Maxillary Anterior Teeth Dimensions and Proportions in a Central Mainland Chinese Population

Sanjay Kumar SAH[1,2], Han Dong ZHANG[1], Ting CHANG[1], Minu DHUNGANA[1,2], Lochana ACHARYA[2], Li Li CHEN[1], Yu Mei DING[1]

Objectives: *To obtain maxillary anterior tooth dimension and proportion values for the Central Chinese population and to evaluate the existence of sexual dimorphism, any consistent relationships between the tooth ratios, and the presence of golden proportions.* **Methods:** *Tooth dimensions and proportions of six maxillary anterior teeth were recorded on gypsum casts obtained from 147 subjects (82 women and 65 men). Of these, 115 casts were digitally photographed in a standardised manner and apparent width values for six maxillary anterior teeth were recorded for golden proportion analysis. Existence of sexual dimorphism, any consistent width/height ratio and golden proportions were statistically analysed. One-sample* t*-test, two-sample* t*-test, and paired* t*-test were used to analyse the data.* **Results:** *There were no significant differences between measurements on the right and left side. Sexual dimorphism existed for various tooth dimensions. There was no statistically significant difference for width/height ratios between the two genders for central incisor and lateral incisor. However, canines showed a statistically significant difference. The golden proportion guideline was not applicable for this population.* **Conclusion:** *The maxillary anterior teeth dimensions were significantly greater for men than women; however, the mean difference was small (< 0.2 mm) and may not be clinically significant. The golden proportion, or any recurring anterior teeth proportions, was not found for the population. There was a significant difference in width/height ratio of canines between the genders, confirming its greatest gender-based morphological difference.*

Key words: *anterior teeth, teeth proportions, aesthetics, central chinese population, golden proportion*

A pleasing dental appearance has a definite psychological significance for the patients and so they associate it with the success of the denture treatment[1]. Many patients wearing partial removable dental prostheses consider aesthetics to be the most important factor[2,3].

A checklist for aesthetic restorative success was first presented in 1979 and updated by Magne and Belser in 2002. It encompassed the most objective principles, including dental aesthetics, gingival aesthetics, and also the more subjective aesthetic integration into the framework of smile, face, and, more generally, the individual.

Within the aesthetic checklist, the relative dimensions of the teeth seem to be among the most objective dental criteria. Actual tooth dimensions have been addressed in many dental anatomy textbooks and journals[4,5]. In these textbooks, the dimensions presented were derived from the skull measurements. Measurements were taken from the cementoenamel junction (CEJ) to the incisal tip, and hence clinical crown height was not measured. Moreover, their reports lacked information about skull age, gender, and overall sample size.

Several mathematical formulas, concepts and theories have been advocated for artificial teeth selection but with little scientific foundation. The "theory of correspondence and harmony", put forward by J. W. White in 1872, was probably the first aesthetic concept regard-

1 Dental Centre, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, P.R. China
2 National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal.

Corresponding author: Dr. Yu Mei DING, Union Hospital, Tongji Medical College, #1277 Jiefang Avenue, Wuhan, 430022, P.R. China. Tel: 86-27-85726165. Email: yumeiding88@126.com

This work was supported by the National Science Fund of China (No. 81100738)

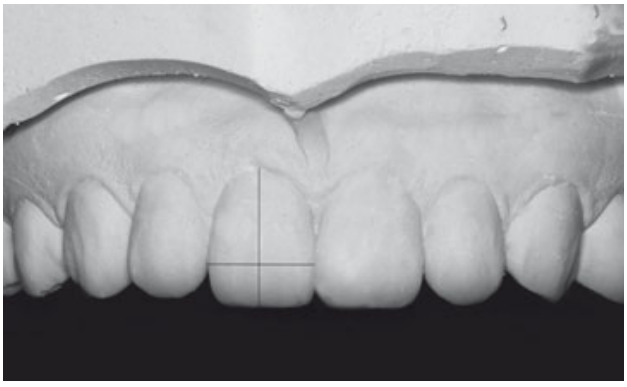

Fig 1 Study cast displaying tooth length and width measurements.

ing maxillary anterior teeth arrangement. This theory was later accepted as "the temperamental theory" of artificial teeth selection. In 1914, Leon William's "geometric theory" replaced "the temperamental theory". Frush and Fisher's "dentogenic theory" was based on the sex, personality, and age (SPA) of each individual.

