentaire de Monastir, en Tunisie. L'étude a inclus 100 participants tunisiens dont 97 femmes et 21 hommes. Pour chaque participant, une empreinte à l'alginate a été réalisée. Les mesures, y compris la largeur et la longueur perçues, ont été prises sur des moulages à l'aide d'un pied à coulisse numérique.

Résultats: Les dimensions des dents antérieures n'étaient pas statistiquement différentes entre les hommes et les femmes. Des différences significatives ont été observées entre le rapport de proportion Golden et Red et le rapport de largeur des dents antérieures (valeur p < 0,05).

Conclusion : Les deux proportions dorée et rouge ne sont pas applicables au sein la population Tunisienne.

Mots clés: Dents antérieures, Proportion dorée, Proportion rouge, Population tunisienne, Rapport, largeur, longueur, dimensions.

Correspondance
Rim Kallala
University of Monastir, Research Laboratory of Occlusodontics and Ceramic Prostheses LR16ES15, Monastir, Tunisia. Department of Fixed Prosthodontics of the Dental Clinic of Monastir, Monastir, Tunisia.
Email: dr.kallalarim@gmail.com

INTRODUCTION

The constant advancement in dental materials and technologies, with the increase of esthetic demands have led to the development of guidelines (1-3). These tools are used to predict the teeth proportion and dimensions, especially for maxillary anterior teeth as they are the most involved in both dental and facial esthetics (2, 4).

Various geometrical and mathematical theories were suggested by researchers (5). Golden proportion (GP) and Red proportion (RP) are the most known theories (6, 7) which could offer guidelines for the smile design (7). The concept of GP was inspired by the theory which states that a relationship exists between nature and mathematics (7). Leonardo da Vinci established a GP of 0.618:1 (62%) between body parts of and published drawings based on this (8). Lombardi, in 1973, was the first who applied this theory in dentistry (7, 6). Levin (6) suggested that, from the front, the apparent width of the maxillary lateral incisor presents about 1.618 of the apparent width of the maxillary central incisor. However, the apparent width of the maxillary canine presents 0.618 of the apparent lateral incisor width.

The recurring esthetic dental proportion (RP), proposed by Ward, establish a constant width proportion between successive maxillary teeth viewed from the front progressing distally (6).

Many studies (2, 6-10) were conducted to check their validity amongst different populations reporting both their approval and disapproval. A systematic review reported that, in natural smiles, the existence of the GP is a myth (1). Among the North-African population, no previous data are available. Thus, the present study aimed to assess the existence of both GP and RP amongst a sample of Tunisian population.

METHODS

Study design

The present study was conducted from August to November 2021 at the Fixed Prosthetic department of the dental clinic of Monastir, Tunisia. It was conducted according to the STROBE guidelines (11). Sample size was calculated using following formula:

N= (Z score)^2 *SD*(|1- SD|) / (error margin percentage)^2

The confidence interval and error margin were respectively set to 95 % and 6%. The standard deviation of was equal to 0.92 according to Abdulaziz S. Alqahtani et al (5). The sample size was calculated to 78.

Ethical clearances were obtained from the ethical committee of the faculty of dental medicine Monastir, Tunisia. All Participants were clearly informed by the study protocol.

Study population

During the elaboration of the study, all patients consulting the cited department above were included. For each one, a careful intra oral examination was performed. Following non -inclusion criteria were, then applied for the selection: More than 40 years, presence of restored decayed or crowned anterior teeth, previous orthodontic treatment, interdental spacing or crowding and passive gingival eruption.

