Relations between Anterior Permanent Teeth, Dental Arches and Hard Palate

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A B S T R A C T

The width and length of the anterior teeth, the dimensions of the frontal dental arches and the dimensions of the hard palate were measured (24 men and 56 women, age range of 18–30 years). The results showed gender-related dimorphism only for the cervical width of the maxillary canine, which were wider in men, p<0.05. The width-to-length ratios of the maxillary frontal teeth varied from 0.82 to 0.91. The tooth-to-tooth width ratios among different maxillary frontal teeth varied from 0.78 to 0.91. The sum of all anterior maxillary teeth widths was equal to the hamular width and to the distal maxillary arch width (p>0.05), meaning that the sum of the frontal artificial teeth width may be selected upon the measurement of the hamular width on the hard palate. The ratios between the maxillary and the mandibular frontal dental arch dimensions are representative values for the skeletal class I.

Key words: anterior teeth, dental arch, hard palate, dimensions, ratios

Introduction

Modern anthropology on studies of genetic admixtures and biological relationship among the various groups of human races, has found that teeth and dental arches have a high genetic component[1]. Number, size and shape of teeth vary among different ethnic groups, for example, the cusp of Carabeli was found to have a higher incidence in Caucasians and Negroids than in Mongoloids. Furthermore, studies of the aetiological factors of malocclusion have shown that growth of the jaws was strongly influenced by genetic, as well as by environmental factors such as nutrition, health, physical status[1].

Measurements of tooth and arch dimensions for different ethnic groups have been reported by different authors and the results of such studies were shown to be of great value not only to practitioners in different fields of dentistry but also to anthropologists[9,25–28]. Tooth size is important in analyzing proportions of maxillary and mandibular teeth[2]. To achieve optimal occlusion, maxillary and mandibular teeth must be proportional in size. The knowledge of the standards for teeth dimensions for different ethnic groups would also help in the choice of

correct moulds of artificial teeth for fixed and removable prostheses[3–5]. Furthermore; anthropologists may use such studies to relate teeth, dental arched and hard palate dimensions to the different hereditary and environmental factors.

Gender-related differences in tooth and dental arch dimensions have been the object of interest in several earlier studies[11,18–24]. Frush and Fisher reported that women have smaller teeth comparing to men, but the difference did not exceed 3 %[23]. According to Lindemann et al., teeth widths were not different between women and men, but the women had shorter teeth[11]. Gender-related differences in tooth and dental arch dimensions are of great value to anthropologists and dentists in their practice. To achieve optimal gender-related occlusion relationship, artificial teeth must be proportional in size and well adapted in dental arch.

The relationship of the dimensions between various landmarks on an individual's face and size of maxillary anterior teeth has also been studied[6–12]. Williams sug-

gested that there was a correlation between the up-side-down facial shape and the shape of the maxillary central incisors[6], although data regarding the dimensions of the teeth were lacking in their study. Some attempts in order to correlate the form of the hard palate and the form of the maxillary incisors have been made[7–12]. Lowery and Nelson proposed that a close relationship among the shape of the face, maxillary central incisors and the dental arch (hard palate form) existed[7,8]. However, recent studies were neither able to confirm the relationship between the facial form and the shape of the maxillary central incisor, nor between the dental arch shape and the shape of the maxillary central incisor[9–12].

The aim of the present study is to obtain data concerning dimensions of maxillary and mandibular anterior teeth, dental arch shape (in skeletal and occlusal Class I sample) and hard palate shape, as well as to find the relations among these variables.

The research hypothesis was that the difference between gender would be found considering the dimensions of teeth, dental arches and hard palate.

Materials and Methods

Study population

A total of 80 individuals consisting of 24 men and 56 women with an age range of 18–30 years old participated in the present study. All individuals had intact teeth, Angle Class I skeletal and occlusal relationship (minimal tooth rotations or compressions were allowed). The exclusion criteria were more than one missing teeth missing (except the third molars) and presence of any restorations (prosthodontic or conservative) or visible tooth attrition on anterior teeth. Patients who had undergone orthodontic treatment or patients with any tooth size or shape deformities were also excluded from the study, as well as patients with marginal periodontitis and gingival recession.

