

# Evaluating Recurring Esthetic Dental Proportion (RED) and Golden Proportion in Natural Dentition

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## Abstract

**Background:** The width ratio of teeth is an important factor in dental and facial esthetics. The Golden proportion (62%) and the recurring esthetic dental proportion (RED) are two theories in this field that have been suggested to create harmony among anterior teeth. These have rarely been studied among the Iranian population.

**Objectives:** The aim of this study was to evaluate the Golden proportion and RED proportion in students, staff, and patients of Shahed dental school.

**Patients and Methods:** This study was conducted with 116 subjects in Shahed dental school photographs of the subject's anterior teeth were taken from the frontal view. The perceived width ratios of canine to lateral incisor and lateral incisor to central incisor were calculated. In this study, the Golden proportion was evaluated within the range of 0.55 – 0.64. To evaluate the existence of the RED proportion in each subject, the width ratio of canine to lateral incisor was compared with the width ratio of lateral incisor to central incisor.

**Results:** The Golden proportion existed in 25% of the perceived width ratios of lateral incisor to central incisor, and 2.1% of the width ratios of canine to lateral incisor in natural dentition. The RED proportion existed in 18.5% of subjects, and the most recurring proportion was 0.73 in these subjects.

**Conclusions:** The Golden proportion and the RED proportion cannot be used as constant proportions to create a harmonious proportion throughout the width of maxillary anterior teeth.

**Keywords:** Dental Arch, Dental Photography, Tooth Crown

## 1. Background

Esthetics is a primary consideration for patients seeking dental treatment (1). When the terms “esthetic” and “unaesthetic” are used, the connotation is that something is seen which is pleasant or unpleasant. Whether the viewer's perception of a visual experience is pleasant or unpleasant may be conditioned to some extent by cultural factors, and what is considered ‘beautiful’ in one culture may be “ugly” in another (2). The development of new dental materials and techniques has led to a greater number of treatment options that maximize the likelihood of an attractive outcome (1).

A smile is a person's ability to express a range of emotions with the structure and movement of the teeth and lips and can often determine how well a person functions in society (3). In social interactions, our attention focuses mainly on the mouth and eyes of the face of the person speaking. As the mouth is the center of communication of the face, the esthetic appearance of the oral region dur-

ing smiling is a conspicuous part of facial attractiveness (4). The smile design theory can be broken down into four parts: facial esthetics, gingival esthetics, micro esthetics, and macroesthetics. Facial esthetics involves the lips and soft tissue curvature during smiling, speech, and laughter. Gingival esthetics involves the health of the gingiva, the shape of the interdental papilla, and the presence or absence of black triangles. Micro esthetic features involve the anatomy of the anterior teeth, incisal translucency, characterization, and lobe development. Macro esthetic features involve the facial midline, as well as the size and shape of the teeth (5).

The size and form of the maxillary anterior teeth are important factors in dental and facial esthetics. The goal of dental techniques is to have the maxillary anterior teeth restore optimal dentolabial relations in harmony with the overall facial appearance. Several studies have reported race and gender as effective factors in the average dimensions of maxillary anterior teeth in specific populations. Although most esthetic disciplines have prescribed pro-

portions or ratios, objective standards defining what is considered to be an esthetically pleasing smile are not well established. Plastic surgeons measure angles and proportions when evaluating patients before planning potential surgeries. Orthodontists routinely measure cephalometric radiographs to determine critical hard-tissue angulations and compare them to accepted norms (6). Cephalometric analysis is vital in orthodontic treatment planning, although it may not equate to dental, dentofacial, or facial esthetics. Therefore, the need exists for an objective analytical method of smile design using accepted proportional smile design norms (6). These findings indicate the need for evaluation of anterior dentition for comparisons among different populations or racial groups. Knowledge of racial norms may help in certain esthetic and functional demands for different racial groups. The most influential factors contributing to a harmonious anterior dentition are the size, shape, and arrangement of the maxillary anterior teeth as viewed from the front (1).

### 1.1. The Golden Proportion

Lombardi was the first who emphasized the importance of order in dental composition, with a recurring ratio noted between all teeth from the central incisor to the first premolar (2). Levin (7), and more recently other authors (8), indicated that the most harmonious recurrent dental ratio was the Golden proportion.

