Eur. J. Prosthodont. Rest. Dent., Vol.19, No. 2, pp 85-89
Printed in Great Britain

doi:10.1922/EJPRD_946Singh05

A Study on the Practical Applicability of the Rule of Golden Rectangle in Dental Aesthetics

Dr Ronauk Singh*, Dr Arvind Tripathi†, Dr Saumyendra V. Singh‡ and Dr Atul Bhatnagar*

Abstract - *Maxillary central incisors are of critical value in the aesthetics of a smile. The Golden Rectangle ratio concept may play an important role in selecting the optimum width and length of this tooth. The aim of the study was to investigate the existence of this ratio among individuals with natural dentition and to validate its role in aesthetic oral rehabilitation. The clinical crown length of the maxillary left central incisor (CI) and combined crown width of the maxillary left and right CI of 70 subjects were measured. The crown width to crown length ratio was calculated and compared with the Golden Rectangle ratio and statistically analysed. Eighty percent of the subjects varied within 2 standard deviations of the ratio of 1.618. No statistically significant influence of gender on the ratio was observed. Golden rectangle was found to have a significant relationship with aesthetic appearance of maxillary central incisors.*

KEY WORDS: Golden Rectangle, aesthetic ratio, maxillary central incisors.

INTRODUCTION

Anterior dento-labial aesthetics is one of the primary considerations for patients seeking prosthodontic treatment. The development of new dental materials and techniques has led to a greater number of treatment options that seek to maximize the likelihood of an attractive outcome. An important aspect of dento-labial aesthetics is the size and form of the maxillary anterior teeth. For an aesthetic restoration or prosthesis, the maxillary anterior teeth should restore optimal dento-labial relationship in harmony with the overall facial appearance.

A checklist for aesthetic restorative success was presented in 1979 and recently updated[1, 2]. It encompassed the objective principles of dental and gingival aesthetics as well as subjective aesthetic integration of frame of the smile, face and the individual.

The definition of ideal tooth dimensions, however, remains a difficult task due to individual variations and proximal or incisal tooth wear. To provide "magic numbers" for the clinician, mathematic theorems such as the "golden proportion"[3, 4] and the "golden percentage"[5] have been proposed, taking into account classic elements of art and architecture. These rules were applied to the apparent size, as viewed directly from the anterior. Lombardi[3], was the pioneer to suggest the application of golden proportion in dentistry. In addition he described the use of "repeated ratio" in maxillary anterior teeth. Levin [4], also suggested the golden proportion in dentistry and related it with successive width of anterior teeth as viewed from labial aspect, he also devised a grid to evaluate and develop harmonious proportion of teeth in relation to golden proportion. However, studies done by Preston [6] & Gillen [7] confirmed the unrealistic nature of the golden rule in this specific context. Further, Magne & Belser [2] observed excessive narrowness of the maxillary arch and compression of lateral segments in situations where strict adherence to the golden proportion rule was followed. It was stated that tooth height, crown width/length ratios, transition line angles, and other special effects of tooth form are likely to influence the perception of symmetry, dominance, and proportion.

Among the aforementioned parameters, measurements of width/length ratios of normal clinical crowns seem to represent the most stable reference; a homogeneous ratio (~80%) was found by Sterrett *et al* [8] for the three anterior maxillary tooth groups. More recently, Marquardt [9] has done much in relating dentofacial proportions and aesthetics; he suggested the concept of Golden Rectangle according to which the height of central incisors is in golden proportion to combined width of maxillary centrals having a value of 1:1.618 (Fig 1).

The purpose of this work was to analyse the combined width to length ratio of central incisors and compare it with the concept of golden rectangle.

MATERIALS AND METHODS

A morphometric study of maxillary central incisors was conducted on student volunteers from Saraswati Dental College Hospital & Research Centre, Lucknow, U.P. India. The participation in the study by student subjects was through informed written consent. Ethical clearance was obtained from the institutional ethical committee for conducting the study.

The inclusion criteria were (1) no missing maxillary or mandibular anterior teeth; (2) no gingival or periodontal conditions or therapy that would undermine a healthy

* MDS (Prosthodontics)
† MDS (Prosthodontics) FACS FACP
‡ MDS (Prosthodontics) FISE

tissue-to-tooth relationship; (3) no interdental spacing or crowding; (4) no anterior restoration; and (5) no history of orthodontic treatment. Exclusion criteria eliminated subjects with (1) evidence of gingival alteration or dental irregularities; (2) apparent loss of tooth structure due to attrition, fracture, caries, or restorations. The study was conducted on 70 subjects (39 male and 31 female), who were within the age group of 18-22 years (mean age of 20 years). Prior to the study, subjects were not evaluated for the presence of an aesthetic or non-aesthetic smile.