Irreversible hydrocolloid impressions (Alginoplast fast set, Heraeus Kulzer, Hanau, Germany) of maxillary and mandibular arches were obtained and the casts were prepared with hard setting dental stone (ISO Type IV, Vel-Mix Stone, Kerr Italia S. p. A., Salerno, Italy). The round end filling instrument was used for precise location of the hamular notch on the hard palate and indelible pencil with a 0.1 mm tip was used for demarcation prior to impressions.

All individuals were well-informed about the aim and the methods of the study, and signed a written consent. The study was approved by the institutional ethic's committee.

Measurements

Measurements were made directly on the casts using a precise calliper (0.1 mm precision) (DKSH Switzerland Ltd. GPM Anthropological Instruments, Zurich, Switzerland). All measurements were made by one trained prosthodontist (Figure 1).
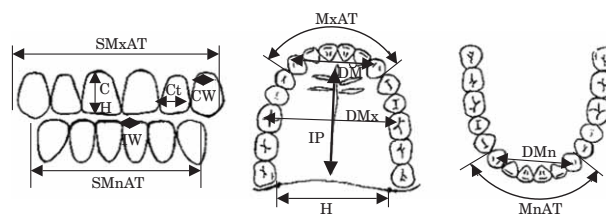

Fig. 1. Measured and calculated dimensions of the maxillary and mandibular teeth, dental arches and hard palate.

The clinical crown height (CH) of all maxillary (MxAT) and all mandibular anterior teeth (MnAT) was measured between the incisal edge and the most apical point of the marginal gingiva. The widths of the maxillary incisors were measured at the incisal edge (IW), at the level of interdental contact points (CtW) and between the tips of interdental papillas (cervical width-CW). The widths of the mandibular incisors were measured at the incisal edge (IW) and between the tips of interdental papillas (cervical width-CW). The CtW and the CW widths of the maxillary and the mandibular canines were measured as well.

The distance between the cusps of the left and the right side maxillary canines (DMxC) and the distance between the cusps of the left and the right side mandibular canines (DMnC) were also measured. The distal maxillary arch width (DMxW) which is the distance between mesial triangular fossae of the right and left maxillary first molar teeth was measured as well. The distance between the disto-proximal contact points of the left and the right maxillary canines (MxATWfr) and the distance between the disto-proximal contact points of the left and the right mandibular canines (MnATWfr) were measured with a flexible ruler (placed over the vestibular side of the maxillary or the mandibular teeth).

The sum of the maxillary anterior teeth widths (SMxATW) and the sum of the mandibular anterior teeth widths (SMnATW) were calculated by summing the largest teeth widths (CtW of maxillary incisors and canines, IW of mandibular incisors). The ratios between different tooth and arch dimensions were calculated, as well.

The hamular width (HW) was measured between the most mesial demarcation point of the left and the right hamular notch. The hard palate length (IP-FP) was measured between the palatine foveas (midline between left and right fovea palatina) and the centre of the incisive papilla.

Reliability

In order to test the reliability of the measurements, 10 randomly selected casts were measured by five dental practitioners within a two-week period. Statistical analysis (ANOVA) revealed no significant differences among different individuals and between the first and the second measurements. (p>0.05).

Data analysis

Normality of the distribution was tested by the Kolmogorov-Smirnov test. Means and standard deviations were calculated. Significance of the differences between dimensions of left and right side of the dental arches was assessed using the paired Student's t-test. Significance of the differences between males and females was assessed by the independent Student's t-test. The probability was let at 95 %.

Results

The distribution of the data was normal (p>0.05), as assessed by the one-sample Kolmogorov-Smirnov test.

There was no significant difference for the obtained dimensions between the left and the right side of the dental arch (p>0.05).

There was no significant difference for the obtained dimensions between men and women (p>0.05), except for the CW of the maxillary canines (men, x=7.92; women, x=7.49; p<0.05) and the distal maxillary arch width (men, x=47.71; women, x=45.37; p<0.05) which were significantly larger in men.

Descriptive statistics for all measured variables is presented in Table 1.

Table 2 presents different ratios between variables. Width-to-length and tooth-to-tooth width size relationships of anterior teeth and width-to-length ratios of the hard palate dimensions are presented. The width-to--length ratios of the maxillary frontal teeth varied from 0.82 to 0.91. The tooth-to-tooth width ratios among different maxillary frontal teeth varied from 0.78 to 0.91. The tooth-to-tooth width ratios among different maxillary and mandibular frontal teeth varied from 1.13 to 1.60.

