RELATIONSHIP BETWEEN HARD PALATE DIMENSIONS AND THE WIDTH OF MAXILLARY ANTERIOR TEETH

Amela Đonlagić[1], Lejla Berhamović[1]*,
Alma Kamber-Ćesir[1], Sanela Strujić-Porović[1],
Emir Berhamović[1], Alma Gavranović-Glamoč[1],
Lejla Kazazić[1], Selma Tosum-Pošković[1]

[1] Department of Prosthodontics and Dental Implantology,
Faculty of Dentistry with Clinics, University of Sarajevo,
Sarajevo, Bosnia and Herzegovina

*Corresponding author

Lejla Berhamović
Faculty of Dentistry with Clinics,
University of Sarajevo
Bolnička 4A, Sarajevo,
Bosnia and Herzegovina
Phone: 38761431901
E-mail:
berhamovic.lejla@gmail.com

ABSTRACT

Objective: This study aimed to determine the reliability of selected anthropometric parameters of the hard palate as individual and simultaneous predictors of the width of the anterior maxillary teeth.

Methods: This retrospective cross-sectional observational study used the maxillary casts of 180 subjects from Bosnia and Herzegovina of both genders aged 20 to 40. Hamular distance, hard palate length, distances between the incisive papilla and left and right hamular notch, the widths of the anterior teeth at the level of contact points were measured on the casts using a digital caliper. For each subject, the sum of the widths of the anterior maxillary teeth was calculated and used as the value of a dependent variable. The obtained data were statistically analyzed.

Results: Established mean differences between the width of the anterior maxillary teeth and hard palate dimensions were statistically significant (p <0.05). Significant positive linear relationships (p <0.000) were found, between the hard palate dimensions and the width of anterior teeth, with correlation coefficients ranging r =0.247-0.398. The coefficient of multiple correlation was moderate (R =0.438, p <0.000).

Conclusions: The multiple linear regression model provides a more reliable prediction of the width of the anterior maxillary teeth compared to the simple linear regression models. Nevertheless, the combined influence of the four evaluated hard palate dimensions can explain at most 19% of the teeth width variability in our subjects, which is insufficient for a reliable prediction. Further studies should be examined some other parameters.

Keywords: anterior maxillary teeth, teeth width, hard palate, dimensions, relationship, complete denture

Introduction

The rehabilitation of qualitative and quantitative changes in the stomatognathic system caused by complete tooth loss is very demanding. Although contemporary Prosthodontics has several different therapeutic modalities, the making of conventional complete dentures remains the most common treatment for edentulous patients [1]. Complete dentures should restore original occlusion, lost dentofacial harmony and the appearance of the patient being impossible to achieve without correct selection and setting of artificial teeth. The anterior maxillary teeth are most exposed to view and judgment, and since their appearance affects the dental and smile aesthetics dominantly [2], special attention in denture construction belongs to the selection of artificial maxillary anterior teeth. The anterior teeth are primarily selected to fulfill aesthetic requirements. Patients, especially those receiving complete dentures for the first time, generally expect a similar appearance between artificial and lost natural teeth [3-5]. The adequately selected size of artificial maxillary anterior teeth mostly influences a denture naturalness [6-8]. Pre-extraction records of the natural tooth dimensions, such as study models, photographs, preserved extracted teeth, as well as old radiographs and dentures, may be useful in selecting artificial anterior maxillary teeth [9]. If pre-extraction records are unavailable, determining the appropriate dimensions of artificial maxillary anterior teeth becomes one of the challenges [10], which is not always easy to respond to satisfactorily. The synthesis of knowledge, experience, creativity, imagination and a sense of the aesthetic is necessary to pass successfully through this step avoiding the distinctive artificial appearance of complete denture. It is easier to determine the appropriate length of artificial maxillary anterior teeth than their width [11] since relatively reliable anatomical and functional parameters permit this [12-14]. However, the mesiodistal width of the anterior maxillary teeth is more relevant for the natural appearance and functionality of the denture [4, 12, 13], but also much harder to estimate accurately. To date, several extraoral and intraoral anthropometric landmarks have been proposed to determine the width of artificial anterior maxillary teeth, and the results of previous studies are inconsistent regarding their reliability. An universally applicable anthropometric indicator of the anterior teeth width is yet to be found [15, 16], and their reliability varies among different ethnic groups around the world [3].