Protocol and measurements

For each participant, an alginate (Algimajor – Major) impression was taken. On casts, using a sharp-edged digital caliper (Mitutoyo, 500/196/30 AOS, Absolute-Caliper (0e6), Illinois, USA), width (W) and length (L) of all anterior teeth were measured by a qualified subject (RK in the authors list) three times. For the accuracy and calibration, the constant values were used. The width (W) was measured between contact zones along a line perpendicular to the longitudinal axis of the tooth. The height or length (L) was measured from the gingival zenith to the incisive edge for the incisors, and to the canine tip for the canines along the longitudinal axis (Figure1). To assess the incidence of the GP, width ratios for maxillary lateral to central incisors and lateral incisor to canine were calculated and, then, compared to the GP of 0.618 and 1.618 respectively. Concerning the RP, the ratios were compared to each other's.

Data analysis. All data were collected, and then analyzed using SPSS software 21. Data normality was checked through Kolmogorov Smirnov test. Descriptive results including the mean (M), the maximum (MAX), the minimum (MIN) and standard deviation (SD) of both widths and lengths were calculated. Matched sample t-tests were used to compare measurements between right and left sides. Anova test was used to compare the measurement between three sites. Independent sample t-tests were used to compare width and height between males and females. To assess the incidence of the GP and RP, one sample t and independent t tests were respectively used. The significance level was fixed at α = 0.05.

RESULTS

All results are summarized in tables 1-5. The main findings are:

A total of 100 participants were included in the study (97 females and 21 males) aged between 19 and 35 years.

- For anterior teeth widths and lengths, statistically not significant differences were observed between right and left sides except for the canine width (Table 1).

- The maxillary central incisors were the largest (8.60±0.58mm) and the longest (9.71±1.14mm). The ratio was 0.89±0.09mm (Table 2).

Table 1. Dimensions of Maxillary anterior teeth per site (in millimeters)

		Right central incisor	Left central incisor	Right Lateral incisor	Left lateral incisor	Right canine	Left canine
Width	**Min**	7.39	7.40	5.28	5.13	6.77	6.00
	Max	9.86	9.85	8.00	8.70	9.11	8.90
	Mean ±Sd	8,63±0.6	8.56±0.56	6.71±0.59	6.60±0.62	7.79±0.52	7.62±0.55
	p		0.12*		0.19*		0*
Length	**Min**	6.70	6.90	5.83	4.90	5.70	5.60
	Max	13.20	13.12	10.30	10.80	11.99	11.60
	Mean ±Sd	9.70±1.11	9.70±1.08	7.76±0.90	7.83±1	8.55±1.09	8.65±1.14
	p		0.9*		0.3*		0.12*

*: Independent t test to compare widths and lengths between left and rights sides

Table 2. Maxillary anterior teeth dimensions per side (millimeters)

	Central incisor	Lateral incisor	Canine	p
W	8.60±0.58	6.66±0.6	7.7±0.53	0*
L	9.71±1.14	7.80±0.95	8.62±1.11	0*
Ratio	0.89±0.09	0.86±0.09	0.90±0.09	0*

* : Anova test to compare measurements between the three sites

- About teeth dimensions and ratios, statistically not significant differences were observed between males and females (Tables 3).

- Calculated width ratios for lateral to central incisors and lateral incisor to canine differences significantly (P=0) from the GP (Table 4). It means that the GP is not applicable among the studied population.
- Calculated width ratio of lateral incisor to central incisor with the width ratio of canine to lateral incisor differences significantly from each other (P=0) (Table 4). It means that the RP is not applicable among the studied population.

Table 3. Gender wise distribution of maxillary anterior teeth's width and length (millimeters)

	Mean width ±SD			Mean Length ±SD			Mean Ratio ±SD		
	Male	Female	p*	Male	Female	p*	Male	Female	p*
Central incisor	8.57±0.55	8.16 ±0.56	0.8	9.84±0.96	9.65±1.15	0.48	0.87±0.07	0.89±0.09	0.35
Lateral incisor	6.8±0.38	6.60±0.5	0.16	7.9±0.75	7.77±0.9	0.32	0.85±0.06	0.85±0.1	0.85
Canine	7.8±0.6	7.68±0.46	0.36	8.88±1.5	8.56±0.93	0.34	0.89±0.11	0.9±0.09	0.55

