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ABSTRACT
Beauty is in the “PHI” of the beholder. PHI represents the Golden number, which signifies the ideal proportion of beauty in nature. The Divine proportion, 1:1.618, is omnipresent as it exists everywhere around us from the majestic planets to minuscule DNAs and also in well balanced beautiful faces. PHI is found in dimensions of teeth, lips and even in smile. Hence, it is imperative for us, orthodontists; the pioneers of esthetic dentistry; to understand golden proportion and its relation to facial esthetics. The purpose of this article is to have an insight on the impact of Divine proportion in clinical orthodontics.

Keywords: Golden Proportion, PHI, esthetics, beauty.

INTRODUCTION
The golden ratio is a geometric proportion that has been theorized to be the most esthetically pleasing to the eye and has been the root of countless mysteries over the centuries. However, only recently its significance in the field of esthetic dentistry has been acknowledged. This divine proportion is the ratio of 1:1.618.

HISTORY
While the proportion known as the Golden Mean has always existed in mathematics and in the physical universe, it is unknown exactly when it was first discovered and applied by mankind. It is reasonable to assume that it has perhaps been discovered and rediscovered throughout history, which explains why it goes under several names.

IN EGYPTIANS AND GREEK ARCHITECTURE
The Egyptians2 used this proportion in the design of the Great Pyramids. The Greeks, who called it the Golden Section, based the entire design of the Parthenon3 on this proportion.

Phidias3 (500 BC - 432 BC), a Greek sculptor and mathematician, studied golden section and applied it to the design of sculptures for the Parthenon. Hence it is called “Phi”3 after him. However, it was in 1900’s that the American mathematician Mark Barr used the Greek letter phi to designate this proportion.

Phi continues to open new doors in our understanding of life and the universe. It appeared in Roger Penrose’s discovery in the 1970’s of “Penrose Tiles,” which first allowed surfaces to be tiled in five-fold symmetry. It appeared again in the 1980’s in quasi-crystals, a newly discovered form of matter. The description of this proportion as Golden and Divine is fitting perhaps because it is seen by many to open the door to a deeper understanding of beauty and spirituality in life.2 That’s an incredible role for a single number to play, but then again this one number has played an incredible role in human history and in the universe at large.

Plato (428 BC - 347 BC), in his views on natural science and cosmology considered the golden section to be the most binding of all mathematical relationships and the key to the physics of the cosmos.

Johannes Kepler, discoverer of the elliptical nature of the orbits of the planets also mentioned the "Divine Proportion," saying: "Geometry has two great treasures: one is the theorem of Pythagoras; the other, the division of a line into this ratio. The first we may compare gold; the second a precious jewel."

Da Vinci provided illustrations for a dissertation published by Luca Pacioli4 in 1509 entitled "De Divina Proportione", perhaps the earliest reference in literature to another of its names, the "Divine

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Proportion." It was probably da Vinci who first called it the golden section. He used it to define all the fundamental proportions of his painting of "The Last Supper," including the dimensions of the table on which Christ and the disciples sat and the proportions of the walls and windows in the background.

By this time this ubiquitous proportion was known as the golden mean, golden section and golden ratio as well as the Divine proportion.¹

**HOW IS GOLDEN PROPORTION CALCULATED?**

Divide a line so that:

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A  B  C
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![Figure 1: AC:AB = AB:BC](image)

The ratio of the length of the entire line (AC) to the length of larger line segment (AB) is the same as the ratio of the length of the larger line segment (AB) to the length of the smaller line segment (BC). This happens only at the point where:

AC is 1.618... times AB and AB is 1.618... times BC.

Alternatively, BC is 0.618... of AB and AB is 0.618... of AC.

**PHI IS OMNIPRESENT**

Phi appears in:
- The proportions of the human body
- The proportions of many other animals
- Plants
- DNA
- The solar system
- Art and architecture
- Music
- Population growth
- Credit Cards
- The Bible and in theology

**GOLDEN PROPORTION CREATES A SENSE OF BEAUTY**

Phi appears throughout life and the universe. Some believe that it is the most efficient outcome, the result of natural forces. Some believe it is a universal constant of design, the signature of God.

Whatever we believe, the pervasive appearance of phi in all we see and experience creates a sense of balance, harmony and beauty in the design of all we find in nature.²

It should be no surprise then that mankind would use this same proportion found in nature to achieve balance, harmony and beauty in its own creations of art, architecture, design, composition, space and even music.
These are the few examples of Divine Proportion in art, architecture, music and nature. For example, golden proportions are present in violin when it is divided into various sections according to its structure. As seen in fig 2d white line is 1.618 times the blue line, which again is 1.618 times the yellow line and so on. Fig 2c shows Golden proportion present in an ant. If we look closely, the famous painting of da Vinci, ‘Last Supper’ (fig 2a) is also made according to Golden ratio.

**FIBONACCI SERIES**

**THE MAGICAL NUMBERS**

Leonardo Fibonacci, around 1200 A.D. discovered the unusual properties of the numerical series that now bears his name. In the series, each number is the sum of the two preceding numbers (1, 2, 3, 5, 8, 13, 21...). Therefore, the sequence can be called a "self-developing" series. Interestingly, dividing two adjacent fibonacci number (8/5 or 21/13, for example) by each other produces increasingly precise approximation of the "Divine Proportion," as the numbers grow larger. Scientists, beginning with Leonardo da Vinci, observed that the displacement of leaves around a stem occurs in patterns defined by the fibonacci series.

