Dental biometrics of the maxillary anterior teeth and their relation to the esthetic parameters among Egyptian population in Cairo: A cross-sectional Observational study.

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ABSTRACT

Introduction: Dental proportions are widely used by dentists as the cornerstones of achieving proper esthetics in dental patients. This study aims to establish the validity of such theories in the Egyptian sample tested. *Aim*: The esthetic dental proportions have long been used in the planning and designing of direct and indirect restorations all over the world. This study investigates the most well-known dental esthetic parameters to establish their accuracy when compared with natural dentition. *Materials and methods*: Thirty casts were selected according to the inclusion criteria and photographed. The apparent widths of investigated teeth were measured on the digitized photographs as well as the height of the central incisors by ImageJ. The relations between the widths of the measured teeth were calculated and compared with the corresponding esthetic parameters. Differences were calculated using a 1-sample t-test with significance value set at $p<0.05$. *Results*: The golden standard (width to height ratio) was an average of 0.92 on the right side and 0.9 on the left side incisors and significantly different to the proposed value of 0.75-0.85. All theories gave significantly different results when compared to natural dentition except the golden percentage theory which gave results that were insignificantly different for the left lateral incisor. *Conclusion*: All tested theories were found to be invalid in the tested population with the golden proportion theory showing the closest results to natural dentition. The golden standard in the tested natural dentition was an average of 90%.

Keywords: Conservative Dentistry, Golden proportions, Golden percentage, RED, width to height ratio

INTRODUCTION

With the introduction of tooth-colored restorations in dentistry, the field has become more inclined towards the best esthetic outcomes. In order to achieve these outcomes, the teeth have to have harmonious size, shape, color, proportions and symmetry.[1] In an effort to create real and measurable methods that can lead to "perfect" esthetics, several theories were created suggesting the perfect sizes, shapes

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and proportions that the human dentition should have. These theories include the Golden Proportion, the Golden Percentage, the Recurring Esthetic Dental proportion and the Width to Height ratio of the central incisors.[1]

The Golden proportion is an ancient Greek theory which states that, for two objects to seem natural and harmonious, the larger one should form a ratio of 1.6 with the smaller.[2] In dentistry, Lombardi was the first to propose the use of the Golden Proportion in human dentition.[3] It was found that the width of the lateral incisor should be 62% that of the central incisor while the canine's width should be 62% that of the lateral incisor.[4] However, it was soon found out that this proportion does not conform to the natural dentition.[1] Later on, Levin suggested that the Golden Proportion could be used. However, it can only be applied to determine the width of the anterior teeth from the frontal view only and not the actual mesio-distal width of the teeth.[5] Nonetheless, several modern studies concluded that the golden proportion is not usually found in the majority of natural dentitions.[2,4–8]

Several studies were conducted to investigate the esthetic proportions. For instance, a study in Turkey found that the Golden Proportion did not coincide with the investigated sample. Moreover, Rosenstiel and Colleagues conducted a survey displaying pictures to 549 dentists in 38 different countries and concluded that the golden proportion is only esthetically acceptable in "tall" teeth.[9]

On the other hand, the Golden Percentage theory was suggested by Snow.[10] This theory does not rely on the individual widths of the anterior teeth; it calculates the proportion of the six anterior teeth by proportionally dividing the entire space that should be occupied by them so that each central occupies 25% of the space while each lateral occupies 15% and each canine occupies 10% of the space.[10] Among other studies, a study conducted in India concluded that this theory was the most closely applicable to their sample compared to the other three theories.[5]

The width-to-height ratio of the central incisor is one of the most important theories that govern the esthetic outcome of the smile. The most widely recognized study concerning this proportion was carried out by Sterrett and his colleagues, in 1999.[11] In their study, they reported that in most natural and esthetically pleasing dentitions with no incisal wear, the most common height-to-width ratio was 0.81.[11] However, the most widely accepted range is 0.75-0.85.[1]