To estimate the size of clinical crown of the maxillary central incisors, measurements for facial width and height (in millimeters) of each tooth (in-vivo) were made. A digital vernier calipers with a sensitivity of + 0.01mm was employed for the purpose (Aerospace Pvt Ltd, Thailand, Figure 2).

The width dimension was recorded by measuring the maximum distance between the mesial and distal contact points of the tooth on a line perpendicular to the long axis. Height was recorded as the longest distance from the cervical gingival margin to the incisal edge of the tooth on a line parallel to the long axis (Figure 3).

Casts and Photographs were not used to measure the above as according to a recent study (Hasanreisoglu *et al* 2005)[11], they gave inaccurate measurements.

In the present study evaluation regarding the occurrence of the golden rectangle proportion was conducted for the two central incisors, by dividing the combined widths of the maxillary central incisors (W^c) to the length (L) of the maxillary central incisor; the thus calculated values were then compared with the expected golden rectangle ratio values of the related teeth. The combined width-to-height ratios computed for the two maxillary central incisors, were also compared on the basis of gender. Additionally, width-to-height ratios of central incisors were compared to the 80% ratio proposed as the most aesthetically pleasing by some authors[7]. Lastly, three non-dental observers were employed to obtain subjective opinion on the aesthetic value of maxillary central incisors during smile as aesthetic (pleasing) or non-aesthetic (non-pleasing) based on their own visual perceptions. The reason for selecting three observers was to bring about objectivity in the subjective perception of aesthetics by three different observers. Agreement of at least two observers on the outcome (aesthetics / non-aesthetic appearance) was taken as the final result.

The data were analysed by comparing the calculated value for each proportional relationship with the related constant proposed for both genders. All measurements were performed by 2 non-calibrated investigators working independently. The 5 sets of measurements were compared. When they varied by 0.2mm or less, the measurements were aver-

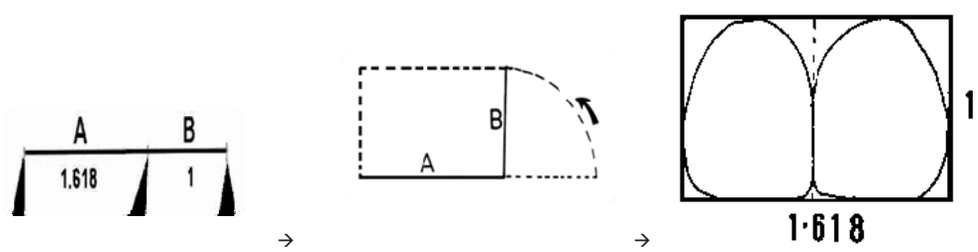

Figure 1. *Golden Rectangle Ratio Concept.*

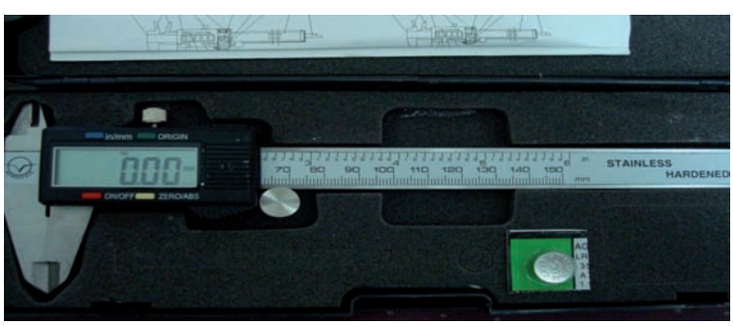

Figure 2. *Digital Vernier Calipers .*

Figure 3. *Method to note the readings*

aged; if they differed by more than 0.2 mm, the procedure was repeated. Statistical analysis (Bivariate correlation) using SPSS (Statistical Package for Social Sciences) Version 15.0 statistical Analysis Software, was performed to evaluate the existence of golden rectangle ratio and a 2 sample t-test was performed to determine whether gender difference existed.

RESULTS

The data collected from the 70 subjects (39 male, 31 female) revealed that mean value of combined width to length ratio of clinical crown of maxillary central incisors was 1.631 with a standard deviation of 0.070 (Table 1). The graph (Figure 4) shows the value of four cases to be described as outliers with minimum value of 1.437 and maximum value of 1.823.