*: Independent t test to compare widths between males and females

Table 4. The assessment of both GP and RP

	Mean ±SD	The assessment of GP	The assessment of RP
Ratio		p	p
W 12/11	0.78 ±0.06	0.00 *	0.00***
W 13/ 12	1.16±0.08	0.00**	
W 22/21	0.77±0.06	0.00 *	0.00***
W 23/ 22	1.16±0.095	0.00**	

*: Independent t-test comparing with the Golden Proportion (1.618)
**: Independent t-test comparing with the Golden Proportion (0.618)
***: One sample matched t-test comparing both successive ratios
w:width; 11: maxillary right central incisor ;12: maxillary right lateral incisor; 21: maxillary left central incisor 22: maxillary left lateral incisor ;13: right canine; 23: maxillary left canine

Scope of the study

The restoration of maxillary anterior teeth is always considered as a challenging task and requires a deep analysis of the clinical situation. A careful attention, should be attributed to their dimensions and proportion. Suggested tools are useful to predict them through mathematical calculations directly or digitally by software's of smile design (12).
Both GP and RP were assessed in various populations (2, 6-10). No previous one was conducted in North-Africa. Thus, the present study aimed to investigate their suitability among a Tunisian population.

Discussion of results

In the present study, the mean widths of maxillary anterior teeth were 8.6, 6.6 and 7.7 mm respectively for central incisor, lateral incisor and canine. Mean lengths were 9.68, 7.8 and 8.62 mm for respectively central incisor, lateral incisor and canine. Findings are close to those reported by previous studies among different populations (5, 13-16) (Table 5). Minor variations could be attributed to the ethnic difference between populations.

DISCUSSION

The overall results showed that GP does not exist between maxillary anterior teeth as statistically differences were observed after the comparison between teeth width ratio and golden ratios. The same conclusions are deduced for the RP after the comparison between ratio of teeth widths to each other's.

Table 5. Anterior teeth dimensions according to several studies

		Isa ZM et al (13)	Marcuschamer E et al (14)	Sah SK et al (15)	Kolte AP et al (16)	Alqahtani AS et al (5)
Year of the study		2010	2011	2014	2016	2021
Population		Turkish	Asian	Chinese	Indian	Saudi
Central Incisor	W	8.6	8.63	8.15	7.63	8.74
	L	9.6	11.93	9.39	8.47±0.9	9.84
Lateral Incisor	W	6.7	8.63	6.64	8.11	6.64
	L	8.17	10.52	7.86	9±0.96	8.09
Canine	W	7.7	7.91	7.62	7.28	7.82
	L	9.05	11.83	8.9	8.22±0.94	9.08
Sample size		100	264	100	200	160

The comparison of teeth widths between left and right sides showed statistically not significant differences for all anterior teeth except the canine width. The same founding was reported by Chu et al (17) and Mavroskouvis and Ritchei (18). However, Abdulaziz S et al (5) and Sanjay Kumar SAH et al (15) reported similar dimensions between left and right sides. Besides, statistically not significant differences were observed between males and females for both width and height of maxillary anterior teeth. Nevertheless, Alqahtani et al (5) found noticeable difference between the two gender only for length and reported significant differences only for canine. Also, Sanjay Kumar SAH et al (15) reported statistically significant differences between the two genders. The

meta-analysis of Londono et al (1) showed that men exhibited greater canine to lateral width ratio than women.

The current study showed that GP was not applicable for maxillary anterior teeth. Consequently, this relationship between seems to be not applied in the Tunisian population. Finding reported by previous studies conducted among different populations are similar (6, 10, 19, 20, 21-24). Researchers agreed that the use GP is theoretical (5). In fact, it was considered as a reliable tool to determine the width of the maxillary central incisors (3). The adherence to a stuked proportion for all patients seems too impractical (25). When designing smiles, ethnic and cultural differences should be taken into consideration (1).