Regarding all the above mentioned, this study aimed to determine the reliability of selected anthropometric parameters of the hard palate as individual and simultaneous predictors of the width of the anterior maxillary teeth since that has not been studied in our population previously.

Materials and Methods

The research was performed at the Dental Prosthetics Department of the Faculty of Dentistry of the University of Sarajevo as a retrospective observational study employing a cross-sectional method. In this study, the values of variables obtained by measuring the maxillary casts of 180 subjects from Bosnia and Herzegovina of both genders aged 20 to 40 were used. The maxillary casts of the completely dentate subjects with proper tooth alignment free of fixed prosthetic restorations, fillings, caries, attrition, spacing or crowding of anterior teeth were included in the study. Slight rotations or inclinations of individual teeth and absence of third molars were tolerated, as well as different skeletal classes. Maxillary casts of subjects with confirmed orthodontic treatment, parafunctional habits, congenital or maxillofacial defects and craniofacial trauma were excluded from the study. Maxillary casts were obtained by pouring alginate impressions (Xantalgin® Select, Kulzer GmbH, Hanau, Germany) with a type IV gypsum (Moldastone, Kulzer GmbH, Hanau, Germany). All impressions have been previously disinfected (Aseptoprint® Liquid, OCC Switzerland, Fehraltorf, Switzerland). Following the gypsum

setting process, the casts were removed from the impressions, analyzed to confirm the anatomical landmark structures were well duplicated and then trimmed. The approval by the Ethics Committee of the Faculty of Dentistry of the University of Sarajevo and the informed consent of participants was obtained for taking the impression, making and measuring the maxillary casts used in this research.

By one person using a digital caliper (Emil Lux GmbH & Co. KG, Wermelskirchen, Germany), the following distances on the casts were measured: the distance between the right and the left hamular notch (hamular distance), the distance between the center of the incisive papilla and the fovea palatine (hard palate length), the distance from the right hamular notch to the incisive papilla, the distance from the left hamular notch to the incisive papilla, and the mesiodistal widths of the anterior maxillary teeth at the level of contact points. Each variable was measured three times on each maxillary cast, and the obtained values were recorded on worksheets. The data later were transferred into the Microsoft Excel tables (Microsoft Excel 2016 MSO) to calculate the mean value of three measurements and get the reference value of variables. The sum of the widths of the

anterior maxillary teeth was also calculated for each subject to obtain the value of the dependent variable.

The obtained data were statistically analyzed using IBM SPSS Statistics v.21. Descriptive statistical parameters were calculated. Testing of research hypotheses was performed by parametric statistical methods. Differences between two dependent samples were tested by the Paired samples t-test. The correlation and the influence of independent variables on the dependent variable were examined in the first procedure by simple linear regression analysis, while in the second procedure, a standard multiple linear regression analysis, the enter method, was used. Before testing the research hypotheses, the universal statistical assumptions of the used parametric statistical methods were screened, namely: normality of the distribution of variables and the presence of univariate atypical points (Outliers). Additionally, the absence of multicollinearity of independent variables with VIF coefficient for the linear regression analyzes was examined. By checking the stated assumptions, no significant violation of them was noticed. The alpha significance level was set at 5% (0.05).

Table 1. Descriptive values of different evaluated dimensions of teeth and hard palate

Dimensions	n	Minimum	Maximum	95% C.I.Mean	Std. Deviation	Skewness
Width of right central incisor	180	7,30	10,37	8,60±0,09	0,61	0,21
Width of right lateral incisor	180	5,37	8,90	6,76±0,08	0,55	0,27
Width of right canine	180	6,75	9,20	7,85±0,08	0,54	0,18
Width of left central incisor	180	5,40	10,17	8,63±0,09	0,63	-0,55
Width of left lateral incisor	180	5,50	8,70	6,77±0,08	0,55	0,42
Width of left canine	180	6,60	9,50	7,84±0,07	0,49	0,14
The sum of the widths of the anterior maxillary teeth	180	40,40	52,90	46,44±0,38	2,61	0,07
Hamular distance	180	32,00	49,93	42,77±0,50	3,45	-0,32
Hard palate length	180	40,09	52,75	45,93±0,40	2,72	-0,02
Distance from the right hamular notch to the incisive papilla	180	41,60	57,16	49,62±0,44	3,03	0,07
Distance from the left hamular notch to the incisive papilla	180	41,00	57,71	49,49±0,49	3,34	-0,16

Table 2. The differences between the average values of measurements on the right and left sides of the upper jaw