To compare the mesiodistal dimensions of the hard palate and the dimensions of the anterior maxillary tooth arch, the ratios between the hamular width and the widths of the maxillary anterior teeth were calculated and the results are presented in Table 3. The ratio between the hamular width and the sum of maxillary anterior teeth widths was almost equal to 1 (1.02), revealing that the dimensions of the distance between the hamular notches and the sum of mesiodistal dimensiones of maxillary anterior teeth were equal in size (p>0.05).

Ratios among various dimensions of the maxillary and the mandibular dental arch are presented in Table 4. The distance between distoaproximal sides of the mandibular canines measured with flexible ruler and the sum of the mandibular anterior teeth width was 1.04. The ratio between the distal maxillary arch width and the sum of the maxillary anterior teeth widths was 1.00.

Discussion

The accuracy of dental casts made from irreversible hydrocolloid impressions as a representation of the actual teeth, dental arches and hard palate dimensions was investigated by different authors[13–16]. The results of their studies revealed that irreversible hydrocolloid impressions produced the most accurate dental casts when poured immediately. Furthermore, Hunter and Priest stated that there was a considerable advantage in measurements of teeth on the dental cast rather than measurements made directly on the teeth of the patient[17]. Mack investigated the hard stone expansion during setting and found it to be as small as 2.2 %, which should not influence the precision of the results[18]. Therefore; all the measurements were performed on the casts poured from the hard stone.

Many studies of tooth and arch dimensions for different ethnic groups have already been reported worldwide, but still new studies for certain ethnic groups have to be implemented[9,25–28]. Although the present study was performed on rather small number of individuals, still the measurements of the tooth and the dental arch dimensions are a contribution to the knowledge of these dimensions in the Croatian ethnic group. However, the results have to be considered only as preliminary results obtained from a pilot study. Preliminary results can be helpful in planning the concept of a larger population studies, presenting the mean values and variability (Table 1).

Gender-related differences in tooth and dental arch dimensions were investigated[11, 23, 24]. In the present study only the cervical width of the maxillary canines displayed a statistical significant gender-related dimorphism in tooth size with higher values in men (Table 1, p<0.05). Frush and Fisher reported that women have 3 % smaller teeth comparing to men[23], while Lindemann et al. stated that women had shorter teeth[11]. The results of the present study were not able to find gender-related dimorphism considering the size of both maxillary and mandibular teeth, except for the cervical width of the maxillary canines. The results of the present study also showed that the distal maxillary arch width differs between men and women, which is in agreement with the results obtained by other authors[24]. The men had wider hard palate than the women, but the hard palate width is not important for the selection of the artificial teeth moulds, only for their alignment in the dental arch.

The mean values of human teeth have been already been presented in the dental literature[9,25–28]. The present study tested the significance of the differences between the dimensions of the left and the right side frontal teeth and no statistically significant differences were found (p>0.05). Mavroskoufis reported that the difference between the dimensions of the left and the right side MxAT to be 0.03 mm[9], however such a small difference has no clinical implementation. Brand and Isselhard [25] and Berkovitz et al.[26] reported that the width of the maxillary central incisor was 8.5 mm, the width of the maxillary lateral incisor was 6.5 mm, and the width of the maxillary canine was 7.5 mm, which is similar to the results of the present study (Table 1). Also, the distance between the cusps of the left and the right maxillary canines was similar to other authors[27,28].

