Determination of the golden proportion and its implications in the esthetic setting of prosthetic teeth in African melanoderm subjects

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Abstract

Introduction: The golden proportion is a sharing considered as the most harmonious of a size in two unequal parts. Its numerical value is approximately 1.618. Several authors have demonstrated that anterior teeth dimensions of the Caucasians are based on the golden section and suggest that the esthetic assembly of the prosthetic teeth holds account of it. The present study searched for a correlation between anterior teeth dimensions and the golden proportion in the African melanoderm.

Materials and Methods: Our study has been carried out in the School of Dentistry, Cocody-Abidjan Felix Houphouet Boigny University, Cote d’Ivoire, Africa. 80 melanoderm Ivorian subjects old 18-32 years were selected. Measurements were carried out on the anterior teeth and ratios were calculated between various measurements according to those established for the Caucasians. Different relationships of the coronary mesiodistal diameter of the anterior teeth were calculated between themselves. The statistical parameter used is null hypothesis test.

Results: The comparison of our results with the golden value for the Caucasians shows differences, not only from 1.618, but it is also inferior.

Conclusion: Compared analysis of the median values obtained with the standard of beauty made it possible to note that there is not a correlation between dimensions of the teeth of the subjects of our study and the golden proportion.

Keywords
African melanoderm, bio morphometrics, dental prosthesis, esthetic assembly, golden proportion

Introduction

Traditionally the desire to be more beautiful exists in all human communities and manifested differently through the ages, influenced by various socio-cultural factors. Among the Greeks of ancient times, the foundation for mathematical beauty including proportion, symmetry, unity, and divine harmony had already been established. It is from this concept that was born the golden number that designates the arithmetic ratio between two homogeneous quantities. Its numerical value is approximately 1.618 (\( \phi = \Phi = 1.618 \)) or its inverse 0.618. According to Ahmad,\(^1\) animate and inanimate objects whose dimensions or details conform to the ratio, expressed an innate beauty. Today, this concept still seems topical in the West and influences the harmony of vision given its scope which has expanded over the ages. Several artists and architects have used in their respective fields.\(^2\-\)\(^6\) His medical applications have been reported, and in dentistry and especially in esthetic dentistry, several authors have developed the concept that mathematical proportions described by the Greek for centuries could be used today to define the ideal of dental beauty. Lombardi\(^6\) defined from the work of Frush and Fisher,\(^7\) the morphology of criteria and clinical design of prosthetic teeth according to the age, sex and personality factors. Levin\(^8\) has shown that the width of the central incisor, the tooth width of the anterior teeth (incisors and canines) compared to smile and tooth width between them (front view), could be in harmonious relationship with the golden number. In 1985, McArthur\(^9\) shows that the average ratio of the width of the maxillary central incisor and the mandibular central incisor is 1.62. In 1993, Preston\(^10\) showed that there is a golden ratio relationship between the mandibular lateral incisor and maxillary central incisor. Marquardt and
Stephen[11] reported in 2002 that the height of the maxillary central incisor is in the golden proportion to the width of both maxillary central incisors. Other authors, however, have asked to reconsider the golden number and for this purpose, proposed different concepts. Snow[12] introduced the concept of “golden proportion” (“golden percentage” or “golden means”) in which the upper central incisor (UCI) is 25% of the length of the incisor-canine block, the upper lateral incisor (ULI), 15%, and upper canine (UC), 10%. Ward[13] defined the concept proportion “Recurring Esthetic Dental (RED) proportion.” In this concept, if UCI = x, then the ULI = 0.7x and UC = 0.49x, the golden ratio corresponding to 62% of the RED proportion. So, esthetic setting of the front teeth is based on this concept of a golden ratio and the various morphometric parameters determined in Caucasians. Regarding the melanoderm populations, it is clear from several odontometric studies in Cote d’Ivoire, West Africa that Caucasian standards are not always superimposed with the values of their bio morphological and biometrics.[14-18] Differences are observable in the form of relatively elongated dental arches, with teeth with slightly larger dimensions and a canine-incisal block which has a greater curvature. Do these features allow the existence of a golden ratio? Is it similar to that described in the literature? What clinical interest is involved in the rehabilitation of melanoderm patients as regards the esthetic setting of artificial teeth? The present study aims at determining the golden proportion in melanoderm subjects, comparing this mean golden proportion to that of the Caucasians, and deduct from these the clinical implications in the esthetic rehabilitation of our patients in prosthodontics.