Preferences are complex and generally supported by beliefs and relationships (1). The GP seems to be strict and rigid to be applied in dentistry (6). That's why, Ward proposed the RP which establish a constant width proportion between successive maxillary teeth offering the possibility to match teeth features with facial proportions (15). The advantage that it is not stuck into 62% ratios like the GP. It includes all ratios from 60 to 80% allowing more flexibility (5).

The present study reports also, that the RP seems to be invalid among the Tunisian population. Many studies are in agreement with these founding among the Kerala (24) Iranian (6) and Bangladeshi (19) populations. Some authors suggested using facial measurements in order to perform natural teeth dimensions (26).

Although, previous studies are in agreement with the present one, it seems unsuitable to calculate the widths ratio and compare them together. The RP should, thus, be assessed individually (6).

Discussion of the methodology

For this study, the sample size (n=100) appears to be acceptable comparing to other studies (6, 19). It was slightly higher than size of a previous studies (10, 21). For the measurement protocol, it was preferred that measurements were taken by only one operator to avoid the inter-examiner variability. For more accuracy, they were performed three times.

To assess the RP, Shetty et al (9) have defined three categories of central incisors "*small*", "*medium*", and "*tall*" and calculated ratios in each category. This subdivision could provide more precise results.

Study limitations

The study limitations were relevant to the measurement protocol. First, it would be more precise if the length has been measured from the cemento-enamel junction instead of the gingival margin (14,27). Then, tooth width would be more precise if width were digitally measured on images (5, 6, 24). Nevertheless, it is a first investigation amongst a North African population which could provide useful data regarding anterior teeth dimensions.

CONCLUSION

Both GP and RP between widths of maxillary anterior teeth were not applicable among the Tunisian Population. Their universal use could not be systematically applied. when restoring patients' smiles, dentists should update their esthetic concepts. Whatever, the used concept, the appropriate communication with the patient is essential to ensure his satisfaction.

List of abbreviations
GP: Golden Proportion
RP: Red Proportion
M: Mean
MAX: maximum
MIN: minimum
SD: standard deviation
W: width
L : length

REFERENCES

1. Londono J, Ghasemi S, Lawand G, Dashti M. Evaluation of the golden proportion in the natural dentition: A systematic review and meta-analysis. J Prosthet Dent. 2023;129(5):696-702.

2. Aldegheishem A, Azam A, Al-Madi E, Abu-Khalaf L, Bani Ali B, Anweigi L. Golden proportion evaluation in maxillary anterior teeth amongst Saudi population in Riyadh. Saudi Dent J. 2019;31(3):322-9.

3. Kallala R, Chaouch MH, Nasr K, Courset T. Step-by-Step Esthetic Rehabilitation with Chairside System. Case Rep Dent. 2021;2021:5558158.

4. Hasanreisoglu U, Berksun S, Aras K, Arslan I. An analysis of maxillary anterior teeth: facial and dental proportions. J Prosthet Dent. 2005;94(6):530-8.

5. Alqahtani AS, Habib SR, Ali M, Alshahrani AS, Alotaibi NM, Alahaidib FA. Maxillary anterior teeth dimension and relative width proportion in a Saudi subpopulation. J Taibah Univ Med Sci. 2021;16(2):209-16.

6. Azimi M, Dinparvar M, Teimourian H, Farhadian M. Evaluating Recurring Esthetic Dental Proportion (RED) and Golden Proportion in Natural Dentition. Avicenna J Dent Res. 2016;9(1):e30267.

7. Tarek R. Esthetic Dental Proportions and Measurements Comprising a Natural Esthetic Smile: A Literature Review. Saudi J Oral Dent Res. 2021;6(6):270-3.

8. Wagh SA, Mantri SS, Bhasin A. Evaluation of maxillary anterior teeth proportion with Chu's Gauge in a population of Central India: an in vivo study. Med Pharm Rep. 2020;93(1):75-80.