Table 2. Shows that 11 subjects (15.7%) fell within + 1% range of the ratio , in 25 subjects (35.7%) were within + 2% of the ratio (1:1.618) while 56 (80%) of subjects fell within 5% range of the ratio (Figure 5).

The data revealed that statistically no significant differences were seen between two genders for any of the categories (Table 3)

Out of 70 subjects enrolled for the study, 53 were adjudged to have a pleasing/aesthetic appearance as adjudged by multiple observers. It was observed that as the range of deviation from the golden proportion increased the subjective opinion of aesthetic appearances decreased (Table 4).

Table 1. *Results*

Property	*Value*
Sample size	70
Mean	1.631
Standard Deviation	0.070
Minimum	1.437
Maximum	1.823

DISCUSSION

In general, the Indian population is genetically diverse due to its geographical location and background of historical migration, giving rise to many dental and facial variations. Therefore information regarding tooth norms in this group may prove useful to clinician when restoring anterior teeth [14,15]. Various anthropometric aids are available to calculate the combined dimension of maxillary anteriors but little is available on individual tooth selection [10,11,12,16,17,18]. Maxillary central incisors due to its position, influence the overall aesthetic of smile[3,5,13], thus selecting correct dimension of maxillary central incisors is very important during oral rehabilitation. One such technique of calculating the dimension of central incisors is using Golden rectangle ratio suggested by Marquardt [9].

In comparison to Marquardt's [9] observation 56 (80%) of subjects in present study were within ±5% range of golden proportion (1.634 + 0.065).

Table 2. *Breakdown of subjects falling within range of Golden Rectangle Ratio.*

S.No.	*Difference*	*No. of cases falling in range*	*No. of cases not falling in range*
1.	±1%	11 (15.7%)	59 (84.3%)
2.	±2%	25 (35.7%)	45 (64.3%)
3.	±5%	56 (80.0%)	14 (20.0%)

Table 3. *Gender variation in combined width (W^c)/Length (L) ratio.*

		W^c/L Ratio					
		Females		*Males*		*Statistical significance*	
S.No.	*Category*	*No.*	*Mean±SD*	*No.*	*Mean±SD*	*c^2*	*P*
1.	Overall	39	1.634±0.065	31	1.627±0.077	–	--
2.	±1% range	5	1.619±0.010	6	1.623±0.017	0.557	0.456
3.	±2% range	14	1.619±0.022	11	1.616±0.019	0.001	0.971
4.	±5% range	33	1.627±0.044	23	1.621±0.040	1.172	0.279

Table 4. *Outcome of subjective observations*

	Aesthetic		*Non-aesthetic*		*Significance of difference*	
Category	*No.*	*%*	*No.*	*%*	*c^2*	*P*
Overall	53	75.71	17	24.29	–	–
±1% range	11	100	0	0	4.186	0.041
±2% range	24	96	1	4.00	8.703	0.003
±5% range	51	91.07	5	8.93	35.913	<0.001
>±5% range	2	14.29	12	85.71	35.913	<0.001