The Recurring Esthetic Dental proportion is a theory that was first introduced by Ward as a replacement for the Golden Proportion theory.[9] This theory

suggests that there can be no predetermined proportion between the consecutive widths of anterior teeth; however, a dentist should set one in his treatment plan and keep it constant throughout the widths of the six anterior teeth.[9] According to a study conducted by Ward himself on almost 300 North American dentists, it was concluded that the best esthetic results were achieved if a ratio of nearly 70% was used as the proportion between the consecutive widths of anterior teeth.[12]

Several countries have published researches and surveys to test the validity of the dental proportions; however, no such data exists for the Egyptian dentition. Therefore, this study will evaluate the prevalence of the Golden Ratio, Golden Mean, and Recurring Esthetic Dental proportion among a sample of the Egyptian population as well as determining the most prevalent Width-to-Height Ratio of the central incisors.

MATERIALS AND METHODS

Study setting

The study was carried out on casts collected from the casting and ceramic labs at the Faculty of Dentistry, Misr International University in June 2020.

Sample size calculation

IBM® SPSS® Sample Power Software Release 3.0.1 was used to calculate the sample size required. This was achieved by a power analysis using

existence of Golden Proportion as the primary outcome. Based upon the results of Azimi M et al (2017)[8], using alpha (α) level of (5%) and Beta (β) level of (20%) i.e. power = 80%; the minimum estimated sample size was a total of thirty subjects.

Inclusion criteria

Selected casts displayed the following according to the following criteria; (1) the casts belonged to adult patients, 20-30 years old[13], (2) showed all anterior teeth[14] (3) had no anterior restorations[14].

Exclusion criteria

All casts that showed (1) apparent attrition [8], (2) apparent crowding or spacing [8], (3) apparent rotations or mal-alignment [8] and (4) missing anterior teeth [8] (5) supernumerary teeth [8] were excluded from the study.

Procedures

The hospital patient management system of Misr International university hospital was accessed by a data manager in order to select patients who conform with the inclusion and exclusion criteria according to their treatment records. Suitable patients were listed and their cast reference number was given to the investigator in order to, anonymously, gather the selected casts from the casting and ceramics lab of Misr International University which belonged to 17 females and 13 males. Knowing that all Misr International University patients sign, upon

admission, an informed consent allowing the use of any and all data provided by the patients for research purposes.

The selected casts were photographed frontally, by the same photographer, using a Canon 100mm f/2.8L macro IS USM lens (Canon corporation, Tokyo, Japan) attached to Canon EOS 750D camera body (Canon corporation, Tokyo, Japan) and a Canon Macro ring lite MR-14EX II ring flash (Canon corporation, Tokyo, Japan) as the light source at a fixed focal distance of 20 cm, verified using a ruler, which produced a 1:1 image to object ratio to ensure the standardization of the pictures.[15]

All casts were set on a glass slab so that the incisal edge of the central incisors coincides with the edge of the glass slab and a black background was set behind the photographed casts.[15] The photography set up is shown in figure 1.

Figure (1): Photography set.

Measurements

Pictures of the photographed casts were stored on a personal computer Lenovo Ideapad 110-15acl (Lenovo Group Limited, Beijing, China). All pictures were measured by the same investigator to minimize inter-personal discrepancy. All

pictures were standardized at 6000x4000 pixels. The pictures were dimensionally analyzed by measuring the perceived frontal width and height of the central incisors, the perceived frontal width of the lateral incisors, the perceived frontal width of the canines and the inter-canine width using the computer software ImageJ version 1.52a [16] which is a Java-based image processing program developed at the National Institutes of Health and the Laboratory for Optical and Computational Instrumentation. The resulting data was stored in a Microsoft Excel worksheet (Microsoft, Washington, USA) for further investigation.