The width-to-length ratio/individual tooth proportion (ITP) and tooth-to-tooth proportion/intra-arch proportion (IAP) of maxillary anterior teeth have been considered as important factors for dental aesthetics and harmonic teeth arrangement[6].

IAP relationships for smile design, the most notably being the golden proportion (GP), has been one of the most confusing topics in dentistry, yet one of the most discussed since Levin and Lombardi published articles in the 1970s[7,8]. The concept of GP was influenced by the theory that a relationship exists between the beauty in nature and mathematics. The ratio is approximately 1.61803:1; that is the size of the smaller section is about 62% of that of the larger one. Applying this ratio, the maxillary central incisor (CI) would be golden in relation to the lateral incisor (LI), and the LI would be golden to the canine (C), and the apparent width of the LI would be 62% of that of the CI, and the C 62% of the LI. In the 1990s, the work of Preston[9] discredited the concept of GP and showed that GP may exist in nature but not in natural dentitions, with an occurrence of only 17%. Later, many authors, in their studies, were not able to confirm the existence of GP[4,5,10-13].

Lombardi[8] was the first to mention the golden numbers for anterior teeth. He discussed the theory of repeated ratio stating that the existing proportion between the width of the CI and that of the LI should be consistent, progressing anteriorly to posteriorly in the mouth. He also stated that "strict application of GP has proved to be too rigid for dentistry". Similarly, in 2001, Ward proposed the idea of recurring esthetic dental (RED) proportions for smile design. The RED proportion stated that the proportion of the successive width of the maxillary teeth as viewed from the front should remain constant, progressing distally[6]. In 2007, in a survey of North American dentists' preference of imaged smiles, he found that they preferred smiles with 70% RED proportion for normal length teeth over GP. The GP (62% RED proportion) was preferred by 58% of the dentists for tall teeth.

Width/height ratios of maxillary anterior teeth are considered to be the most stable reference, since they have least variation among races and between genders. However, different authors have proposed different ratios. Brisman[14] proposed that the optimal width/height ratio of the maxillary CI should be 75%, while others like Sterret, and Magne suggested ratios up to 85%[5,15].

Previous studies have confirmed the presence of sexual dimorphism within the human dentition[16-18] and examples of ethnic differences and geographic variability in tooth size have been documented[12]. These findings suggested the need for evaluation of tooth dimensions and proportions in different populations. With no surprise, these parameters had been studied in various populations[5,13,19-21]. Until recently, no data for tooth dimensions and proportions in a central Mainland Chinese population was available.

The Chinese are a mixture of five major and many smaller races, altogether forming more than one-fifth of the world's population. There are 56 ethnic groups in Mainland China, of which the Han Chinese is the largest ethnic group, accounting for about 91.59% of overall population. Han Chinese also represents the major population of the overseas Chinese.

China has a total of 23 provinces. According to the National Bureau of Statistics June 13, 2011, China is divided into four major economic regions: eastern, central, western, and northeastern. Central China has six provinces that comprise Henan, Anhui, Hubei, Shanxi, Jiangxi, and Hunan. The total population of Central China accounts for 28.1% of the Chinese population[22].

The people of Northern China are different from those of Southern China in that the former are taller, stronger and with higher BMI (body mass index)[23]. Overseas Chinese are different from the Mainland Chinese as they may be mixed with local races to form another variation.

The aim of the current study was to investigate a mainland Central Chinese population (18–25 years of age) to determine:

- The length and the width dimensions of six maxillary anterior teeth.
- The existence of sexual dimorphism, if any.
- The width/height ratios of maxillary anterior teeth.
- If the golden proportion applies to this population group.

Materials and methods

Ethical approval for the study was obtained from the Faculty of Health Sciences Research Ethics Committee, Tongji Medical College, Wuhan, China.

Chinese students (age 18–25 inclusive), studying at Tongji Medical College, were invited to attend the study. Subjects needed to be of Chinese lineage to their grandparents. Those who belonged to any of the six provinces of the Central China only were included. The inclusion criteria for the study were:

- No missing, veneered, crowned, fractured, or, rotated teeth.
- No restoration on anterior teeth.
- No interdental spacing or crowding.
- No history of orthodontic treatment.
- No gingival or periodontal conditions that would undermine a healthy tooth-to-tissue relationship.

Dental staff at the hospital that satisfied the above inclusion criteria were also included for the study. Informed consent was obtained from all the participants who were included in the study.

