Research Article

Golden proportion of the mandible in different classes of skeletal malocclusions - A pilot study

Sunita Sugumaran[1], Saravana Pandian[2], Sunita Sugumaran*

ABSTRACT

Background and Aim: Physical beauty of a person was said to be visually pleasing, if it follows the "golden proportion" in the human face. The mandible is considered as one of the most pleasing structures. Hence, it is thought to follow the golden proportion which is a well-proportioned and normal face. However, does this apply to skeletal malocclusions? **Materials and Methods:** Pre-treatment lateral cephalograms of patients were evaluated, for which three groups were formed with 20 patients in each group: Group 1 - Class-I skeletal bases, Group 2 - Class-II skeletal bases, and Group 3 - Class-III skeletal bases. The cephalograms were traced on FACAD software and the ratio between condylar and corpus axis was calculated; the mean ratio obtained was compared to the golden ratio (0.6180) of the dental skeletal patterns using sample *t*-test. **Results:** Statistically significant difference ($P < 0.05$) was found only in Group 3 - skeletal Class III patients, mainly between the mean value of the ratio of condylar to corpus axis of the mandibles and the golden ratio. **Conclusion:** In this study, the ratio of condylar axis to corpus axis was significantly different in Class III skeletal pattern.

KEY WORDS: Condylar axis, Corpus axis, Esthetic, Golden ratio, Skeletal malocclusion

INTRODUCTION

The one definition of beauty which has been consistent through many decades in the past until now would be the golden proportion. The concept of golden proportions seems to exist in mathematics and literature for a long time (since at least 2400 years ago). It seems to have occurred and reoccurred over a vast period of time. However, there is no exact information of when and who introduced this concept. A Greek sculptor and mathematician named Phidias studied *phi* and applied it to the design of sculptures for the Parthenon. As he used the golden proportion so much, it was called *phi*, the Greek letter for the first part of his name after the 21st letter of the Greek alphabet. However, the fascination with the golden ratio is not just confined to mathematicians. There were many artists such as Plato, Euclid, Leonardo Fibonacci, Leonardo da Vinci, and Johannes Kepler who have spent endless hours over this simple ratio and its applications. Artists, biologists, musicians, historians, psychologists, architects, and even mystics have pondered and debated the basis of its presence and appeal. Thus, we can conclude that the golden ratio has inspired thinkers of all disciplines like no other number in the history of mathematics.[1,2] Currently, mathematicians and architects use the tern phi originating from the initial letter of the Greek Phidias who used the golden ratio in his sculptures.[2]

Access this article online

Website: jprsolutions.info | ISSN: 0975-7619

It is interesting to note the presence of mathematical ratios influencing esthetics. There are two famous ratios:

1. The silver ratio: This ratio is used by Japanese to construct temples, statutes, and paintings. In mathematics, silver ratio (also silver mean or silver constant) can be explained as the ratio of the sum of the smaller and twice the larger of those quantities, to the larger quantity, is the same as the ratio of the larger one to the smaller one (see below). The silver ratio can be explained as an irrational mathematical constant, whose value of one plus the square root of 2 is approximately 2.4142135623.[1]
2. The golden ratio: This is a special number found by dividing a line into two parts so that the longer part divided by the smaller part is also equal to the whole length divided by the longer part. It is represented by phi.

$$A/b = (a+b)/a = 1.6180339887498948420^{[1,3]}$$

Department of Orthodontics, Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India

***Corresponding author:** Sunita Sugumaran, Department of Orthodontics, Saveetha Dental Institute of Medical and Technical Science, Tamil Nadu, India. E-mail: Sunita_eco@yahoo.co.in

Received on: 10-08-2018; Revised on: 22-09-2018; Accepted on: 27-10-2018

The concept of ideal body proportions has been pondered upon not only by anatomists,scientists, dentists but also artists and esthetes. The face, in particular, is the most expressive part of the human body, responsible for visual evaluation and recognition.[4-6] Enhancement of the facial beauty is one of the primary elective goals of patients seeking dental care. Improving deficient facial proportion and integumental form aids surgeons, orthodontists, and restorative dentists to address these esthetic needs. Ricketts was one of the first people to evaluate the golden proportion associated with the human face. He said that there were a number of proportions within the face. Mandible being the only movable bone of the face plays a very important role in symmetry, profile, and esthetics of the patient. In a study by Ricketts, he noticed that, in a normal mandible, the corpus axis and the condylar axis of the mandible follow the golden proportion.[7] This analysis can be considered useful because since it is a proportion, it is irrespective of the age or gender. This study aims to determine the presence of golden proportion in mandible of patients with skeletal Class I, II, and III relationships.