The Golden proportion (1.618:1.0) is a mathematically constant ratio that defines the dimensions between larger and a smaller length. This specific relation is unique, perfect, ideal, and desirable. It has been used in many areas, including studying beauty to designing esthetic restorations. It is also a valuable tool for the evaluation of symmetry, dominance, and proportion in the diagnosis of tooth arrangement and in the application of esthetic dental treatment (9). There are conflicting reports, however, which indicate that the majority of beautiful smiles do not have proportions coinciding with the Golden proportion formula (10-14).

### 1.2. The Recurring Esthetic Dental Proportion

Ward states that when the Golden proportion formula is used, the lateral incisor appears too narrow and the resulting canine is not prevalent enough. Therefore, he introduced the RED Proportion concept, stating that clinicians may use a proportion of their own choice, as long as it remains consistent, proceeding distally in the arch. The successive width proportion, when viewed from the facial aspect, should remain constant as we move posteriorly from the midline. This offers great flexibility to match tooth properties with facial proportions (10). Generally,

the values of the RED proportion used are between 60% and 80%. Once the ideal size of the central incisor has been calculated, the width of the central incisor is multiplied by the desired RED proportion to determine the frontal view width of the lateral incisor. The resulting lateral incisor width is multiplied by the same RED proportion to yield the desired frontal view of the canine (15). Ward, in 2007, stated that smiles created using the principle of the RED proportion were preferred by a majority of North American dentists surveyed (16).

Murthy et al. in 2008, and Fayyad et al. in 2006, compared the average width ratio of maxillary lateral incisor to central incisor with the average width ratio of maxillary canine to lateral incisor. They concluded that the RED proportion was an unsuitable method to relate the successive width of the maxillary anterior teeth in natural dentition (17, 18).

Shetty et al., in 2011, evaluated the existence of the RED proportion in natural dentition. They divided central incisors into three categories: 'small,' 'medium,' and 'tall'. Then they calculated an average width ratio of maxillary lateral incisor to central incisor and maxillary canine to lateral incisor in each category. They concluded that the RED proportion was not seen in natural dentition (5).

To appear attractive, the maxillary anterior teeth must be in proportion to facial morphology (19-21). Several anatomic measurements have been proposed to aid in determining the correct size of the anterior teeth; among them are the inter-commissural width, bizygomatic width, and interpapillary distance (22-26). Certain authors have proposed a relationship between the width of the maxillary central incisor and the interpapillary distance (24, 27). Similarly, a proportional relationship between the widest part of the nose and the anterior dental arch has been reported (1).

In this field, a few studies have been conducted in Iran and those simply evaluated the existence of the Golden proportion in the Iranian population; therefore, it is necessary to identify the existence of the RED proportion in the Iranian population as a measure of esthetic.

## 2. Objectives

The aim of this study was to evaluate the Golden proportion and the RED proportion in students, staff, and patients of Shahed University as a sample of the Iranian population.

## 3. Patients and Methods

This descriptive study used sequential sampling and was conducted with 116 subjects (88 women and 28 men)

in Shahed dental school in Iran.

The inclusion criterion for case selection was well-aligned anterior dentition and the exclusion criteria were crowding, spacing, missing, supernumerary tooth, severe tooth wear, caries, restoration, congenital dental defect in anterior maxillary teeth, and history of orthodontic treatment, maxillofacial surgery, orofacial trauma.

Photographs of the subjects were taken from the frontal view using a digital camera (Fujifilm S402), in the following manner:

Subjects were positioned in the natural head position.

The distance between the camera and the subject was fixed at a working distance of 15 cm. The photographs were taken by the same and single investigator and in the same light source throughout the study.

The images were transferred to a personal computer.

The perceived width of the maxillary central incisors, lateral incisors and canines were measured by a single investigator, using the software Digitize.

The width of each lateral incisor was divided by the width of the adjacent central incisor and the width of each canine was divided by the width of the adjacent lateral incisor; the calculated values were compared with the Golden proportion within the range of 0.55 - 0.64. To evaluate the existence of the RED proportion, the ratio of the width of maxillary lateral incisor to central incisor was compared with the ratio of the width of maxillary canine to lateral incisor. In each subject, 0.05 or less difference was accepted as existence of the RED proportion. Then, to identify the most recurring proportion, the mode of the mentioned ratios was calculated.