Maxillary arch impressions were made, using stock trays (HI-tray; Zhermack, Badia) with irreversible hydrocolloid impression material (Neocolloid; Zhermack), similar to protocols used previously[4,19]. Tray adhesive (Universal Tray Adhesive; Zhermack) was applied to the tray 5 minutes prior to use, making sure that a thin layer of adhesive was applied uniformly and beyond the rims of the tray.

Manufacturer-recommended amounts of powder and tap water (18–22°C) were dispensed into a bowl and mixed using an automatic alginate mixer with a plastic spatula. An automatic mixer (Alghamix II; Zhermack) was used because it provided repeatability of the impression mix, minimised air entrapment, and produced a constant viscosity mix. The impression tray was loaded with the mix and introduced into the subject's mouth and removed after the material was set. The impressions that were not suitable for the study were discarded and repeated.

After the impression was removed, it was washed under running tap water and dipped in disinfectant (CIDEX OPA; Johnson and Johnson) for one minute and again washed in running tap water. The impression was taken to the laboratory and poured with type IV dental stone (Dentstone; HeraeusKulzer) within 10 minutes. The manufacturer-recommended powder/liquid ratios were used and the stone mixed using a vacuum mixer (VPM2, Whipmix) for pouring. All the anatomic landmarks were poured and then based with the same stone.

Fig 2 Apparent width measurements.

The casts were retrieved between one and three hours of pouring. Sample numbers were scribed on the palatal surface of casts with a rosehead carbide bur (Mani Carbide FG burs, Mani Inc) in a straight handpiece (Marathon BM50S1, Saeyang Microtech Co) mounted on micromotor (Marathon Multi 600, Saeyang Microtech Co). The casts were trimmed, washed using clear slurry water, allowed to bench dry for 24 hours before being wrapped in tissue and stored.

Tooth dimension measurement

After all the casts were retrieved, length and width dimensions of maxillary six anterior teeth were measured with a digital caliper (Absolute Digimatic Caliper, Mitutoyo Corporation) with an accuracy of 0.01 millimeters. Clinical crown dimensions were measured (Fig 1). For crown length, the longest distance between the gingival zenith (the most apical point of the marginal gingiva) and the incisal edge, on a line parallel to the long axis of the tooth, was recorded. For width dimension, the measurement was completed at the maximum distance between the mesial and distal contact points of the tooth on a line perpendicular to the long axis of the tooth. All measurements were of facial surfaces of the teeth and recorded in millimeters. Measurements were recorded by the same person who was calibrated prior

Table 1 Average (right and left sides of arch) female values for sample size, mean, standard deviation for tooth length and width dimensions

Tooth	N	Mean	SD
CI-L	82	9.3106	.07193
LI-L	82	7.8297	.14962
C-L	82	8.8364	.11289
CI-W	82	8.1129	.08440
LI-W	82	6.5989	.10470
C-W	82	7.6115	.07676

CI: the maxillary central incisor; LI: lateral incisor; C: canine; L: Length; W: wideth; N: sample size; SD: standard deviation.

Table 2 Average (right and left side of arch) male values for sample size, mean, standard deviation for tooth length and width dimensions

Tooth	N	Mean	SD
CI-L	65	9.5029	.08245
LI-L	65	7.9107	.04630
C-L	65	8.9771	.07527
CI-W	65	8.2104	.02804
LI-W	65	6.7040	.02483
C-W	65	7.6439	.02364

CI: the maxillary central incisor; LI: lateral incisor; C: canine; L: Length; W: wideth; N: sample size; SD: standard deviation.

to making the recordings by measuring on a sample cast on several separate occasions. Each tooth dimension was measured three times and an average was taken as a recording for the study.

Measurement of apparent tooth width dimensions for GP

All casts were then digitally photographed from the front taking care that the occlusal surface of the casts were parallel to the floor. Frontal aspect was directly perpendicular to the labial surfaces of central incisors and the midline between the central incisors was the midline of the image. The same person took all the images in a standardised manner with a digital SLR camera (Pentax K-x; Pentax Ricoh Imaging) with a 105 mm macro lens (Sigma 105 mm f/2.8 EX DG; Sigma), and a ring flash (Pentax AF160) so that the field of view of each image was similar. All the images were transferred to a personal computer, and imported to Photoshop (Adobe Photoshop CS6, Adobe System UK). The measurement tool was used to measure the digital apparent width (pixel-based measurement) of the maxillary six anterior teeth (Fig 2). The measurements were then recorded in excel spreadsheets (Microsoft Excel 2007).