MATERIALS AND METHODS

Lateral cephalograms of untreated subjects were used for this study from the records of the Department of Orthodontics and Dentofacial Orthopedics, Saveetha Dental College and Hospitals, Chennai, India. The inclusion criteria were as follows:

- No history of orthodontic or surgical treatment.
- Adult non-growing individuals.
- Mild-to-moderate malocclusion or skeletal dysplasia.
- No syndrome or any medical condition involving head and neck region.

The exclusion criteria were as follows:

- History of previous orthodontic treatment.
- Severe skeletal dysplasia such as syndromes and craniofacial deformities.

His pre-treatment lateral cephalograms of the patients were traced using FACAD® software and analyzed. The landmarks were located, and the following parameters were recorded [Figure 1].

- ANB angle to indicate the sagittal skeletal relation
- Condylar axis - from xi point to dc point in the condyle and extended to the top of condyle.[7] xi point is the center of the ramus as described by Ricketts[7]
- Corpus axis - from xi point to suprapogonion (pm)[7]
- Ratio of condylar axis to corpus axis, when condylar axis was measured from the top of condyle.

The patients were categorized into three groups of 20 cases each. The characteristics of each group were as follows:

1. Group 1 - patients with skeletal Class I relationship
2. Group 2 - patients with skeletal Class II relationship
3. Group 3 - patients with skeletal Class III relationship.

The mean values and standard deviation of condylar axis, corpus axis, and ratio of condylar to corpus axis for the 20-sample size were calculated for each group separately. The mean of the ratio of condylar to corpus axis that was calculated for each group was compared with the golden ratio (0.6180) using one sample *t*-test. In this study, the null hypothesis was that the mean value was not significantly different from the given ideal value. The alternate hypothesis was that the computed mean value is significantly different from the given ideal value. $P = 0.05$ was considered to be statistically significant.

Statistical Analysis

One sample *t*-test was carried out to compare each group with the golden proportion: 0.168. *P* value was set at 0.05.

RESULTS

The result of the study is as follows: Group 1: The mean value of this group was 0.6117, and statistically was not significantly different from the golden proportion [Table 1 and Figure 2]. Group 2: The mean value of this group was 0.630 and was not significantly different from the golden proportion [Table 2 and Figure 2]. Group 3: The mean of this group was 0.549 and was found to be significantly different from the golden proportion [Table 3 and Figure 2].

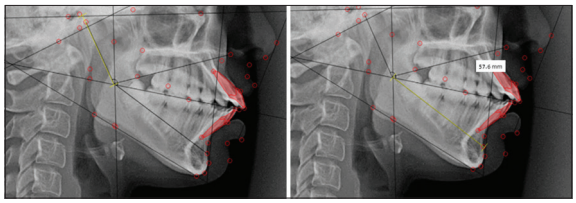

Figure 1: Condylar and corpus length measured from xi point on FACADE

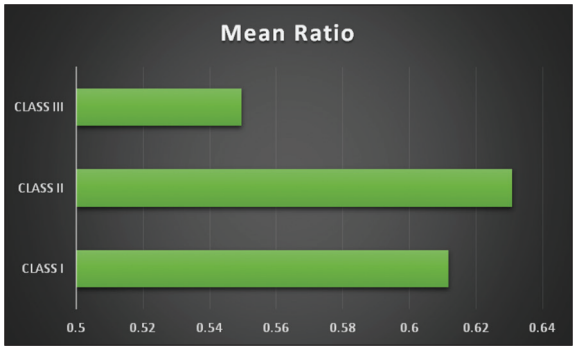

Figure 2: Graph comparing the ratios of different groups

Table 1: One sample *t*-test for skeletal Class I pattern

Class I	*N*	Mean	Standard deviation	Standard error mean	Statistics	
	20	0.61425	0.033424	0.007474		
	Test value= 0.6180					
	T	dt	Significant (two-tailed)	Mean difference	95% confidence interval of the difference	
					Lower	Upper
	−0.502	19	0.622	−0.00375	−0.01939	0.01189