The width-to-height ratio was investigated first. The width of the measured central incisors was divided by their height and the mean of the results obtained was compared to the most widely accepted width to height ratio of 75% to 85%.[1]

To investigate the Golden Proportion theory, the ideal and the actual ratio of the teeth were compared. Since the theory states that the ratio of the central incisor to the lateral incisor to the canine is 1.618:1:0.618 [3], the actual ratio of the teeth was obtained by dividing the width of the central incisor and the canine by the width of lateral incisor which resulted in a ratio that could be compared to the ideal ratio. The Golden Percentage theory states that

the width of each central incisors should be 25% of the inter-canine width, the width of each lateral incisor should be 15% of the inter canine width and the width of each canine should be 10% of the inter canine width.[10] To test this theory, the ideal and the actual width percentage of the teeth in the investigation were compared. This was done by dividing the width of each of the investigated teeth by the inter-canine width and multiplied by 100 so that it can be compared with the ideal percentages proposed by the theory.

Finally, the Recurring Esthetic Dental theory was investigated. This theory suggests that there is a fixed relation between the anterior teeth in each segment.[9] Which means that the ratio between the width of the lateral incisor to the central incisor is the same as the ratio between the canine and the lateral incisor or that if the frontal width of the lateral incisor is smaller than the frontal width of the central incisor by X% then the frontal width of the canine is smaller than the frontal width of the lateral incisor by X%. to investigate this theory, the measured width of the lateral incisor was divided by the measured width of the central incisor and multiplied by 100. The resulting figure was then compared to the resulting figure obtained by dividing the measured width of the canine by the measured width of the lateral incisor

multiplied by 100 to determine if these two figures are constant.

Statistical analysis

The analysis was done for each side separately. The resulting figures were statistically analyzed using Jupyter v1.0.0, Jupyter client v 5.3.4, Jupyter console v6.1.0, Jupyter core v4.6.1 and jupyter lab v1.2.6 [17] along with python [18] packages Pandas for data manipulation [19], Matplotlib [20] and Seaborn for visualization [21] and Scipy for statistical analysis [22]. Box plots were used to investigate for outliers. One sample t-test was used to determine the difference between the compared group with a significance value set at $p<0.05$. The data was also analyzed for distribution using a distribution plot to analyze for maximum, minimum, mean and standard deviation and line charts were generated for easier visualization of the data.

RESULTS

All the measured dimensions including the height and width of both central incisors, the width of both lateral incisors and the width of both canines were analyzed for outliers.

For the golden standard, the calculated width to height ratio showed a mean of (0.92 ± 0.07) for the right side and (0.90 ± 0.066) for the left side as shown in figure 2.

When compared with the ideal golden standard using a t-test, the results showed a significant difference (p=3.651e-90 and

5.438e-90 for the right and left sides respectively). Another t-test was conducted between the right and left sides which indicated a non-significant difference p=0.9417.
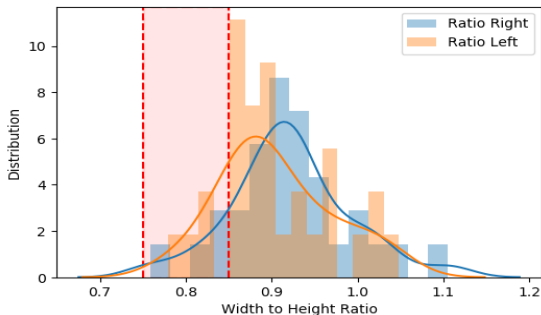

Figure (2): Distribution chart of the measured width to height ratio against the ideal range (dotted lines).