Statistical analysis

The data obtained was transferred to statistical software (SPSS v20; IBM Corporation) for statistical analysis. Paired sample *t*-tests were performed to compare measurements on the right side of the arch with that of the left. An independent 2-sample *t*-tests were performed to determine whether there were gender difference in width, height, and width/height ratio of each tooth group. Also, 1-sample t-test was performed to compare width/height ratios of all tooth groups with the proportion of 80%, and to assess the incidence of the golden proportion. The level of significance was established as $\alpha = 0.05$ for all statistical evaluations.

Results

A total of 178 subjects attended the study, of which 31 were excluded, as they did not satisfy the inclusion criteria. One hundred and forty-seven subjects (82 female and 65 males) were included in the study. Of 147 casts obtained only 115 (66 female and 49 male) were selected for the golden proportion analysis because of factors that did not hinder the tooth dimensions measurements but were not suitable for the GP analysis, such as slight rotation of teeth, or spacing between the teeth.

To determine the measurement repeatability, one cast was randomly selected and the same person performed width and length measurements of all maxillary anterior teeth on 10 separate occasions. The coefficient of variation ranged from 0.05–0.07 mm for width and 0.08–0.11 for the length values. These values were considered to provide an accurate measure of repeatability.

All data sets were normally distributed. As there was an apparent difference in male and female tooth width and length values, therefore the measurement results values are given by gender. (Table 1 and Table 2). There was no statistically significant difference in right and left side measurements for either gender ($P > 0.05$), so an average was taken for right and left sides for all teeth measurements for further analysis.

Male and female tooth measurement values were compared using 2-sample *t*-test ($\alpha = 0.05$). The results of *t*-test comparing male and female values are shown in Table 3. There was statistically significant difference for length and width values for all teeth between the genders. ($P < 0.05$)

Table 3 Two sample *t*-test comparing male vs. female tooth length and width measurements.

Tooth	*P* value	Mean difference	95% confidence interval of the mean	
			Lower	Upper
CI-L	.000	.19229	.16710	.21748
LI-L	.000	.08099	.04292	.11906
C-L	.000	.13873	.10654	.17093
CI-W	.000	.09749	.07590	.11908
LI-W	.000	.10507	.07882	.13132
C-W	.001	.03237	.01285	.05189

CI: the maxillary central incisor; LI: lateral incisor; C: canine; L: Length; W: wideth; N: sample size; SD: standard deviation.

Table 4 Height-width ratio found in different studies

Height width ratio	Magne[15]	Hasanreisoglu1[9]	Condon[21]	Present study
CI	1.28	1.11	1.12	1.15
LI	1.37	1.21	1.23	1.18
C	1.37	1.17	1.20	1.17

CI: the maxillary central incisor; LI: lateral incisor; C: canine.

Table 4 shows the average values of tooth height/width ratio according to previous studies. Average (in percentage) tooth width/height ratios of men and women are presented in Table 5. Result of two sample *t*-tests showed that there were no statistically significant differences for width/height ratios of CI and LI between the genders, however, a statistically significant difference was observed for C (Table 6). A statistically significant difference was observed ($P < 0.05$) when 1-sample *t*-tests were used to compare mean values (%) of width/height ratio of the maxillary CI with 80% width/height ratio. Some authors have suggested 80% width/height ratio for the maxillary CI as a guide for pleasing proportion.

The mean values of apparent width/width ratios of LI/CI and C/LI for the right and left sides of the arch were not significantly different for either gender. So, an average of right and left side values were taken for further evaluation. One sample *t*-test was performed to evaluate associations between the calculated values with the proposed golden proportion guideline (62%). No significant association was found between the recorded proportions and Golden Proportion guidelines (Fig 3).

Table 5 Male and female values for sample size, mean, standard deviation for tooth width to height ratio (given in percentage)

Sex	Tooth	N	Mean	SD
Female	CI	82	86.14	.01493
	LI	82	84.32	.02541
	C	82	87.14	.00997
Male	CI	65	85.15	.00497
	LI	65	84.74	.00247
	C	65	86.40	.00491

CI: the maxillary central incisor; LI: lateral incisor; C: canine.