Table 2: One sample *t*-test for skeletal Class II pattern

Class II	*N*	Mean	Standard deviation	Standard error mean	Statistics	
	20	0.63025	0.050661	0.011328		
	Test value=0.6180					
	T	dt	Significant (2-tailed)	Mean Difference	95% confidence interval of the difference	
					Lower	Upper
	1.081	19	0.293	0.01225	−0.01146	0.03596

Table 3: One sample *t*-test for skeletal Class III pattern

Class III	*N*	Mean	Standard deviation	Standard error mean	Statistics	
	20	0.54965	0.038556	0.008621		
	Test value=0.6180					
	T	dt	Significant (2-tailed)	Mean difference	95% confidence interval of the difference	
					Lower	Upper
	−7.928	19	0	−0.06835	−0.08639	−0.05031

DISCUSSION

In this study, it is seen that Group 1, which included skeletal Class I pattern, the condylar, and the corpus length ratio, was similar to the golden proportion. Group 2, with skeletal Class II pattern, too had the condyle to corpus ration comparable to the golden proportion. One explanation to this is the mandible which is only retro positioned, but the condyle and the corpus are proportionate to each other, thus meeting the golden proportion. Figure 1 shows that the mean of Class II is 0.630, indicating a relative decrease in the mandibular length when compared to Class I. Class II malocclusion is a very commonly observed clinical problem. Various studies show that Class II subjects had shorter mandibles when compared with normal subjects only in the earlier stages of development. However, the differences were not significant when the permanent dentition had completely erupted, suggesting a possibility of a late "catch up growth."[8,9] Lateral cephalogram of only adult patients was included in this study. Hence, a majority of adult skeletal Class II patients present with retro positioned, normal length mandible, thereby fulfills the golden proportion. Group 3, however, shows a significant difference from the golden proportion. This can be explained by the fact that Class III pattern is usually associated with increased mandibular length and average or reduced maxillary length. In Class III patients, several aberrant cephalometric features have been reported which include the cranial base as well as mandibular length. An increase in mandibular length has been established by various authors.[10-14] This increase in the mandibular length affects the golden ratio. Thus, only Group 3 shows a significant difference from the normal value.

This study correlates with the findings of Ricketts that the mandible follows the divine or golden proportion. Since the study uses proportion rather than linear or angular measurements, it is independent of influences such as the age and head position. Various disciplines have studied the nature of facial beauty. Individually, they provide partial answers. However, when viewed together, they begin to weave provocative insights as to its biological significance. It is intricately related to the divine proportion, and all living creatures have the genetic potential to develop it. The numerical value of the divine proportion is 1:1.618. This ratio is a law of equilibrium in nature that presents a relationship between math and beauty to create both harmony and to give the illusion of perfection. The "divine

proportion" is one of several terms used to describe the division of a line such that the ratio of the smaller section to the larger one equals that of the larger section to the whole, to be considered pleasing to the eyes.

Ricketts stated that beauty arouses an emotional sense of pleasure. This level of perception is an instinct that is contained in the limbic system.[7] There are two major concepts: Fibonacci number and the golden proportion. In 1202, Fillies Bonacci proposed that the numbers could be demonstrated in the multiplication of rabbits. Hence, starting with 0 and 1, the total is 1. Fibonacci number represents a pattern where in adding the preceding number, we get the succeeding number. eg: 0,1,1,2,3,5,8,13,21,34,55,89,144,etc. Moreover, surprisingly, it is noticed that each new addition is precisely 1.618 times the previous number, and this ratio of addition continues on to infinity.[7]