Materials and Methods

Study framework and sampling

The study was conducted at the Department of Prosthodontics of the School of Dentistry of the University Felix Houphouet Boigny of Cocody in Abidjan, Cote d’Ivoire in 2010. The sample is from a melanoderm population living in Abidjan, Côte d’Ivoire; it was formed from the following criteria:

Inclusion criteria

- Melanoderm
- Young adults, aged between 18 and 35
- Full and healthy natural teeth without dental-maxillary disharmony.

Non-inclusion criteria

- Non melanoderm
- Age <18 or >35
- Toothless, especially in the anterior region
- Abraded anterior teeth, fractured, decayed, restored or prosthetic
- Malformation of the anterior teeth.

Based on these criteria, 80 subjects were selected.

Protocol

The implementation of the protocol needs the following equipment:

- Trays and examination gloves, tongue depressors
- Bowls and spatulas alginate and plaster, alginate and plaster
- Caliper, pencil, calculator, PC.

After a clinical examination of the oral cavity, we made the impression and the realization casts. The measurements were then performed on these objects cast using an electronic foot slides “DIGIMATIC” (MITUTOYO) precision 2/100th.

Measurements

The parameters measured are: Coronary height (CH), coronary mediostial diameter (CMD) and the total width of the maxillary central incisors (total width of the upper central incisors [TW UCI]).

- CH: The distance from the highest point (maxilla) or lower (mandible) to the free edge or cusp of the top, most sloping point of the neck of the tooth
- Coronary mesiodistal diameter: Corresponds horizontally to the greatest width of the labial surface of the crown [Figure 1]. In our study, we measured CMDD all anterior upper and lower anterior teeth. Then, the value of CMDD of each tooth type was obtained from the average of the measurements of two homologous teeth. Thus, for each subject, three measures CH respectively to central incisor, lateral incisor, and canine were collected, or 240 for the entire sample.
- Coronary mesiodistal diameter: Corresponds horizontally to the greatest width of the labial surface of the crown [Figure 1]. In our study, we measured CMDD all anterior upper and lower anterior teeth. Then, the value of CMDD of each tooth type was obtained from the average of the measurements of two homologous teeth. Thus, for each subject, 6 CMDD measures respectively central incisor, lateral incisor, and canine maxillary and mandibular were collected, that being 480 for the entire sample.
- TW UCI: It is the sum of mesiodistal diameters of these teeth. For each subject, we calculated the TW UCI, that being 80 measurements for the entire sample.

In total, for each subject, we gathered for the three parameters,
10 measurements, that being 800 measurements for the entire sample. It is from measurements of these parameters we have determined the golden number.

**Determination of the golden proportion**

To demonstrate if the teeth of the subjects in our sample are or not in the golden ratios, we calculated different relationships:

- The relationship between the CMDD of the UCI on the CMDD of the upper lateral incisor (ULI) or CMDD UCI/CMDD ULI. This relationship has allowed us to verify Levin’s conclusions which stated that the CMDD UCI/CMCC ULI is equal to 1.618 that is to say in a golden proportion [Figure 2].
- The relationship between the CMDD of the upper canine (CMDD UC) on the CMDD of the ULI or CMDD UC/CMDD ULI. This relationship has allowed us to verify Levin’s conclusions which stated that the CMDD UC/CMDD ULI is equal to 1.618 that is to say in golden proportion.
- The relationship between the CMDD of the UCI on the CMDD of the lower central incisor (CMDD LCI) or CMDD UCI/CMDD LCI. This relationship has allowed us to verify McArthur’s conclusions according to which CMDD UCI/CMDD LCI is equal to 1.62 that is to say in golden proportion.
- The relationship between the CMDD of the UCI on the CMDD of the lower lateral incisor (CMDD LLI) or CMDD UCI/CMDD LLI. This relationship has allowed us to verify Preston’s conclusions which stated that the CMDD UCI/CMDD LLI is equal to 1.618 that is to say in golden proportion.
- The relationship between the TW UCI on the CH of the UCI or TW UCI/CH UCI. This relationship has allowed us to verify Marquardt’s conclusions according to which, TW UCI/CH UCI is equal to 1.62 that is to say in golden proportion. In other words, the UCIs are in a rectangle respecting the golden proportion [Figure 3].

For each individual, the five relationships above have been calculated; hence 400 relationships have been obtained for the whole sample.

All the steps including the clinical examination, impressions, casts realization, measurements and study parameter calculation have been carried out by the same operator. The individuals had given their agreement beforehand.

**Computerized and statistical data processing**

The collected data were entered and processed in Epi Info 6 and using an Excel 2010 spreadsheet on Windows XP. In their statistical analysis, we calculated for each variable studied, the mean, standard deviation, confidence intervals, and made comparisons with Caucasian standards with the test of the null hypothesis.