TABLE 1
DESCRIPTIVE STATISTICS FOR ANTERIOR TEETH DIMENSIONS, DENTAL ARCHES DIMENSIONS AND HARD PALATE DIMENSIONS

	X (mm)	SD	min	max
CH of maxillary central incisor	9.48	0.86	7.30	11.45
CH of maxillary lateral incisor	8.22	0.88	6.25	10.10
CH of maxillary canine	9.35	1.03	7.05	11.50
CH of mandibular central incisor	8.14	0.90	5.70	10.00
CH of mandibular lateral incisor	8.36	0.78	6.20	10.00
CH of mandibular canine	9.62	1.05	7.15	12.35
IW width of maxillary central incisor	8.29	0.56	6.65	9.70
CtW width of maxillary central incisor	8.55	0.52	6.50	10.15
CW width of maxillary central incisor	8.26	0.50	7.35	9.85
IW width of maxillary lateral incisor	6.19	0.50	5.15	7.70
CtW width of maxillary lateral incisor	6.66	0.49	5.65	7.65
CW width of maxillary lateral incisor	6.36	0.44	5.30	7.60
CtW width of maxillary canine	7.81	0.41	6.80	8.75
CW width of maxillary canine	7.70	0.43	6.80	8.75
CW width of maxillary canine (men)	7,92	0,46	7.05	8.75
CW width of maxillary canine (women)	7,49	0,39	6.80	8.50
IW width of mandibular central incisor	5.35	0.35	4.65	6.05
CW width of mandibular central incisor	4.79	0.33	3.95	5.80
IW width of mandibular lateral incisor	5.92	0.34	5.20	6.70
CW width of mandibular lateral incisor	5.33	0.40	4.20	6.45
CtW width of mandibular canine	6.78	0.44	5.90	8.05
CW width of mandibular canine	6.54	0.46	5.50	7.60
Sum of the maxillary anterior teeth width (SMxATW)	46.05	2.19	42.00	51.20
Sum of the mandibular anterior teeth width(SMnATW)	36.13	1.86	31.90	39.70
Distance between distoaproximal sides of maxillary canines measured with flexible ruler (MxATWfr)	52.05	2.39	47.5	57.0
Distance between distoaproximal sides of mandibular canines measured with flexible ruler(MnATWfr)	37.41	1.95	33.11	41.21
Distance between cusps of maxillary canines	34.16	1.84	29	38
Distance between cusps of mandibular canines	25.42	1.67	22.5	30.4
The distal maxillary arch width (DMxW)	46.10	3.07	37	53
The distal maxillary arch width (men)	47,71	2,78	42	53
The distal maxillary arch width (women)	45,37	3,18	37	52
Hamular width (HW)	47.10	4.71	36	55
Hard palate length (IP-FP)	44.80	3.48	37.3	55.1

Since the anterior teeth are the most prominent teeth and very important for dental aesthetics, the ratios between their dimensions were calculated (Table 2). Such data might be helpful for artificial teeth industry. According to Magne width-to-length ratio of the maxillary central incisor was 0.87[30], compared with 0.91 ratio, which was obtained in the present study. Brisman proposed that the optimal ratio would be 0.75[3], while Sterret proposed the ratio of 0.85[29]. Furthermore, the tooth-to-tooth width ratio between the maxillary lateral incisor and the maxillary central incisor obtained in this study was 0.78. Similar ratio has been already proposed by Magne, while Wolfart suggested the ratio in range from 0.43 to 0.81, based on the dentists and the patient's preferences[31].

According to Lowery and Nelson a close relationship exists between the shape of the maxillary central incisor and the shape of the hard palate[7,8]. It has also been reported that the sum of the widths of MxAT equals to the hamular width[32]. Therefore, it seemed reasonable to compare the MxAT dimensions and the hamular width dimension. According to the results of this study HW, DMxW and SMxATW are not significantly different in size (Table 3). Therefore both, HW or DMxW might be useful tools for determination of the anterior maxillary teeth size. The alveolar ridge of the DMxW is subjected to

TABLE 2
WIDTH-TO-LENGTH (W/L) AND TOOTH-TO-TOOTH WIDTH RATIOS (W/W)

Ratio	X	SD	min	max
W/L of hard palate	1.05	0.11	0.82	1.34
W/L of maxillary central incisor	0.91	0.84	0.68	1.12
W/L of maxillary lateral incisor	0.82	0.10	0.57	1.13
W/L of maxillary canine	0.84	0.10	0.69	1.20
W of maxillary lateral incisor / W of maxillary central incisor	0.78	0.06	0.66	1.14
W of maxillary canine / W of maxillary central incisor	0.91	0.06	0.77	1.14
W of maxillary lateral incisor / W of maxillary canine	0.86	0.07	0.73	1.06
Width of maxillary central incisor / Width of mandibular central incisor	1.60	0.09	1.25	1.81
Width of maxillary lateral incisor / Width of mandibular lateral incisor	1.13	0.08	0.93	1.33
Width of maxillary canine / Width of mandibular canine	1.15	0.05	0.97	1.32

TABLE 3
RATIOS BETWEEN THE HARD PALATE AND THE SUM OF FRONTAL MAXILLARY TEETH WIDTHS

Ratio	X	SD	min	max
Hamular width / Sum of the maxillary anterior teeth widths	1.02	0.11	0.75	1.21
Hamular width / Distance between distoapproximal sides of maxillary canines measured with flexible ruler	0.91	0.09	0.69	1.08
Hamular width / Distance between cusps of maxillary canines	1.38	0.15	1.02	1.73

severe resorption after distal teeth extraction while the HW remains within the same dimension[33].