The golden proportion, as discussed earlier, is expressed by the 1:1.618 ratio, represented by the Greek letter "*phi.*"[1,3] The golden proportion has long been used in dentistry to improve facial function, harmony, and esthetics (Jackson's triad).[15,16] The concept of golden proportion in improving esthetics in orthodontics has, however, always been highly controversial. Baker and Woods had evaluated the golden proportion in a patient undergoing orthodontic and orthognathic treatment and concluded that a couple of measured ratios moved away from the golden proportion, and still, the outcome was highly esthetic.[10] However, many authors have suggested that the esthetic appreciation of one's face seems to be related to facial structures following the golden proportion.[11-13] Thus, while some studies indicate that the golden proportion is highly influential on facial esthetics, others disagree that the golden proportion is a universal phenomenon influencing smile, esthetic, and beauty.[17-21]

Majority of studies on golden proportion in orthodontics is restricted to the face[17-25] and the dentition.[26-28] According to Snow, the concept of the golden percentage is a useful application in the diagnosis and development of symmetry, dominance, and proportion for an esthetically pleasing smile.[29] However, a very few studies exist on golden proportion on hard tissues using a lateral cephalogram.[7,30] According to Ricketts, the normal human face is possibly the most beautifully perfect structure in all of the animal kingdoms and prominent part of the face is the mandible, and a golden proportion between the corpus and the condyle made the mandible a beautifully pleasing structure. He also throws light on the importance of how individual parts come together for a functional harmony or the mechanisms which involve dysplasia. Various linear and angular measurements in cephalometric serve as a guide for the treatment planning for both orthodontic treatment and surgical correction. With the findings of the golden relationship, we can consider it as another approach that can aid the clinician in determining the area out of harmony and balance and hence determine the best treatment to achieve "harmonic unity" in esthetics, which in most instances leads to functional efficiency.[7]

It is, however, important to establish different standards to different races, as well as for different sections within the same race. Variation is what makes every race unique. Hence, these variations are usually considered normal. Hence, the standard should be a range rather than a value. On the other hand, facial disharmonies such as long face syndrome, short face syndrome, facial asymmetries, and other craniofacial disharmonies should be considered abnormal. This study should be carried out on larger population sample and different races so as to get a better understanding of the divine proportion of the mandible.

Nature is dynamic and consists of wide variations, esthetics in dentistry cannot be based and justified mathematically, and hence, individuals should not be standardized in the same way. Although dentists should follow some fundamental guidelines in esthetic treatment planning, it should be kept in mind that esthetics varies greatly from person to person and it is important to consider the specificities of each individual. Individual cultural characteristics and perceptions of beauty must be considered.

CONCLUSION

The golden proportion has been considered ideal, perfect, and desirable, and it has been used for many years by engineers and architects in studying beauty and designing patterns. This study aimed to evaluate the condylar and the corpus ration and to compare it with the golden proportion in different skeletal malocclusion. It is seen that, in both skeletal Classes I and II, the mandible followed the golden proportion. However, in skeletal Class III, the ratio was significantly different from the golden proportion, indicating a deviation from a pleasing appearance. However, we must keep in mind that we must look at a person as a whole; the mandible alone is not the sole factor that determines the esthetic appeal of a person but acts as a contributing factor and aids as a useful diagnostic aid.

REFERENCES

1. Bashour M. History and current concepts in the analysis of facial attractiveness. Plast Reconstr Surg 2006;118:741-56.
2. Priya H. Divine Proportion: Phi in Art, Nature, and Science. New York: Sterling; 2005. p. 20-1.