**Results**

**Golden number determination**

Table 1 shows the mean value of the relationships.

**Comparisons of mean values according to the sex**

Table 2 shows the mean values according to the sex.

### Table 1: Mean value of the relationships

<table>
<thead>
<tr>
<th>Relationships</th>
<th>Mean values</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMDD UCI/CMDD ULI</td>
<td>1.240±0.082</td>
</tr>
<tr>
<td>CMDD UCI/CMDD LLI</td>
<td>1.145±0.108</td>
</tr>
<tr>
<td>CMDD UCI/CMDD LCI</td>
<td>1.585±0.094</td>
</tr>
<tr>
<td>CMDD UCI/CMDD LLI</td>
<td>1.419±0.08</td>
</tr>
<tr>
<td>TW UCI/CH UCI</td>
<td>1.794±0.103</td>
</tr>
</tbody>
</table>

The mean values of our different relationships are different from one another. TW UCI: Total width of the upper central incisors, CMDD: Coronary mesiodistal diameter, ULI: Upper lateral incisor, LCI: Lower central incisor, LLI: Lower lateral incisor, CH: Coronary height.
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Comparison between our mean values and the caucasian norms

Table 3 shows the comparison between our mean values and the golden number.

Comparison between our mean values and the golden number

Table 2: Mean values according to the sex

Table 3: Comparison between our mean values and the golden number

Discussion

Methodology

The sample consists half of men (40) and women (40); age between 18 and 32 years. So, these are young people or young adults who have completed their growth and with proper occlusal articular balance. Their selection have not been selected while taking into consideration the respective shapes of the UCIs (rectangular, triangular or square), but rather the proportions meet the golden ratio are more pleasing to the sight. By limiting only the visible part of the canine or by selecting only those with rectangular teeth were more likely to get the golden proportion. This allows us to minimize this hypothesis. Furthermore, the methods of analysis identified in the literature call, either direct measurements on the patient using a double decimeter or using the Levin’s golden rule; either indirect measurements on analog photography, or a slide projected on a viewer or on the screen of a computer from a digital photograph. In this case, the actual reference of a central incisor measures are always noted down according to Paris et al. However, our method of study is based on analysis of data obtained from measurements made on the cast. This could introduce a bias in our results. Nevertheless, we can consider that the volumetric changes of impression materials and casting taking place in every sense of space, the proportions remain constant. In all cases, since it is an analysis of relationships, both measures concerned (numerator and denominator) undergo the same variations; therefore, the differences due to the properties of these materials can be neglected.

Results analysis

According to Table 1 about the mean values of our various relationships, the five average values of our study are different from each other, unlike Caucasian standards. Indeed, getting identical values would mean that on the one hand, the UCI and the UC, and on the other hand the ULI, the LCI, and the LLI have the same widths. Thus, our values confirm the dominance of the UCI on the other anterior teeth, because the ratio between the mesiodistal diameter and that of the other teeth is greater than one.

We realize that the relationship CMDI UCI/CMDI LCI = 1.240 and the relationship CMDI UC/CMDI ULI = 1.145. This means that the UC is larger than the ULI. Furthermore, the value of the relationship CMDI UC/CMDI LLI (1.585) is itself higher than that of the relationships between the UCI and the other teeth. This result confirms that the LCI is the narrowest of all the anterior teeth.
Comparison of values according to the sex

Results obtained for the two sexes show the same characteristics as those of the global sample, that is, they differ from one another [Table 2]. However, we have tried to know whether the slight differences observed between the values of the two sexes are statistically significant. Moreover, we note that there are slight differences between the two sexes. However, they are not statistically significant; results of the different tests result in an effect to the acceptance of the null hypothesis at significance level of 5%. In other words, in female as in male, the mean values of ratios are equal; and there is only a 5% chance that this equality is a matter of chance. This is consistent with the observation of Jefferson[21] that esthetic concept based on the golden ratio does not differ according to the sex.

Comparison of our results with the golden proportion

Comparison between the CMDD UCI/CMDD ULI relationship and the golden number

The result of the null hypothesis test at the 5% threshold, indicates that CMDD UCI/CMDD ULI of our subjects, which is equal to 1.24 is statistically lower than 1618[8] in a confidence interval of 1.221-1.258 [Table 3]. There is, therefore, no correlation between the mesiodistal diameters of maxillary incisors (central and lateral) of the Ivorian melanoderm and the golden proportion.

Comparison between the CMDD UC/CMDD ULI relationship and the golden number

On the threshold of 5%, CMDD UC/CMDD ULI of our study which is equal to 1.145 is statistically lower than Levin.[8] The level of 5% confidence interval for this value is 1.121; 1.264. The ULI and the UC of the melanoderm Ivorian are therefore not in a golden proportion.