9. Shetty S, Pitti V, Satish Babu C, Surendra Kumar G, Jnanadev K. To evaluate the validity of Recurring Esthetic Dental proportion in natural dentition. J Conserv Dent. 2011;14(3):314-7.

10. Al-Marzok MI, Majeed KRA, Ibrahim IK. Evaluation of maxillary anterior teeth and their relation to the golden proportion in malaysian population. BMC Oral Health. 2013;13(1):9.

11. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg. 2014;12(12):1495-9.

12. Silva AO, Fabre HSC, Ursi WJS, Hoeppner MG, Do Amaral ALM. Anterior Upper Teeth Golden Proportion Analysis with Millimetric Templates: An Invention Developed at Londrina State University. Int J Dent. 2022;2022:1520812.

13. Isa ZM, Tawfiq OF, Noor NM, Shamsudheen MI, Rijal OM. Regression methods to investigate the relationship between facial measurements and widths of the maxillary anterior teeth. J Prosthet Dent. 2010;103(3):182-8.

14. Marcuschamer E, Tsukiyama T, Griffin TJ, Arguello E, Gallucci GO, Magne P. Anatomical crown width/length ratios of worn and unworn maxillary teeth in Asian subjects. Int J Periodontics Restorative Dent. 2011;31(5):495-503.

15. Sah SK, Zhang HD, Chang T, Dhungana M, Acharya L, Chen LL, et al. Maxillary anterior teeth dimensions and proportions in a central mainland chinese population. Chin J Dent Res. 2014;17(2):117-24.

16. Kolte AP, Kolte RA, Pajnigara NG, Pajnigara NG. A Clinical and Radiographic Assessment of Positional Variations of Gingival Papilla and Its Proportions. Int J Periodontics Restorative Dent. 2016;36(2):213-8.

17. Chu SJ. Range and mean distribution frequency of individual tooth width of the maxillary anterior dentition. PPAD. 2007;19(4):209-15.

18. Mavroskoufis F, Ritchie GM. Variation in size and form between left and right maxillary central incisor teeth. J Prost Dent. 1980;43(3):254-7.

19. Aziz M, Hossain MZ. Validity of mathematical proportions in maxillary anterior teeth among Bangladeshi population. APOS Trends Orthod 2017;7:41-8.

20. Swelem AA, Al-Rafah EM. Evaluation of "Golden Proportion" in Saudi individuals with natural smiles. Saudi Dent J. 2019;31(2):277-83.

21. Murthy BV, Ramani N. Evaluation of natural smile: Golden proportion, RED or Golden percentage. J Conserv Dent. 2008;11(1):16-21.

22. Ali Fayyad M, Jamani KD, Agrabawi J. Geometric and mathematical proportions and their relations to maxillary anterior teeth. J Contemp Dent Pract. 2006;7(5):62-70.

23. Amuasi AA, Acheampong AO, Owusu S, Larmie R, Sabbah DK, Buabeng A-R, et al. Evaluation of the Golden Proportion in Patients Visiting the Oral Health Directorate of the Komfo Anokye Teaching Hospital, Kumasi. J Biosci Med. 2020;08(08):116-26.

24. Baghiana G, Peter D, Manju V, Babu AS, Krishnan V. Relevance of Recurring Esthetic Dental (RED) proportion and golden proportion among patients attending a tertiary care center at Kochi, Kerala. J Oral Biol Craniofac Res. 2022;12(6):890-3.

25. Chander NG, Kumar VV, Rangarajan V. Golden proportion assessment between maxillary and mandibular teeth on Indian population. J Adv Prosthodont. 2012;4(2):72-5.

26. Esan TA, Oziegbe OE, Onapokya HO. Facial approximation: evaluation of dental and facial proportions with height. Afr Health Sci. 2012;12(1):63-8.

27. Magne P, Gallucci GO, Belser UC. Anatomic crown width/length ratios of unworn and worn maxillary teeth in white subjects. J Prost Dent. 2003;89(5):453-61.