3. Wiener RC, Wiener Pla RM. The occurrence of phi in dento-facial beauty of fine art from antiquity through the renaissance. Eur J Esthet Dent 2012;7:440-52.
4. Ghyka M. The Geometry of Art and Life. New York: Dover Publications; 1946.
5. Vegter F, Hage JJ. Clinical anthropometry and canons of the face in historical perspective. Plast Reconstr Surg 2000;106:1090-6.
6. Sforza C, Laino A, Grandi G, Tartaglia GM, Ferrario VF. Anthropometry of facial beauty. In: Preedy VR, editor. Handbook of Anthropometry: Physical Measures of Human Form in Health and Disease. New York: Springer Science Business Media llc.; 2012. p. 593-609.
7. Ricketts RM. A principle of arcial growth of the mandible. Angle Orthod 1972;42:368-86.
8. Bishara SE, Jakobsen JR, Vorhies B, Bayati P. Changes in dentofacial structures in untreated Class II division 1 and normal subjects: A longitudinal study. Angle Orthod 1997;67:55-66.
9. Bishara SE. Mandibular changes in persons with untreated and treated Class II division 1 malocclusion. Am J Orthod Dentofacial Orthop 1998;113:661-73.
10. Williams S, Andersen CE. The morphology of the potential Class III skeletal pattern in the growing child. Am J Orthod 1986;89:302-11.
11. Järvinen S. Saddle angle and maxillary prognathism: A radiological analysis of the association between the NSAr and SNA angles. Br J Orthod 1984;11:209-13.
12. Battagel JM. The aetiological factors in Class III malocclusion. Eur J Orthod 1993;15:347-70.
13. Horowitz SL, Converse JM, Gerstman LJ. Craniofacial relationships in mandibular prognathism. Arch Oral Biol 1969;14:121-31.
14. Guyer EC, Ellis EE 3rd, McNamara JA Jr. Behrents RG. Components of Class III malocclusion in juveniles and adolescents. Angle Orthod 1986;56:7-30.
15. Parnia F, Hafezeqoran A, Mahboub F, Moslehifard E, Koodaryan R, Moteyagheni R, *et al.* Proportions of maxillary anterior teeth relative to each other and to golden standard in Tabriz dental faculty students. J Dent Res Dent Clin Dent Prospects 2010;4:83-6.
16. Singh R, Tripathi A, Singh S, Bhatnagar A. A study on the practical applicability of the rule of golden rectangle in dental aesthetics. Eur J Prosthodont Restor Dent 2011;19:85-9.
17. Baker BW, Woods MG. The role of the divine proportion in the esthetic improvement of patients undergoing combined orthodontic/orthognathic surgical treatment. Int J Adult Orthodon Orthognath Surg 2001;16:108-20.
18. Jahanbin A, Basafa M, Alizadeh Y. Evaluation of the divine proportion in the facial profile of young females. Indian J Dent Res 2008;19:292-6.
19. Pancherz H, Knapp V, Erbe C, Heiss AM. Divine proportions in attractive and nonattractive faces. World J Orthod 2010;11:27-36.
20. Prokopakis EP, Vlastos IM, Picavet VA, Nolst Trenite G, Thomas R, Cingi C, *et al.* The golden ratio in facial symmetry. Rhinology 2013;51:18-21.
21. Cesario VA Jr., Latta GH Jr. Relationship between the mesiodistal width of the maxillary central incisor and interpupillary distance. J Prosthet Dent 1984;52:641-3.
22. Mahshid M, Khoshvaghti A, Varshosaz M, Vallaei N. Evaluation of "golden proportion" in individuals with an esthetic smile. J Esthet Restor Dent 2004;16:185-92.
23. Kiekens RM, Kuijpers-Jagtman AM, van 't Hof MA, van 't Hof BE, Maltha JC. Putative golden proportions as predictors of facial esthetics in adolescents. Am J Orthod Dentofacial Orthop 2008;134:480-3.
24. Jahanbin A, Poosti M, Salari S, Esmaily H, Sagha H. Effect of changes in divine proportion on esthetic perception of smile in frontal view. J Craniofac Surg 2013;24:1946-9.
25. Mizumoto Y, Deguchi T Sr, Fong KW. Assessment of facial golden proportions among young Japanese women. Am J Orthod Dentofacial Orthop 2009;136:168-74.
26. Levin EI. Dental esthetics and the golden proportion. J Prosthet Dent 1978;40:244-52.
27. George S, Bhat V. Inner canthal distance and golden proportion as predictors of maxillary central incisor width in South Indian population. Indian J Dent Res 2010;21:491-5.
28. Preston JD. The golden proportion revisited. J Esthet Dent 1993;5:247-51.
29. Snow SR. Esthetic smile analysis of maxillary anterior tooth width: The golden percentage. J Esthet Dent 1999;11:177-84.
30. Amoric M. The golden number: Applications to cranio-facial evaluation. Funct Orthod 1995;12:18-21, 24-5.

Source of support: Nil; Conflict of interest: None Declared