The golden proportion and its application to the human face

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SUMMARY

The golden proportion or *phi* is 1.618. Throughout history, this ratio for the length-width of rectangles has been considered the most pleasing to the eye. The golden section – a precise way of dividing a line, music or anything else – goes back to least as far as around 500 BC, when Pythagoras proved that the Golden Section was the basis for the proportions of the human figure and that the human body was built with each part in a definite Golden Proportion to all the other parts. This study involved seventy-five first-year dental students of 17-19 years of age. The length of the face was the vertical distance in the midline of the face between the hairline and lower border of the chin. The width of the face was the horizontal distance between the prominent points laterally on the body of both the zygomatic bones. The size of the face was the ratio between length of the face and width of the face. The shape of the face was normal when its size was equal to 1.6; it was long when the size was > 1.6; and was short when the size was < 1.6. Only fourteen individuals (19%) had normal faces; eleven (15%) had a long face; and fifty (67%) had a short face. The sixty-one individuals (81%) with an abnormal size of the face may be at risk of developing maxillofacial, jaw, respiratory, occlusal, and sleep disorders due to disproportionate face size and tooth size. This simple technique of applying the Golden Proportion to the face and identifying individuals with long or short faces in mass surveys, and their percentage in a given population at risk of respiratory and jaw disorders, facilitates early preventive and corrective interventions so that the population can lead a healthy and normal life.

Key words: Face – Golden proportion

INTRODUCTION

Egyptians used the Golden Proportion, *phi*, in the construction of the great pyramids and in the design of hieroglyphs found on tomb walls. The ancient inhabitants of Mexico embraced *phi* in the Sun Pyramid at Teotihuacan. The Greeks used *phi* in their architecture. The Parthenon at Athens, Greece, was a classic example of the use of the Golden Rectangles throughout this structure, which had thus become to be known as the «perfect building» and was perhaps the best example of a mathematical approach to art. These unusual mathematics properties were key reasons for a building's aesthetic beauty and the

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attention received for ages. Plato, in his Timaeus, considered the Golden Proportion the most binding of all mathematical relations, and made it the key to the physics of the cosmos. Renowned artists such as Michelangelo, Raphael, and Leonardo da Vinci made use of it for they knew of its appealing qualities.

Throughout history, the ratio of 1.6180339887..., for the length-width of rectangles, has been considered the most pleasing to the eye. The Golden Section is a special ratio that is also called the Golden Ratio, the Divine Proportion or the Golden Rectangle. Euclid's visually pleasing geometric proportion, regarded as the formation of accepted beauty, is the ratio between the two dimensions of a plane figure or the two divisions of a line, such that the smaller element is to the larger as the larger is to the whole: the Golden Proportion. The Golden Section – a precise way of dividing a line, music or anything else – goes back at least as far as 300 BC, when Euclid described it in his major work the *Elements*, and to around 500 BC, when Pythagoras (560-480 BC) proved that the Golden Section was the basis for the proportions of the human figure and that the human body was built with each part in a definite Golden Proportion to all the other parts. Pythagoras' proportions of the human figure had a tremendous effect on Greek art. In order to describe the golden section, a line that is one unit long is divided in two unequal segments, such that the shorter one equals x, the longer one equals $(1 - x)$ and the ratio of the shorter segment to the longer one equals the ratio of the longer segment to the overall line; that is, $x/(1 - x) = (1 - x)/1$. This equality leads to a quadratic equation that can be used to solve for x, and substituting that value back into the equality yields a common ratio of approximately 0.618. The Greek letter *phi* is used for this Golden Proportion and, also, *Phi* is used for the closely related value 1.6180339887...

The Golden Section relationship asserts a natural balance, a dynamic symmetry and the Golden Mean is present in the proportions in nature, specifically the human body. For example, the length of the first finger joint to the length of the next two joints is equal to the length of the two joints to the length of the whole finger. Similarly, the length of the middle finger to the length of the palm is equal to the length of the palm to the length of the whole hand. Also, the length of the hand to the length of the forearm is equal to the length of the forearm to the length of the finger to the elbow. This amazing discovery is the main reason for the beauty of the human figure and the patterns commonly found in nature, art, and architecture. The Golden Section, also known as *Phi*, is manifested in the structure of the human body. The human face abounds with examples of the Golden Section. The head forms a Golden Rectangle with the eyes at its midpoint. The mouth and nose are each placed at golden sections of the distance between the eyes and the bottom of the chin. *Phi* defines the dimensions of the human profile. Even when viewed from the side, the human head illustrates the Golden Proportion.