Hamular notches and incisive papilla have been considered as reliable landmarks on the hard palate since their position has been determined by anatomical structures. Therefore, they are not submitted to the resorptive changes after teeth extraction[34]. Therefore, only HW and IP-FP dimensions may be chosen as reference landmarks and the HW distance can be recommended as a guide for the selection of the sum of the maxillary anterior teeth widths.

The mesiodistal anterior tooth sizes and the ratio between the maxillary and mandibular frontal dental arch size must relate to each other in order to obtain the optimal occlusion. Therefore, the maxillary and the mandibular mesiodistal tooth sizes were compared (Table 4) and

TABLE 4
RATIOS OF MAXILLARY AND MANDIBULAR FRONTAL TEETH WIDTHS

Ratio	X	SD	min	max
Sum of the maxillary anterior teeth width / Sum of the mandibular anterior teeth width	1.28	0.04	1.19	1.35
Distance between cusps of maxillary canines / Distance between cusps of mandibular canines	1.35	0.10	1.13	1.67
Distance between distoaproximal sides of maxillary canines measured with flexible ruler / Distance between distoaproximal sides of mandibular canines measured with flexible ruler	1.39	0.05	1.28	1.49
Distance between distoaproximal sides of maxillary canines measured with flexible ruler / Sum of the maxillary anterior teeth width	1.13	0.03	1.07	1.22
Distance between distoaproximal sides of maxillary canines measured with flexible ruler / Sum of the mandibular anterior teeth width	1.44	0.05	1.33	1.54
Distance between distoaproximal sides of mandibular canines measured with flexible ruler / Sum of the mandibular anterior teeth width	1.04	0.02	0.96	1.07
Distance between distoaproximal sides of mandibular canines measured with flexible ruler / Sum of the maxillary anterior teeth width	0.82	0.03	0.71	0.88
Distal maxillary arch width / Sum of the maxillary anterior teeth widths	1.00	0.07	0.82	1.15

the ratios between the maxillary and the mandibular teeth for the eugnathic Class I skeletal and occlusal subjects (tip of the maxillary canine is located between mandibular second incisor and canine during maximal interocclusion). According to McArthur[35], the ratio between the sum of the maxillary anterior teeth widths and the sum of the mandibular anterior teeth widths in the Class I canine relationship should be 1.30, which is in accordance with the results of this study (1.28).

The results obtained in the present study include teeth dimensions, the dental arch dimensions, the hard palate dimensions, and tooth-to-tooth and width-to-length teeth ratios. These dimensions and ratios can not only be helpful for reconstructive dental prosthodontics treatment and aesthetic, but also for the dental industry.

Conclusions

The only difference between men and women considering the anterior teeth dimensions was observed for the cervical width of the maxillary canines, which was significantly larger in men. The hamular width was equal to the sum of all maxillary anterior teeth and to the distal maxillary arch width. The hamular width can be used as a guide in selection of the sum of the maxillary anterior artificial teeth.

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ODNOSI PREDNJIH TRAJNIH ZUBA, ZUBNIH LUKOVA I TVRDOG NEPCA

S A Ž E T A K

Širina i duljina prednjih zuba, dimenzije prednjeg dijela zubnih lukova te dimenzije tvrdog nepca su izmjerene kod 24 muškarca i 56 žena (18–30 godina starosti). Rezultati su pokazali spolni dimorfizam samo za cervikalnu širinu gornjih očnjaka, koji su bili širi u muškaraca (p<0,05). Omjer širine i duljine gornjih prednjih zuba bio je između 0,82 i 0,91. Omjer širina gornjih prednjih zuba bio je između 0,78 i 0,91. Zbroj širina svih gornjih prednjih zuba bio je jednak hamularnoj širini i stražnjoj širini gornjeg zubnog luka (p>0,05), što ukazuje na mogućnost izbora zbroja širina svih gornjih prednjih zuba prema izmjerenoj hamularnoj širini tvrdog nepca. Omjeri gornjih i donjih prednjih zubnih lukova su reprezentativne vrijednosti skeletalne klase I.