Compared dimensions	n	Paired Differences		t value	P value
		95% C.I.Mean	Std. Deviation		
Width of right central incisor - Width of left central incisor	180	-0,03±0,07	0,45	-0,964	0,336
Width of right lateral incisor - Width of left lateral incisor	180	-0,01±0,08	0,51	-0,281	0,779
Width of right canine - Width of left canine	180	0,01±0,05	0,36	0,205	0,838
Distance from the right hamular notch to the incisive papilla - Distance from the left hamular notch to the incisive papilla	180	0,12±0,26	1,81	0,912	0,363

Results

The descriptive statistics results, including the arithmetic means and confidence intervals, standard deviations, value ranges and asymmetry coefficients for various measured dimensions of the teeth and the hard palate, are shown in **Table 1**.

The dependent t-test examined the mean differences between the measured dimensions on the right and left side of the maxilla and the obtained results are presented in **Table 2**. The average values of the widths of the anterior homologous teeth were not significantly different, nor the average values of the distances from hamular notch to incisive papilla on the right and the left sides of the hard palate.

The Paired samples t-test compared the mean differences between the sum of the widths of the anterior maxillary teeth and the four evaluated dimensions of the hard palate (**Table 3**). The most similar to the widths of the anterior maxillary teeth

was the hard palate length with a mean difference of 0.51 ± 0.45 millimeters, while the most different was the hamular distance with a mean difference of 3.67 ± 0.55 millimeters. Nevertheless, the results of the t-tests showed that all established differences between the average values of the sum of the widths of the anterior maxillary teeth and the four evaluated dimensions of the hard palate were statistically significant ($p < 0.05$).

In the separate simple linear regression models, the individual correlation and influence between the measured dimensions of the hard palate and the sum of the widths of the anterior maxillary teeth were quantified. A statistically significant weak positive linear relationship ($r = 0.247$, $p < 0.000$) was found between the hamular distance and the dependent variable. Other evaluated dimensions of the hard palate also had a statistically significant ($p < 0.000$) but a moderate positive linear relationship with correlation coefficients ranging $r = 0.324-0.398$. The results of

Table 3. The differences between the average values of the sum of the widths of the anterior maxillary teeth and the dimensions of the hard palate

Compared dimensions	n	Paired Differences		t value	P value
		95% C.I.Mean	Std. Deviation		
The sum of the widths of the anterior maxillary teeth - Hamular distance	180	3,67±0,55	3,77	13,059	0,000
The sum of the widths of the anterior maxillary teeth - Hard palate length	180	0,51±0,45	3,10	2,214	0,028
The sum of the widths of the anterior maxillary teeth - Distance from the right hamular notch to the incisive papilla	180	-3,18±0,46	3,14	-13,595	0,000
The sum of the widths of the anterior maxillary teeth - Distance from the left hamular notch to the incisive papilla	180	-3,05±0,48	3,32	-12,351	0,000

Table 4. Simple linear regression models for predicting the value of the sum of the widths of the anterior maxillary teeth

Regression models	Mean			Regression parameters			
	X	Y	X/Y	r	a	b	P value
Hamular distance -> The sum of the widths of the anterior maxillary teeth	42,76	46,44	0,92	0,247	38,45	0,19	0,000
Hard palate length -> The sum of the widths of the anterior maxillary teeth	45,93	46,44	0,99	0,324	32,18	0,31	0,000
Distance from the right hamular notch to the incisive papilla -> The sum of the widths of the anterior maxillary teeth	49,62	46,44	1,07	0,388	29,87	0,33	0,000
Distance from the left hamular notch to the incisive papilla -> The sum of the widths of the anterior maxillary teeth	49,49	46,44	1,07	0,398	31,06	0,31	0,000

Table 5. Representativeness of the multiple linear regression model
for predicting the value of the sum of the widths of the anterior maxillary teeth

R	R Square	Adjusted R Square	Std. Error	F	P value
0,438	0,192	0,173	2,37	10,386	0,000

Table 6. Realized regression parameters for predicting the value of the sum of the widths of the anterior maxillary teeth

	Unstandardized Coefficients		Standardized Coefficients	t value	P value	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
a	25,621	3,612	-	7,094	0,000	18,493	32,749
Hamular distance (X1)	0,122	0,054	0,162	2,245	0,026	0,015	0,230
Hard palate length (X2)	0,010	0,120	0,010	0,083	0,934	-0,228	0,248
Distance from the right hamular notch to the incisive papilla (X3)	0,119	0,120	0,138	0,992	0,323	-0,118	0,356
Distance from the left hamular notch to the incisive papilla (X4)	0,186	0,108	0,239	1,731	0,085	-0,026	0,399

the performed simple linear regression analysis are shown in **Table 4**.