For the Golden Proportion theory, the calculated ratios for the central incisors showed a mean of (1.4825 □ 0.112) for the right side and (1.4868 □ 0.105) for the left side as shown in figure 3.
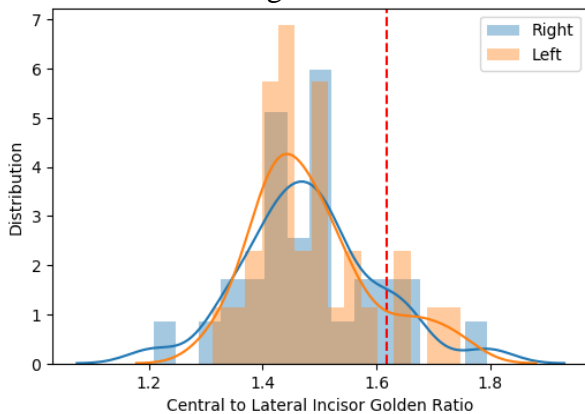

Figure (3): Distribution of the central incisor measured ratio against its ideal ratio.

When compared with the ideal value, the results showed a statistically significant difference (p=7.197e-07 and p=1.649e-07 on the right and left sides respectively).

The calculated ratios for the canine showed a mean of (0.8223 □ 0.093) for the

right side and (0.7662 □ 0.095) for the left side as shown in figure 4. When compared with the ideal value, the results showed statistically significant difference (p=8.35e-29 and p=2.138e-29 for the right and left sides respectively).
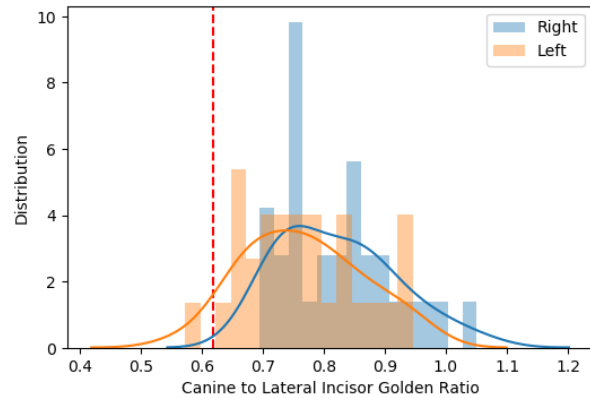

Figure (4): Distribution of the canine measured ratio against its ideal ratio.

For the golden percentage theory, the calculated central incisor percentages showed a mean of (22.878 ± 0.749) on the right side and a mean of (22.34 ± 0.898) as shown in figure 5.
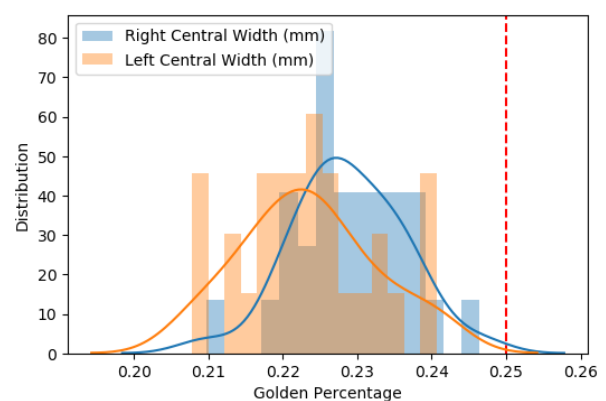

Figure (5): Distribution chart of central incisors' width percentage.

When compared with the ideal value, the central incisor showed a statistically significant difference (p=1.419e-15 for and p=4043e-16 for the right and the left sides respectively).

The calculated lateral incisor percentages showed a mean of (15.506 ± 1.062) for the right side and a mean of (15.068 ± 0.774) for the left side as shown in figure 6. When compared with the ideal
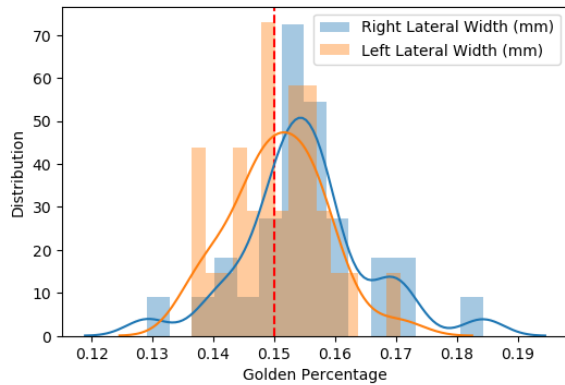

Figure (6): Distribution chart of lateral incisors' width percentage.

value, the lateral incisor showed a slightly significant difference for the right side and no significant difference for the left side (p=0.0143 side and p=0.6342 for the right and the left sides respectively).