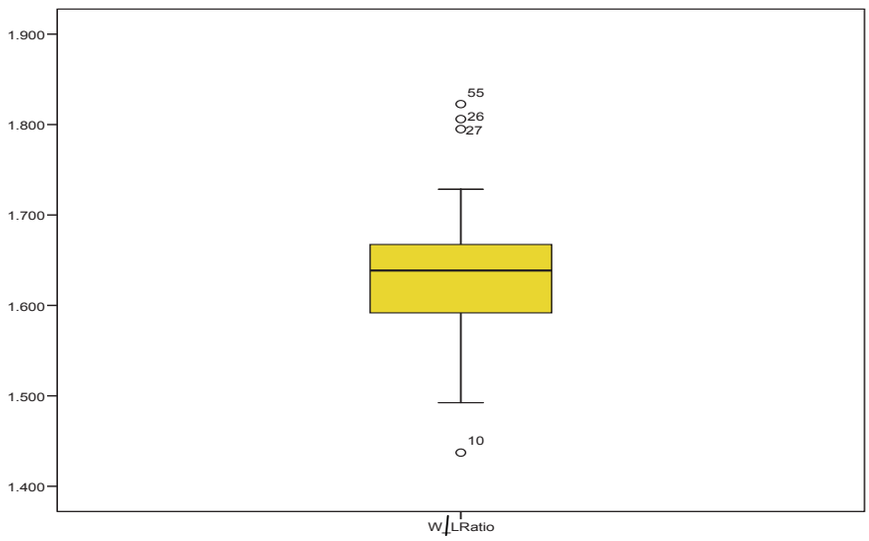

Figure 4. *Outliers*

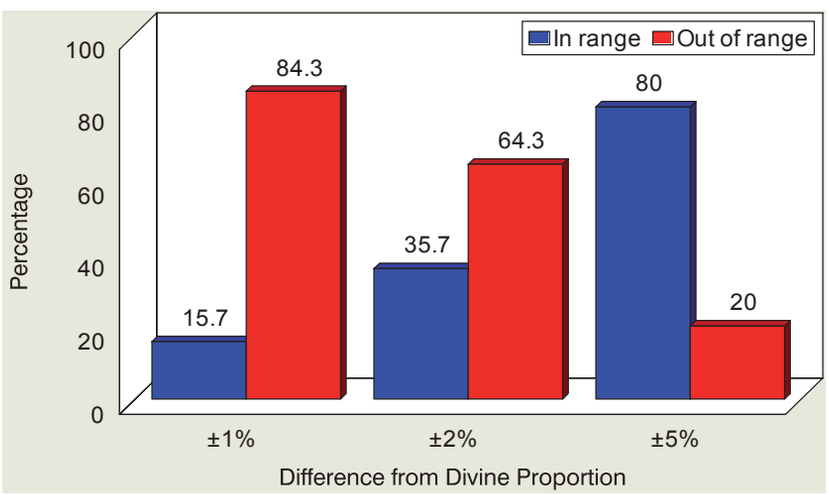

Figure 5. *Breakdown of cases falling within range of Golden Rectangle Ratio.*

Gender variations in the dimensions of the anterior teeth have been noted for most racial groups, with men exhibiting wider anterior teeth than women. Gillen *et al*[7] reported that the maxillary anterior teeth of men were wider and longer than those of women in both white and black populations. Similarly, Sterrett *et al*[8] reported that the mean width and length of the clinical crowns of the maxillary anterior teeth of men were found to be significantly greater than the corresponding dimensions in women, in a white population.

Owens *et al*[19] measured the width of the maxillary central incisor in several racial groups and noted variations in most of them, with men again having wider central incisors than women. In the present study statistically, no significant differences were seen between two genders.

The present study had cases termed as "outliers ",which had either very high combined width of maxillary central incisors to length of central incisor (W^c/L) ratio or very Low W^c/l ratio(Figure 6,7). On observation it was found that individuals with higher W^c/L ratio had broader or square centrals and individuals with lower W^c/L ratio had longer and narrower centrals. In the opinion of independent observers both groups had low aesthetic value.

Sterett el al[8] reported that the mean width to length ratio of clinical crowns was found to be approximately 80% (L=1 W= .8;Figure 8). This was similar to Marquardt's[9] concept where L=1 and combined width(W^c) = 1.618[8]. Our study also had a similar result with slight variation (+ 5%) from 1.618 (1.634+0.065).

CONCLUSION

One of perplexing aspects of the oral rehabilitation is the selection of appropriately sized maxillary central incisors. There is no universally accepted method to guarantee the adequate tooth to tooth relationship that can be used reliably to aid in determining dimension of maxillary central incisors; for this reason when restoring or replacing the natural teeth dental professional should also consider other

Figure 6. *LowWc/L ratio = squarish/ broad centrals Figure :7 - High Wc/L ratio = long/ narrow centrals*

Figure 7. *High Wc/L ratio = long/ narrow centrals .*

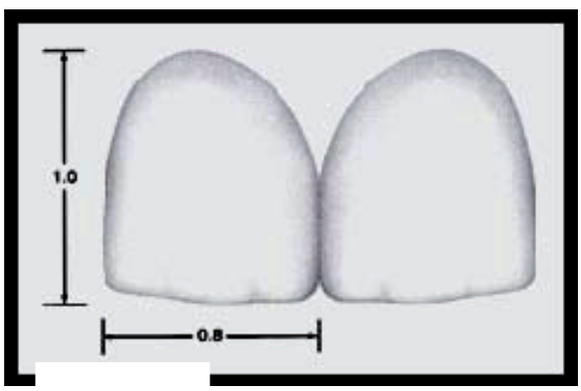

Figure 8. *Sterett et al concept*

useful guidelines for creating a pleasing aesthetic result. The maxillary central incisor is the dominant element of anterior dental composition thus should have an appropriate proportion of width and length for best aesthetic results.