The golden section is a proportion that occurs when something (e.g. a line) is divided into two unequal parts such that the smaller (m) is to the larger (M) as the larger is to the sum of the two ($(m/M = M/(m+M) = 0.618$); Dalzell's theorem means that the use of $M/(M+m)$ ratios leads to results that are more supportive of the golden section hypothesis than does the use of m/M ratios (Benjafield 2000). Measurements of the human face have been performed since the Greek era, and many aspects of ancient measurements can be found in modern clinical anthropometry (Vegter and Hage, 2000). The Golden Number, what the ancient Greeks called the «Divine Proportion», has a value of 1.618; this number is found in numerous natural phenomena, geometrical propositions, and human architectural constructions; these proportions are worth comparing to those of the human face; this Golden Proportion is found in many cephalometric measurements and in various stages of facial growth (Amoric, 1989; Amoric, 1995). The golden proportion mathematically states that the ratio of a smaller length to a larger length is equal to the ratio of the larger length to the whole length, which is equal to 'phi' that is equal to 1.618. The concept of the golden proportion was used (Javaheri and Shamavaz, 2002). The present study was carried out to determine whether or not the length of the face divided by bizygomatic width is 1.618. If that value was for normal face, any deviation from that value produced a long or a short face and hence such an individual could be at risk of developing maxillofacial or respiratory or jaw disorders.

Material and Methods

Seventy five first year dental students (37 males and 38 females) of 17-19 years of age in Saveetha Dental College at Chennai were used.

Length of the face was the vertical length which was the vertical distance in the midline of the face between the hairline and lower border of the chin (Fig. 1). The width of the face was the bizygomatic width of the face, which was the horizontal distance between the prominent points laterally on the body of both the zygomatic bones (Fig. 1). These two parameters were measured in centimetres without parallax error using a sliding calliper. The size of the face was the ratio between the length of the face and the width of the face. The Golden proportion or *phi* was 1.6. The shape of the face was normal when its size was equal to 1.6; the shape of the face was long when its size was larger than 1.6, and was short when its size was smaller than 1.6.

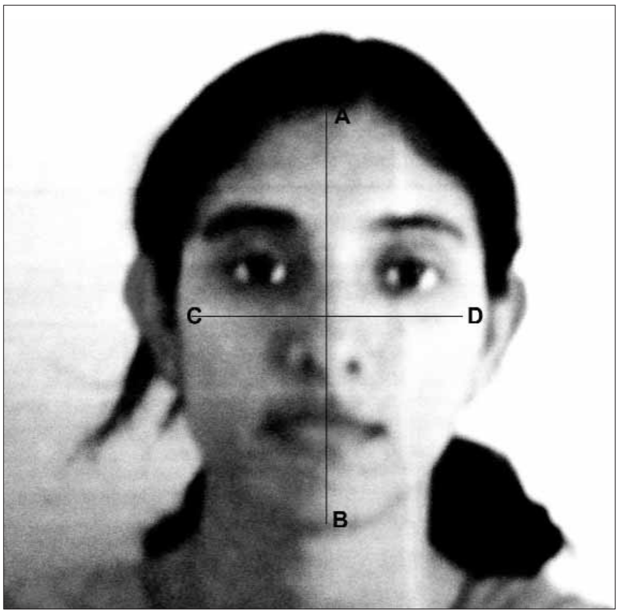

Fig. 1. Measurements of face. AB = length of the face; CD = width of the face.

Results

Table 1 gives length, width, size, and shape of the faces in 38 women. Nine (24%) had a normal size (1.6). Five (13%) had a long face (> 1.6). Twenty-four (63%) had a short face (< 1.6).

Table 1. Proportion between the vertical length and bizygomatic width of the face in the women (n = 38).

Serial Number	Vertical length (cm)	Bizygomatic width (cm)	Ratio	Shape of face
1.	16.5	11.7	1.41	Short
2.	15.0	11.0	1.36	Short
3.	17.0	11.3	1.50	Short
4.	14.0	10.0	1.40	Short
5.	16.0	11.0	1.45	Short
6.	13.5	11.0	1.23	Short
7.	14.0	11.8	1.18	Short
8.	10.5	09.0	1.16	Short
9.	15.0	11.6	1.29	Short
10.	15.2	11.0	1.38	Short
11.	13.1	11.2	1.16	Short
12.	14.2	12.0	1.18	Short
13.	15.1	10.0	1.51	Short
14.	14.3	11.6	1.23	Short
15.	16.5	10.2	1.61	Normal
16.	14.4	09.0	1.60	Normal
17.	14.3	11.4	1.25	Short
18.	16.2	10.8	1.50	Short
19.	15.0	11.6	1.29	Short
20.	11.6	09.0	1.28	Short
21.	12.2	10.0	1.22	Short
22.	13.4	11.2	1.19	Short
23.	15.3	10.2	1.50	Short
24.	17.6	10.5	1.67	Normal
25.	12.2	10.0	1.23	Short
26.	19.1	09.8	1.95	Long
27.	17.4	10.4	1.67	Normal
28.	17.1	10.3	1.66	Normal
29.	18.4	10.3	1.78	Long
30.	15.7	10.9	1.44	Short
31.	17.1	10.3	1.66	Normal
32.	17.9	09.0	1.98	Long
33.	16.6	10.3	1.61	Normal
34.	17.6	10.8	1.63	Normal
35.	18.4	10.8	1.70	Long
36.	17.9	11.7	1.52	Short
37.	17.4	10.3	1.69	Normal
38.	18.4	09.8	1.87	Long

Table 2 gives length, width, size, and shape of the face of 37 men. Five (14%) had a normal size (1.6). Six (16%) had a long face (> 1.6) and twenty six (70%) had short faces (< 1.6).