Table 6 Two sample t- test comparing male vs female tooth width-to-height ratios

Tooth	*P* value	Mean Difference
C	.000	.00989
LI	.187	.00420
CI	.126	.00233

CI: the maxillary central incisor; LI: lateral incisor; C: canine.

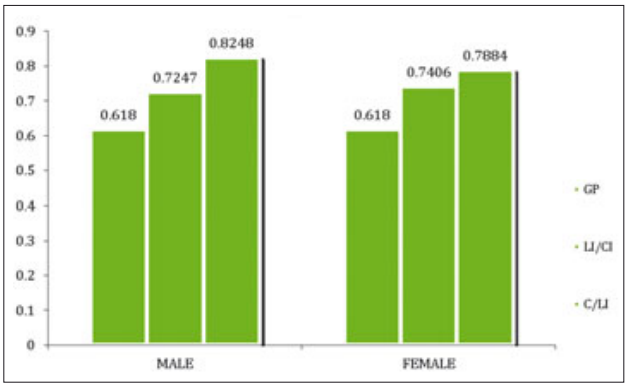

Fig 3 Bar chart showing comparison of apparent width ratios of maxillary anterior teeth with proposed golden proportion guideline. GP: golden proportion; CI: the maxillary central incisor; LI: lateral incisor; C: canine.

Discussion

Either the gingival zenith or the CEJ can be used as apical landmark for tooth length measurements. Measurements based on the CEJ have more precision when measured on extracted teeth as level of marginal gingiva may vary because of various conditions such as inflammation, while the CEJ is a fixed point. However, most of the time, in such cases, race, sex and age of the person from whom those samples were obtained was not specified. The present study used the gingival zenith point as the apical limit for the tooth length measurement because of its clinical relevance.

It is a common practice to combine right and left tooth measurements in comparative population studies assuming that they are similar. Marvoskoufis measured 140 central incisors, 70 each side, from 70 dental students and reported that 86–90% of the examined subjects did not have identical dimensions or form of the left and the right maxillary central incisors[23]. However, measurements of 658 incisors in a similar study failed to identify any significant differences[24]. In the present study, tooth measurements for the right and the left sides of the arch had no significant difference for either gender ($P > 0.05$). This did not preclude an individual from having the asymmetric tooth dimensions.

Ling and Wong[25] studied 459 casts (295 males, 164 females) of 12 years old Hong Kong Chinese children and found that southern Chinese had larger tooth dimensions than the Japanese and white Americans. Brook et al[26] measured mesiodistal crown dimensions on dental casts obtained from four different populations, including southern Chinese and concluded that the southern Chinese sample had the largest teeth overall. Those studies, though including southern Chinese, used different methodologies and different age groups than the present study. So, the tooth dimension values of the present study are not comparable to the above-mentioned studies.

The mean values of the tooth dimensions in the present study were comparable to those presented in the studies similar to this[4,19,21]. Average length values for the maxillary anterior teeth presented by Magne were approximately 1 mm larger than those of the present study, the increased length may be because measurements were completed on extracted teeth and that the study population was different.

Coronal tooth dimensions of maxillary anterior teeth have an order of CI> LI> C21. This order remains the same even when different genders and racial groups are considered[4,12,18]. The results in the present study [CIW (M: 8, F: 8.11) CIL (M: 9.5, F: 9.31) > CW (M: 7.64, F: 7.61) CL (M: 8.98, F: 8.84) > LIW (M: 6.70, F: 6.60) LIL (M: 7.91, F: 7.83)] are consistent with this finding. Sexual dimorphism has been reported previously for maxillary anterior tooth dimensions for most racial groups[4,5,18]. The mean width and the length values of the maxillary anterior teeth were described to be significantly greater in men than in women[4,5,19]. Statistically significantly differences were found for the mean length and width values of CI ($P < 0.01$), LI ($P < 0.05$), C ($P < 0.05$) between men and women in the current study. The mean difference however is small (< 0.2 mm) for all measurements and therefore, clinically it may not be significant.

Length to width ratio suggests the relative shape of the tooth. The average length to width ratios of maxillary anterior teeth for various similar studies in other populations is presented in Table 4. The discernible increased ratio reported by Magne was probably due to measurements having been completed on extracted teeth.