The calculated canine percentage showed a mean of (12.704 ± 1.264) for the right side and a mean of (11.504 ± 1.196) for the left side as shown in figure 7.
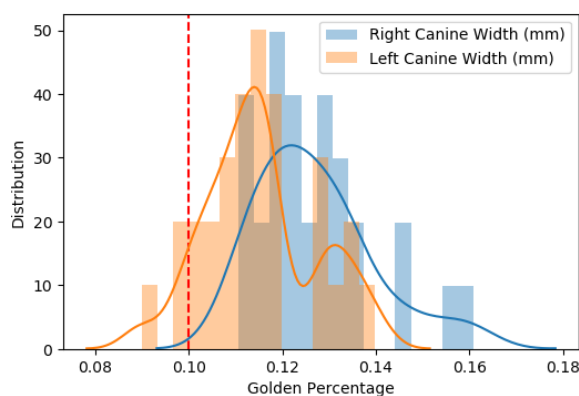

Figure 7: Distribution chart of canines' width percentage.

When compared with the ideal value, the canines showed a statistically significant difference (p=1.64e-12 and p=1.438e-07 for the right and the left sides respectively)

For the Recurring Esthetic Dental proportion theory, the calculated relations between the lateral incisors and central incisors were compared with the calculated relations between the lateral incisors and the canines in order to determine if there were any occurrences where they were equal within the same case. No such occurrences were present.

DISCUSSION

Throughout the years, dentists have strived to standardize and quantify beauty and esthetics in order to produce repeatable and comparable results. In doing so, four main theories were generated to achieve that goal. The golden standard theory suggests an ideal width to height ratio for the central incisors which ranges from 0.75 to 0.85.[1] The golden proportion theory proposed by Lombardi[3] follows the Greek proportions of symmetry and suggest a ratio of 1.618:1:0.618 between the frontal widths of the central incisor, lateral incisor and canine respectively.[4] The golden percentage theory was suggested by Snow and uses the inter-canine width to estimate the frontal widths of the anterior teeth stating that each central incisor should occupy 25% of that space, each lateral

incisor should occupy 15% and each canine should occupy 10%.[10] The Recurring Esthetic Dental proportion, suggested by ward, proposes a fixed ratio between the frontal width of adjacent teeth with 70% being his suggested ratio for best esthetic outcome.[9]

The importance of this study stems from the fact that no research of this nature has ever been conducted in Egypt at any point in time. The closest Egyptian paper to this study is one that was published by Cairo University in 2019; however, it only discussed the effect of gender on the width to length ratio of anterior teeth and their gingival display.[13] Unfortunately, this study does not contribute at all to the validity of the esthetic parameters discussed. On the other hand, countries such as Turkey, Saudi Arabia, Nepal, Brazil and many European countries have evaluated these parameters and have even established their own parameters such as the Napalese Dental Proportion.[14,23_31]

The decision to investigate dental casts instead of patients or students was done out of convenience for the investigators. Moreover, this method was adopted in numerous studies. [11,14,23,27,28,32,33] Furthermore, the decision to photograph the casts instead of measuring them directly with a caliper was supported by literature that tested the reproducibility of this measure and concluded its efficiency given

that the photography setting used was accurate and standardized by using a ruler to maintain a fixed distance and a reproducible position for the cast.[15] A macro lens was used to produce a picture of a 1:1 ratio to minimize distortion and allow accurate digital measurement.