Comparison between the CMDD UCI/CMDD LCI and the golden number

On the threshold of 5%, the null hypothesis test indicates that CMDD UCI/CMDD LCI of our study which is equal to 1.585, is statistically lower than McArthur[9] which is 1.62. The level of 5% confidence interval for this value is 1.564 to 1.605. So, the maxillary central incisor Ivorian melanoderm is not in a golden proportion relationship with the mandibular central incisor.

Comparison between the CMDD UCI/CMDD LLI relationship and the golden number

The result of the null hypothesis test at the 5% threshold, indicates that CMDD UCI/CMDD LLI of our study (1.419) is statistically lower than Preston[10] (1.618) with a confidence interval (1.132; 1.436). The UCI and the LLI of the melanoderm Ivorian are therefore not in a golden proportion.

Comparison between the TW UCI/CH UCI and the golden number

On the threshold of 5%, the test of the null hypothesis indicates that TW UCI/CH UCI of our study which is equal to 1.794 is statistically higher than that of Marquardt and Stephen,[11] which is 1.618 in a confidence interval (1.771-1.817). Hence in the melanoderm Ivorian, the dimensions of the rectangle formed by the UCI are not in a golden proportion.

In total, comparing the mean value of each relationship studied in subjects in our sample with the standard of beauty, shows that there is no correlation between the size of their front teeth and the golden number.

Thus, the observation of Jefferson[21] that the golden ratio is indifferent to race seems not verified in our study. Our results are rather in the sense of the conclusions of Ali Fayyad et al.[22] in Jordan, Basting et al.[23] in Brazil, Hasanreisoglu et al.[24] in Turkey, Mashid et al.[25] in Iran and Paris et al.[20] in France. These authors have shown that there is no relationship between the arrangement of the anterior teeth and concepts of the golden number, the golden percentage or RED proportion.

Relationships between our subjects

Our study has also allowed us to establish relationships between anterosuperior teeth dimensions on one side and between those of upper and lower anterior teeth.

- The width of the ULI is 80.64% that of the UCI and 87.33% that of the UC (CMDD ULI = 80.64% × CMDD UCI and 87.33% × CMDD UC)
- The width of the LCI is 63.1% that of the UCI (CMDD LCI = 63.1% × CMDD UCI)
- The width of the LLI is 70.47% that of the UCI (CMDD LLI = 70.74% × CMDD UCI)
- The CH of the UCI is equal to 55.74% the TWUCI (CH UCI = 55.74% × TW UCI).

Limitations of our work

Our study does not take into account the surrounding structures of the teeth, shape and facial expression, morphopsychology and position of teeth, especially among the African melanoderm. Consequently, these results cannot on their own guarantee the success of an esthetic prosthetic treatment. We need to take into consideration also the color and the regularity of the teeth, the situation of the smile line and the absence of opacity in the prosthetic restorations.[26,27]

Clinical significances

From a clinical point of view, this study contributes in the choice of mediodistal diameters for anterior teeth and the height of UCI in African melanoderm. Following these results, we can affirm that the LCIs, as well as the ULIs and LLIs of the melanoderm Ivorian are wider than those of the Caucasians. In addition to that, the UCI of the melanoderm Ivorian are wider and shorter than those of the Caucasians.

These different relationships could be useful in the choice of the length as well as the height of anterior teeth if at least one of these teeth is present on the arch. In fact, the rule of three can be used to get the value of the dimensions of the other absent teeth.

If these relationships are applied, they will allow preventing gross proportional errors in esthetic prosthetic restorations.
Hence, it is a means for esthetic diagnosis for practitioners, students and laboratory technicians.

**Conclusion**

If for a long time, the golden number, seen as an instrument of harmony and beauty served as a standard or guide in aesthetic dentistry, we can now question its universality, in light of studies that show that the uniqueness of its value does not seem proved. It is, moreover, what emerges from this study that shows there is no correlation between the dimensions of the front teeth of the Ivorian melanoderm and the golden number (average values of our reports are all different from 1.618). By cons, there are several "golden ratios" because we got five different values from each specific type of relationship. Furthermore, we have established on one hand for African melanoderm relationships between the dimensions of anterior superior teeth and between the upper and lower anterior teeth on the other hand. Clinically, these relationships can contribute to the determination of the mesiodistal diameter of the front teeth and the height of the UCl. But these data are not sufficient in themselves to satisfy all esthetic demands of prosthetic rehabilitation. Therefore, we suggest to always associating them with other dental esthetics parameters, including the outline shape, the color and position of the teeth and surrounding structures.

**References**