For maxillary anterior teeth, the crown width/height ratio is considered to be the most stable reference because it had minimum variation among teeth and between genders. In a study by Brisman, dental students and patients preferred a width/height ratio of 75% when they were asked to assess a variety of tooth shapes. Various other studies have concluded that the maxillary anterior teeth especially CI should have a width/height ratio of approximately 80% to achieve a pleasing appearance[14]. However, Hasanreisogluet al[19] in their study of Turkish population found it to be in a

range of 72% to 124%. Similarly, Magne in his study of worn and unworn maxillary teeth found this ratio to be in the range of 73% for unworn C and LI, and 87% for the worn CI. Tsukiyama et al[27] compared the anatomic crown width/height ratios of extracted maxillary teeth in Asian and White subjects (157 Asian and 142 White subjects). They found that there were significant differences in width/height ratio for all maxillary teeth between the two ethnic groups. According to the results of the present study, the width/height ratio for the maxillary teeth were between 84% (for LI) and 87% (for C). There was no statistically significant difference for width/height ratio for CI and LI between the genders except for C, which showed a statistically significant difference ($P < 0.01$). Similar findings were presented in some other studies[4,5]. Previous studies have established that C exhibits the greatest gender-based morphological difference compared to other tooth groups[24]. The width/height ratio of C for men was less than that for women. This discrepancy can be attributed more to increased length of C than to its decreased width as according to the present study the differences of means for length of the C was more than that for the width between male and female.

Most of the proportional relationships for maxillary anterior teeth are based on their perceived width as seen from the front, GP being one of them. According to GP rule, perceived width of LI should be 62% of that of CI, and C, 62% of LI7. Since its proposal in the 1970s, various studies in different populations have tried to evaluate the existence of GP in the perceived width of maxillary anterior teeth. But, existence of GP could not be recognised[4,5,12-13,19,21]. In the present study, no such relations were identified. The ratio of apparent width between LI/CI was (M: 0.7247, F: 0.8248) and between C/LI was (M: 0.7406, F: 0.7884). The increased ratio as compared to 0.618 (ratio according to GP guideline) suggested a flatter arch with a greater width of LI and C visible as seen from the front and hence, rejected the concept of GP for the population studied. According to some authors, GP can be found more consistently in persons with esthetically pleasing smiles rather than randomly selected smiles[6,28]. Mashid et al[10] considered aesthetic smiles in a group of 157 dental students (age 18–30) to be where the 'natural smile did not develop any visual tension'. They measured the scanned frontal photographs of the dental students and were unable to validate the existence of GP. For the current study, rather than selecting subjects with aesthetically pleasing smiles, randomly selected smiles were chosen. The criterion for an aesthetically pleasing smile was more subjective than objective and varies from person to person and culture to culture. Furthermore, it is not merely a function of teeth, rather the face as a whole. Since, the number of subjects having so called aesthetically pleasing smiles is unknown for the present study, it is difficult to infer the lack of GP for the population.

Application of GP results in an abnormally constricted arch with a very small width of canine visible from the front. Rosenstiel and colleagues[28] found that GP was preferred only in relation to tall teeth. Lombardi[8] was the first to propose the use of repeated numbers instead of golden proportion. Similarly, instead of focusing on the 62%, Ward recommended use of some other ratios such as 70% for a pleasing appearance[6]. In the present study, however, no such repeated or recurring proportion was identified. The results of the present study are in accordance with the findings of some other studies[19,21].

Conclusion

The results and conclusions of this study are applicable to the population studied. According to the findings of this study, there was no significant difference in maxillary anterior tooth dimensions for right and left sides of the arch. Length and width dimensions of CI were greater than those of LI and C for either gender, suggesting CI to be the dominant anterior tooth. Tooth measurements for men and women were statistically significant, but as the mean differences were small and may not be clinically significant. Furthermore, tooth dimensions guidelines can be provided for the population rather than for each gender separately. No statistically significant difference was found between left and right sides of the arch for any tooth ratios. Width/height ratios seem to be a constant finding with no statistically significant difference between the genders for CI and LI, except for C, which showed a statistically significant difference. GP guideline was not applicable for the Central Chinese population for either gender. According to results of the current study, apparent width ratios ranged from 72.47% to 82.48%.

Recommendation

China being a large country, and Chinese people consisting of one fifth of the world's total population, a study incorporating all the provinces of china with a larger sample size, and comparing the findings with those of southern Chinese, overseas Chinese and other races is recommended.