We used a Chi-square homogeneity test and independent t-test to evaluate whether there was a significant difference between men and women.

## 4. Results

The proportions evaluated in this study were estimated in the population, patients of Shahed university, with a 95% confidence level regarding the proportions in the samples.

### 4.1. Evaluating the Existence of the Golden Proportion

Evaluation of the teeth ratios indicated that the Golden proportion in the range of 0.55 - 0.64 existed in 25% of lateral to central incisors and 2.1% of canine to lateral incisor in maxilla (Table 1).

### 4.2. Evaluating the Existence of the RED Proportion

Comparing the ratio of the width of lateral incisor to central incisor with the ratio of the width of canine to lateral incisor in each subject revealed that the recurring proportion existed in 18.1% of women, 19.6% of men, and 18.5% of all subjects. The Chi-squared homogeneity test revealed that there is no significant difference between men and women ( $P > 0.05$ ) (Table 2).

In these subjects, the most recurring proportion was 0.73. Independent t-test revealed that there was no significant difference between men and women ( $P$  value = 0.362) (Table 3).

### 4.3. Evaluation of Symmetry

Comparing the width ratios of lateral to central between the right and left side of each subject revealed that the ratio's similarity exists in 55.2% of subjects. The Chi-squared homogeneity test revealed that there was no significant difference between men and women ( $P > 0.05$ ) (Table 4). Also, comparing the width ratios of canine to lateral between the right and left side showed that the ratio's similarity existed in 37.1% of subjects. There was no significant difference between men and women ( $P > 0.05$ ) (Table 5).

## 5. Discussion

A perfect smile is an important component of esthetics, and this goes beyond having white and straight teeth. The smile should also be in proportion with the rest of the face. The proportion of facial structures, and the relationship between facial measurements and natural teeth, could be used as a guide to achieve this. One of the most difficult aspects during the selection of maxillary anterior teeth for anterior restorations is determining the appropriate mesiodistal width of the six maxillary anterior teeth (28). Many attempts have been made to establish methods of estimating the combined width of these anterior teeth, and thereby improving the esthetic outcome. In this study, we aimed to evaluate the Golden proportion, the RED proportion, and symmetry in anterior teeth. This evaluation helps clinicians to create dental prostheses.

This study indicates that a Golden proportion in the range of 0.55 - 0.64 exists in 19% - 30% of lateral to central incisors and 0.2% - 3% of canine to lateral incisor in maxilla, with a 95% confidence level.

In earlier studies, measurements were made using extracted teeth. However, recent studies have attempted to measure the clinical tooth dimensions either with casts, using computer-based images, or intraoral evaluations (28). Therefore, in this study, measurements were made

**Table 1.** Existence of Golden Proportion Within the Range of 0.55 - 0.64 in Maxillary Anterior Teeth

Existence of Golden Proportion	Canine/Lateral	Lateral/Central
<b>Gender</b>		
Female	4 (2.2)	47 (26.7)
Male	1 (1.7)	11 (19.6)
Total	5 (2.1)	58 (25)

**Table 2.** Existence of the RED Proportion in Maxillary Anterior Teeth<sup>a,b</sup>

Existence of RED Proportion	SUM	NO	YES
<b>Gender</b>			
Female	176 (100)	144 (81.8)	32 (18.1)
Male	56 (100)	45 (80.3)	11 (19.6)
Total	232 (100)	189 (81.4)	43 (18.5)

<sup>a</sup>Data are presented as No. (%).<sup>b</sup> $\chi^2$ : 0.061; df: 1; p = 0.806 N.S.**Table 3.** Statistic Parameters of the RED Proportion in Maxillary Anterior Teeth

Statistic Parameter	Maximum	Minimum	Standard Deviation	Median	Mean	Mode	Number
<b>Gender</b>							
Female	.81	.61	.043	.727	.722	.73	64
Male	.78	.68	.029	.732	.732	.73	22
Total	.81	.61	.040	.729	.725	.73	86

**Table 4.** Existence of Symmetry in the Ratio of Lateral Incisors to Central Incisors<sup>a,b</sup>

Existence of Symmetry	SUM	NO	YES
<b>Gender</b>			
Female	88 (100)	38 (43.2)	50 (56.8)
Male	28 (100)	14 (50)	14 (50)
Total	116 (100)	52 (44.8)	64 (55.2)