The results yielded by this study are in accordance with many other studies. As far as the golden proportion is concerned, only one study carried out in the southwestern part of Saudi Arabia found it to be absolutely true.[33] Another study also carried out in Iraq on an Arab and Kurdish sample found that this theory is correct only between the lateral incisor and the canine. [28] However, most of the studies concluded that the golden proportion does not apply.[2,4,26,27,29,34,35,5_8,14,23_25]

As for the golden percentage theory, literature has shown that authors have concluded that it is correct if adjusted according to the population's mean.[5,25] In fact, a study conducted in Jordan found that the mean percentages are 23%, 15% and 11% for the central incisor, lateral incisor and canine respectively.[25] It is possible that the golden percentage theory is proving to be the best matched theory due to the fact that it takes the inter-canine distance into consideration. This indicates that it may be worthwhile if more attention was directed towards that factor. However, the Recurring Esthetic Dental proportion was

found to be incorrect in all the studies investigated.[5,7,8,14,25,31] Concerning the golden standard, many studies concluded that the mean golden standard of their investigated samples was inclined more towards a more square profile for the central incisor.[4,7,14,23,28,30] There was, on the other hand, one study that concluded the mean width to height ratio of its sample to be less than the proposed range of 75%-85%.[36]

It has been repeatedly pointed out that ethnicity plays a major role in the proportions of teeth. Therefore, it is important to point out results from other studies that show such a correlation. A study showed that the mean width to height ratio found in Malay, Chinese and Indian samples in Malaysia was found to be around 80% [2] which is close to the mean value of 82%-83% found in a study conducted in Iran.[4] On the other hand, a Chinese population investigated in the USA found that the sample's mean width to height ratio was 72% which is a lot less than the Chinese sample studied in Malaysia.[36] It is also worth noting that a study conducted in Turkey found that the mean width to height ratio was 85%-86% which is closer to the mean found in the Egyptian sample studied.[7] In the meantime, studies carried out on Arabs in Saudi Arabia, Arabs and Kurds in Iraq and a Nepalese sample in

Nepal found that the mean width to height ratios of their respective samples was very close to 90% which is exactly similar to the value yielded in the Egyptian sample investigated.[23,28,30] Moreover, a study carried out in Jordan found that the mean golden percentage values obtained were 23%, 15% and 11% for the central incisor, lateral incisor and canine respectively which is almost exactly similar to the mean values found in the investigated Egyptian sample.[25]

The strongest limitation that affects this study is the limited sample size. Other limitations include the lack of comparison between male and female subjects and that the sample selected is mainly representative of the population living in Cairo and not Egypt as a whole. However; this study, being the first to investigate the validity of the esthetic theories, is the first of its kind in Egypt.

There are many future recommendations that can be pointed out from this study. Extending the investigated sample to cover all areas of Egypt which will allow a more accurate determination of the effect of ethnicity on the proportions on teeth. Moreover, it will allow for the possible creation of a customized proportion that is tailor made for the Egyptian population like the Nepalese Esthetic Dental proportion.[30]

Moreover, a remake of ward's famous study where he displayed pictures with different proportions between the anterior teeth on 300 dentists from North America to determine the most esthetically pleasing proportion.12 Such a study can be conducted in Egypt, or the Middle East and North Africa (MENA) region in general, to investigate their standard for esthetics.

CONCLUSION

Within the limitations of this study, it can be concluded that the studied sample of the Egyptian population does not confer with the previously investigated theories regarding the esthetic proportions. However, the golden percentage showed the closest results to the natural dentition and it can be probably adjusted to give suitable results. The width-to-height ratio leans more towards the square proportions (90%). Further studies and surveys are required to develop a mathematical formula that can more accurately represent the Egyptian population.

CLINICAL SIGNIFICANCE

The esthetic dental proportions have long been used in the planning and designing of direct and indirect restorations all over the world. This study investigates the most well-known dental esthetic parameters to establish their accuracy when compared with natural dentition.

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