References

1. Davis LG, Ashworth PD, Spriggs LS. Psychological effects of aesthetic dental treatment. J Dent 1998;26:547–554.
2. Vallittu PK, Vallittu ASJ, Lassila VP. Dental aesthetics--a survey of attitudes in different groups of patients. J Dent 1996;24:335–338.
3. Brewer A. Selection of denture teeth for esthetics and function. J Prosthet Dent 1970;23:368–373.
4. Gillen RJ, Schwartz RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. Int J Prosthodont 1994;7:410–417.
5. Sterrett JD, Oliver T, Robinson F et al. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J Clin Periodontol 1999;26:153–157.
6. Ward DH. Proportional smile design using recurring esthetic dental (red) proportion. Dent Clin North Am 2001;45:143–154.
7. Levin EI. Dental esthetics and the golden proportion. J Prosthet Dent 1978;40:244–252.
8. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. J Prosthet Dent 1973;29:358–382.
9. Preston JD. The golden proportion revisited. J Esthet Dent 1993;5:247–251.
10. Mahshid M, Khoshvaghti A, Varshosaz M, Vallaei N. Evaluation of "golden proportion" in individuals with an esthetic smile. J Esthet Restor Dent 2004;16:185–192.
11. Ward DH. A study of dentists' preferred maxillary anterior tooth width proportions: comparing the recurring esthetic dental proportion to other mathematical and naturally occurring proportions. J Esthet Restor Dent 2007;19:324–337.
12. Jensen E, Kai-jen yen P, moorrees CF, Thomsen SO. Mesiodistal crown diameters of deciduous and permanent teeth in individuals. J Dent Res 1957;36:39–47.
13. Isa ZM, Tawfiq OF, Noor NM et al. Regression methods to investigatethe the relationship between facial measurements and widths of the maxillary anterior teeth. J Prosthet Dent 2010;103:182–188.
14. Brisman AS. Esthetics: a comparison of dentists' and patients' concepts. J Am Dent Assoc 1980;100:345–352.
15. Magne P, Gallucci GO, Belser UC. Anatomic crown width/length ratios of unworn and worn maxillary teeth in white subjects. J Prosthet Dent 2003;89:453–461.
16. Townsend G, Alvesalo L. Tooth size in 47,XXY males: evidence for a direct effect of the Y chromosome on growth. Aust Dent J 1985;30:268–272.
17. Townsend GC, Alvesalo L. The size of permanent teeth in Klinefelter(47,XXY) syndrome in man. Arch Oral Biol 1985;30:83–84.
18. Richardson ER, Malhotra SK. Mesiodistal crown dimension of permanent dentition of American Negroes. Am J Orthod 1975;68:157–164.
19. Hasanreisoglu U, Berksun S, Aras K, Arslan I. An analysis of maxillary anterior teeth: facial and dental proportions. J Prosthet Dent 2005;94:530–538.
20. Hattab FN, al-Khateeb S, Sultan I. Mesiodistal crown diameters of permanent teeth in Jordanians. Arch Oral Biol 1996;41:641–645.
21. Condon M, Bready M, Quinn F et al. Maxillary anterior tooth dimensions and proportions in an Irish young adult population. J Oral Rehabil 2011;38:501–508.
22. Huang Z, Wu X, Stamler J et al. A north-south comparison of blood pressure and factors related to blood pressure in the People's Republic of China: a report from the PRC-USA Collaborative Study of Cardiovascular Epidemiology. J Hypertens 1994;12:1103–1112.
23. Mavroskouvis F, Ritchie GM. Variation in size and form between left and right maxillary central incisor teeth. J Prosthet Dent 1980:43:254–257.
24. Garn SM, Lewis AB, Kerewsky RS. Sex difference in tooth size. J Dent Res 1964;43:306.
25. Ling JY, Wong RW. Tooth dimensions of southern Chinese. Homo 2007;58:67–73.
26. Brook AH, Griffin RC, Townsend G et al. Variability and patterning in permanent tooth size of four human ethnic groups. Arch Oral Biol 2009;54 Suppl 1:s79–85.
27. Tsukiyama T, Marchushamer E, Griffin TJ et al. Comparison of the anatomic crown width/length ratios of unworn and worn maxillary teeth in Asian and white subjects. J Prosthet Dent 2012;107:11–16.
28. Rosenstiel SF, Ward DH, Rashid RG. Dentists' preferences of anterior teeth proportion- a web-based study. J Prosthodont 2000;9:123–136.