The same phenomenon occurs in pinecones and the hearts of sunflowers.

A golden rectangle is a rectangle whose side lengths are in the golden ratio, that is, approximately 1:1.618. A distinctive feature of this shape is that when a square section is removed, the remainder is another golden rectangle, that is, with the same proportions as the first. Square removal can be repeated infinitely, which leads to an approximation of the golden spiral.

A golden triangle is an isosceles triangle in which the two longer sides have equal lengths and in which the ratio of this length to that of the third smaller side is the golden ratio.

**GOLDEN PROPORTION AND HUMAN BODY**

In the average human body, golden proportion is observed when the distance between the navel and the foot is taken as 1 unit: the height of a human being is equivalent to 1.618. Some other golden proportions in the average human body are:

The distance between the finger tip and the elbow / distance between the wrist and the elbow (Fig 6b), the distance between the shoulder line and the top of the head / head length, the distance between the navel and the top of the head / the distance between the shoulder line and the top of the head, the distance between the navel and knee / distance between the
 Examples of Golden Proportion in Human Body

Each succeeding finger bone is 1.618 the length of the preceding finger bone. Phalanges are also in golden proportion (Fig 6d). The graph shows a heartbeat. The distance between the last two ECG peaks is 1.618 the distance between the first two peaks. (Fig 6c)

FACIAL PROPORTIONS AND THE GOLDEN PROPORTION:
Human beauty is based on the Divine Proportion. Ricketts1 was the first to claim that the analysis of a physically beautiful face should be approached mathematically, and he advocated the use of golden proportions in that respect. He observed dozens of photographs of models to select pairs of distances representing golden proportions in those beautiful faces. On this basis, he performed a small study using 10 beautiful faces and defined several golden proportions in them.

DENTAL RELATIONSHIPS:
The front two incisor teeth form a golden rectangle, with a phi ratio in the height to the width. The ratio of the width of the central incisor to the lateral incisor from the center is also phi. The ratio of the width of the smile to the third tooth from the center is phi as well. (fig. 7)

Golden Proportion in Anterior teeth measured by Golden Proportion Guage1
The four front teeth, from central incisor to premolar are the most significant part of the smile and they are in the Golden Proportion to each other.\textsuperscript{11}

Golden Proportion grids show the inter-tooth relationship between the 8 teeth of the anterior aesthetic segment whereas the rectangle confirms the width of the incisors, related to their height. The combination of grid and rectangle will mutually confirm the esthetic solution with a certainty that it will look attractive and natural. These grids are complementary to the Golden Proportion rectangle. The combination of the two gives a powerful tool to confidently determine good esthetics.

**ORTHODONTIC IMPLICATIONS:**

The first Golden Proportion relationship in dentistry, and the most important to be discovered, is a simple tooth to tooth Golden Proportion as shown in Fig 8a, 8b, 8c\textsuperscript{9}. This shows the Golden Mean Gauge superimposed on a photograph of teeth showing that the width of the central incisor is in the Golden Proportion to the width of the lateral incisor\textsuperscript{10}. Similarly, the Gauge shows the lateral incisor is in the same Golden Proportion to the canine\textsuperscript{11} and the canine is in the Golden Proportion to the first premolars.

Soft tissue proportional analysis of an esthetically pleasing face traced from an advertisement. The divine proportion is 1.618 or 1.62 in this scale of accuracy. Facial height from Trigion on menton (1) is divided into the height from eye to chin (2) which is 1.62 times the distance from eye to Trigion (4). Trigion to alar rim of nose (3) is 1.62 times the distance from nose to chin (5). Eye to mouth (6) is 1.62 times mouth to chin (7). Nose to chin (5) in 1.62 times nose to eye (8). Eye to nose (8) is 1.62 times nose to mouth (9). Chin to mouth (7) is 1.62 times mouth to nose (9). Chin to nose (5), mouth to eye (6) and eye to Trigion (4) are about equal.
Figure 12: Corpus axis (Xi-Pm) is 1.62 times the condyle axis (Xi-C).\textsuperscript{12}

Figure 13: A Frankfort plane, Menton nasal floor is 1.62 times nasal floor to canthus of the eye. Lower incisor Pm is 1.62 times lower incisor point A.\textsuperscript{12}

Figure 14: S N is 1.62 times S Ba. CC N is 1.62 times CC Ar. ANS PNS is 1.62 times PNS to the ramus base of the condylar process, A PNS is 1.62 times PNS to the soft tissue wall of the posterior pharynx.\textsuperscript{12}

CONCLUSION

Thus, we conclude that there exists a proportion that mind registers at the subconscious level that provides beauty, comfort and pleasure to the senses. Because the jaws, teeth and face are geometric structures, the more closely they are allied to this proportion the more pleasing are the sensations conveyed to the beholder. Hence, we can say that, "Beauty is not in the eye but the Phi of the Beholder".

With recognition of this divine proportion principle, these relationships can be employed by the clinician on the practical basis and objective relationships can be assessed and planned.

Esthetic dentistry will continue its golden years with the application of golden section. Hence, we orthodontists, known as the pioneers of esthetic dentistry, should acknowledge this divinity of nature and its golden proportions for beautiful results!

REFERENCES