<sup>a</sup>Data are presented as No. (%).<sup>b</sup> $\chi^2$ : 0.4; df: 1; p=0.527 N.S.**Table 5.** Existence of Symmetry in the Ratio of Canine to Lateral Incisors<sup>a,b</sup>

Existence of Symmetry	SUM	NO	YES
<b>Gender</b>			
Female	88 (100)	58 (65.9)	30 (34.1)
Male	28 (100)	15 (53.6)	13 (46.4)
Total	116 (100)	73 (62.9)	43 (37.1)

<sup>a</sup>Data are presented as No. (%).<sup>b</sup> $\chi^2$ : 1.385; df: 1; p=0.239 N.S.

using photographs of the subjects that were taken from the frontal view using a digital camera Mahshid et al. evaluated the existence of the Golden proportion in subjects with an esthetically pleasing smile. They revealed that the Golden proportion was present between the central and lateral incisors in 34.9% of subjects and between the canine and lateral incisor in 6.2% of subjects, within the range of 0.5 - 0.64. They concluded that the Golden proportion did not exist in natural dentition (11).

In 1993, Preston reported that only 17% of maxillary lat-

eral incisors' widths were in the Golden proportion with the width of maxillary central incisors, and none of the canines' widths were in the Golden proportion to the width of maxillary lateral incisors, within the range of 0.61 - 0.63 (12).

The results of the present study were similar to the studies conducted by Mahshid et al. and Preston (11, 12). Variations in the values obtained in this study, as compared to the Preston study, may be attributed to the difference between the range in the present study (0.55 - 0.64) and the

range in the Preston study (0.61 – 0.63).

The results of the studies conducted by Gillen et al. and Shirinzad et al. were similar to the present study (13, 14).

Hasanreisoglu et al. and Mazaheri et al. stated that the Golden proportion did not exist in natural dentition. Their studies revealed that significant differences emerged when the mean ratios between various perceived widths (lateral to central incisors and canines to lateral incisors) were compared with the Golden Ratio (1, 6). It seems more reasonable that reporting the percentage of the Golden proportion in any population be based on the mode scale of subjects, for which the width ratios of their anterior teeth are in the range of the Golden proportion, instead of comparing the mean of width ratios in the subjects' anterior teeth with the Golden proportion.

In this study, in order to evaluate the existence of the RED proportion, the ratio of the width of maxillary lateral incisor to central incisor was compared with the ratio of the width of maxillary canine to lateral incisor in each subject. The RED proportion was observed in 18.5% of subjects, and its value was  $0.73 \pm 0.05$ . This value was close to the 70% RED proportion suggested by Ward (10).

The overall result revealed that 13% – 23% percent of the population of the study has the RED proportion.

Hasanreisoglu et al. stated that no continuous proportion was found in their study population (1), but they did not explain the details of this evaluation.

Shetty et al. divided central incisors into three categories: "small," "medium," and "tall." They calculated the average width of maxillary lateral incisor to central incisor and maxillary canine to lateral incisor in each category and compared them to evaluate the existence of the RED proportion. They concluded that the RED proportion was not seen in natural dentition (5).

Murthy in 2008, and Fayyad in 2006, compared the average width ratio of maxillary lateral incisor to central incisor with average width ratio of maxillary canine to lateral incisor. They concluded that the RED proportion is an unsuitable method for creating harmony in the width of the maxillary anterior teeth (17, 18).

Although, those studies are in agreement with the present study, it seems unsuitable to calculate the proportional means and compare them together, because the recurring proportion should be evaluated for each person, one by one. So, by modifying the evaluation method, considering the limitations of this study, we concluded that the RED proportion did not exist in natural dentition.

The existence of the Golden proportion and the RED proportion is not significant; therefore, if clinicians do not use these proportions, patients would not have a vision of being abnormal in regards to their prostheses. In summary, clinicians can choose any proportion, as long as they

are considering factors such as facial appearance.

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## Footnotes

**Authors' Contribution:** Study concept and design: Maryam Azimi; analysis and interpretation of data and drafting of the manuscript: Maryam Dinparvar; critical revision of the manuscript for important intellectual content: Hosna Teimourian; statistical analysis: Maryam Farhadian.

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