Within the limitation of the present study following conclusion could be drawn:

- 80% of the subjects from the current study varied by +/- 5% from the golden rectangle ratio of 1.618 giving a mean value = 1.634 + 0.065. Thus though slight variation exists golden rectangle concept can be used for choosing dimensions of maxillary centrals which are aesthetically pleasing.
- No statistical significant influence of age and gender on golden rectangle ratio value has been observed.
- The outliers were subjectively adjudged to be non-aesthetic.
- Additional research on greater sample size is needed before extrapolating the results to general population

MANUFACTURERS DETAILS

Digital Vernier Calipers- Aerospace Pvt Ltd, Thailand.

ADDRESS FOR CORRESPONDENCE

Dr Ronauk Singh, Saraswati Dental College Hospital & Research Centre, 233 Tiwari Ganj, Faizabad Road, P.O. Juggour (Via Chinnhat), Lucknow- 227105 (U.P), India. E-mail:ronauksin@ yahoo.com, ronauksin@rediffmail.com.

REFERENCES

1. Belser UC. Esthetics checklist for the fixed prosthesis. Part II: Biscuit-bake try-in. In: Schärer P, Rinn LA, Kopp FR, editors. Esthetic guidelines for restorative dentistry. Chicago: *Quintessence*; 1982. p. 188-92.
2. Magne P, Belser U. Bonded porcelain restorations in the anterior dentition: a biomimetic approach. Chicago: *Quintessence*; 2002. p. 57-96.
3. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. *J Prostbet Dent* 1973;**29**:358-82.
4. Levin EI. Dental esthetics and the golden proportion. *J Prostbet Dent* 1978;**40**:244-52.
5. Snow SR. Esthetic smile analysis of maxillary anterior tooth width: the golden percentage. *J Esthet Dent* 1999;**11**:177-84.
6. Preston JD. The golden proportion revisited. *J Esthet Dent* 1993;**5**:247-51.
7. Gillen RJ, Schwartz RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. *Int J Prosthodont* 1994;**7**:410-7.
8. Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM.Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. *J Clin Periodontol* 1999;**26**:153-7.
9. Marquardt SR. Dr. Stephen R. Marquardt on the Golden Decagon and human facial beauty. Interview by Dr. Gottlieb. *J Clin Orthod* 2002;**36**:339-47.
10. Black GV. Descriptive anatomy of the human teeth. Philadelphia: The S.S.White Dental Manufacturing; 1902.
11. Ash MM. Wheeler's dental anatomy, physiology and occlusion. 7th ed. Philadelphia: WB Saunders; 1992.
12. Shillingburg HT Jr, Kaplan MJ, Grace SC. Tooth dimensions—a comparative study. *J South Calif Dent Assoc* 1972;**40**:830-9.
13. Hasanreisoglu U *et al*. An analysis of maxillary anterior teeth: Facial and dental proportions,*J Prosthet Dent* 2005; **94**:530-538
14. Lukacs JR, Hemphill BE. Odontometry and biological affinity in south Asia: analysis of three ethnic groups from northwest India. *Hum Biol*. 1993 Apr;**65**(2):279-325.
15. Papiha SS. Genetic variation in India. *Hum Biol*. 1996 Oct;**68**(5):607-28.
16. Bjorndal AM, Henderson WG, Skidmore AE, Kellner FH. Anatomic measurements of human teeth extracted from males between the ages of 17 and 21 years. *Oral Surg Oral Med Oral Pathol* 1974;**38**:791-803.
17. Gargiulo A, Wentz F, Orban B. Dimensions and relations of the dentogingival junction in humans. *J Periodontol* 1961;**32**:261-7.
18. Ash M. Physiologic form of the teeth and the periodontium. In: Ash M,editor. Wheeler's dental anatomy, physiology and occlusion. 7th ed. Philadelphia: WB Saunders; 1992. p. 102-27.
19. Owens EG, Goodacre JC, Loh PL, Hanke G, Okamura M, Jo K, *et al*. A multicenter interracial study of facial appearance. Part 2: a comparison of intraoral parameters. *Int J Prosthodont* 2002;**15**:283-8.
20. Scandrett FR, Kerber PE, Umrigar ZR. A clinical evaluation of techniquesto determine the combined width of the maxillary anterior teeth and the maxillary central incisor. *J Prostbet Dent* 1982;**48**:15-22.