Table 2. Proportion between the vertical length and bizygomatic width of the face in the men (n = 37).

Serial Number	Vertical length (cm)	Bizygomatic width (cm)	Ratio	Shape of face
1.	17.0	11.8	1.44	Short
2.	20.1	10.2	1.97	Long
3.	18.2	11.	1.63	Normal
4.	16.0	11.3	1.41	Short
5.	15.5	10.2	1.51	Short
6.	19.2	12.0	1.60	Normal
7.	18.6	12.4	1.50	Short
8.	17.2	11.4	1.50	Short
9.	16.8	11.2	1.50	Short
10.	17.2	11.5	1.49	Short
11.	16.8	11.3	1.48	Short
12.	17.3	11.2	1.54	Short
13.	16.0	12.0	1.33	Short
14.	15.4	11.2	1.37	Short
15.	14.0	12.0	1.16	Short
16.	15.0	11.6	1.29	Short
17.	14.5	11.2	1.29	Short
18.	17.3	12.2	1.42	Short
19.	17.0	11.8	1.44	Short
20.	15.6	11.3	1.38	Short
21.	14.9	10.9	1.36	Short
22.	15.1	11.2	1.35	Short
23.	15.0	10.8	1.39	Short
24.	14.2	11.1	1.28	Short
25.	16.6	12.1	1.37	Short
26.	18.4	09.5	1.90	Long
27.	16.6	15.9	1.04	Short
28.	18.3	10.5	1.74	Long
29.	17.6	10.5	1.67	Normal
30.	19.8	11.7	1.69	Normal
31.	18.8	10.8	1.74	Long
32.	16.6	11.0	1.50	Short
33.	17.1	10.3	1.66	Normal
34.	17.1	11.2	1.52	Short
35.	17.4	11.0	1.58	Short
36.	18.3	10.8	1.70	Long
37.	15.9	10.8	1.47	Long

Discussion

The application of a system of aesthetic predictions to dental aesthetics was facilitated by a dental grid for the anterior aesthetic segment (Levin, 1978). The principle of Golden Proportion (1.6:1:0.6) can be achieved among the centrals, laterals and cuspids (Blitz, 1996). The Golden Proportion (1.618) is found in many cephalometric measurements and in several stages of facial growth (Amoric, 1995). The mean intercanthal distance and maxillary central incisor width were significantly higher for male subjects, and inner canthal distance, when multiplied by a decreasing function value of the geometric progression term (0.618) and then divided by 2, is a reliable predictor of maxillary central incisor width (Abdullah, 2002). The maxillary central incisor and canine dimensions of the men were significantly greater than those of the women, and bizygomatic width and interalar width could serve as reference for establishing the ideal width of the maxillary anterior teeth, particularly in women (Hasaureisoglu et al., 2005). The influence of the Greek proportional sciences on modern facial anthropometry, the golden proportion, and the canons of important Renaissance artists, physical anthropology and cephalometry were discussed and for reconstructive and cosmetic surgery, realistic sizes and proportions have been assessed using anthropometric techniques and used as guidelines to correct deformities or disproportions (Vegter and Hage, 2000). Apparent individual tooth width was considered as a percentage of the total apparent width of the anterior segment, and the concept of the golden percentage has been a more useful application in diagnosing and developing symmetry, dominance, and proportion for aesthetically pleasing smiles (Snow, 1999).

The vertical craniofacial dimension was a more accurate measure of facial proportion; alterations in the vertical dimension of occlusion could dramatically affect the aesthetics of the soft facial tissue; faces with deficiencies in lower facial balance (brachyfacial) often exhibited insufficient height of the occlusal plane; facial balance and location of the occlusal planes are the primary determinants for establishing an appropriate vertical dimension of occlusion (Mack, 1991). The Golden Proportion was closer to the proportions of the serious and relaxed faces than of the smiling ones (Haralabakis et al., 1989). Golden Proportion has been considered useful for maxillofacial surgery (Kawakami et al., 1989).

In the present study on seventy-five individuals, only fourteen (9 F, 5 M) (19%) had a normal shape of the face. Therefore, sixty-one (29 F, 32 M) individuals (81%) had abnormally shaped faces. Eleven individuals (15%) had a long face and fifty individuals (67%) had a short face. The sixty-one individuals with an abnormal size of the face may be at risk of developing maxillofacial, jaw, respiratory, occlusal, and sleep disorders due to disproportionate face size and tooth size. This simple technique of applying the golden proportion to the face and identifying individuals with any values larger or smaller than it in mass surveys in order to determine the individuals and the percentage in a given population at risk of respiratory and jaw disorders facilitates early preventive and corrective interventions so that the population can lead a healthy and normal life.

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