The multiple linear regression investigated the simultaneous influence of the measured dimensions of the hard palate on the prediction of the sum of the widths of the anterior maxillary teeth. Results confirmed that the regression model with a set of independent variables has a statistically significant moderate multiple linear relationships (R = 0.438, p <0.000) with the dependent variable (**Table 5**).

When the individual influences of independent variables in the model on the contribution to the prediction of the value of the sum of the widths of

the anterior maxillary teeth were analyzed, the hamular distance showed a statistically significant contribution (Beta = 0.162, p <0.026) compared to other predictors that did not have statistical significance (**Table 6**). The result of performed multiple linear regression is the multiple linear regression equation with included regression coefficients as follows: The sum of the widths of the anterior maxillary teeth = 25,621+ 0,122 X1 + 0,010 X2 + 0,119 X3 + 0,186 X4, where X1 through X4 are distinct predictor variables given in Table 6.

Discussion

According to the literature, some of the extraoral factors have been frequently used to determine the width of anterior maxillary teeth, particularly the intercommissural, interalar, intercanthal, interpupillary and bizygomatic distance [17]. The relationships between teeth and facial dimensions have been extensively examined, but the results of performed studies are not consistent. Several previous studies have shown that some parts of the face and dimensions of the anterior teeth have a proportional relationship [11, 12, 14, 18-23]. Other studies have not confirmed the correlation [8, 24-29] or found it only in a particular gender [13, 30]. The general opinion is that harmony between the dimensions of the teeth and the patient's face is needed to achieve a satisfactory aesthetic result with dentures, but none of the studied facial dimensions can be recommended as universally applicable and reliable for determination of the width of the artificial anterior maxillary teeth. Additionally, the reliability of using the facial dimensions also compromises the absence of a static relationship of structures due to mobility and possible changes in soft tissue landmarks due to aging [31], body weight variability [32], aesthetic surgical or cosmetic corrections. It is considered that only fixed anatomical landmarks should be used to determine the width of artificial upper anterior teeth, which does not change due to the previously mentioned [33] or some other factors. Several intraorally located structures are known to remain constant throughout life [34]. The hamular notch is located at the junction of the maxilla and the pterygoid hamulus of the sphenoid bone [35]. It is an easily noticeable bilateral landmark that does not change after tooth loss, bone resorption, or due to aging or body weight changes [33]. Previous studies have found that the average values of hamular distance and the sum of individual mesiodistal widths of the anterior maxillary teeth are not significantly different, are significantly correlated and that this dimension of the hard palate is a reliable clinical guide [33, 36-39]. This study revealed that hamular distance was a significant but the weakest predictor of the sum of widths of the anterior maxillary teeth. All other dimensions of the hard palate showed a stronger association with the dependent variable. Similar to other previous studies [32, 40], the present study also found that the average values of the hamular distance and the sum of widths of the anterior maxillary teeth differ significantly. According to a recently published approach, a more reliable determination of the width of the anterior maxillary teeth performs if 10 millimeters are added to a measured value of the hamular distance [4, 15]. However, the results of this and some other studies [27] do not support this method. The incisive papilla is also considered a reliable and relatively stable anatomical landmark [34] that does not change position after tooth loss [41] and even years later [42]. Its center is usually used as a reference point [41, 42]. Larasati et al., founded that the distances between the center of the incisive papilla and the hamular notch on the right and left side and the width of the anterior maxillary teeth are significantly correlated and that these distances may explain 25.7% of tooth width variability [40]. In some studies, the strength of correlation between the distance from the center of the incisive papilla to the hamular notch and the width of the upper anterior teeth varies regarding ethnicity [39] and gender [40], but authors [38] still consider this distance of the hard palate as a reliable guide for determining the width of the upper anterior teeth. In the present study, this distance on the hard palate showed a significant

positive relationship with the width of the anterior maxillary teeth, the strongest of all variables analyzed by simple linear regression.

However, based on the realized coefficients r = 0.388 for the right and r = 0.398 for the left side, the correlation was only moderate. Baker et al., considered a hamular distance a more reliable guideline of the width of the anterior maxillary teeth than the distance between the center of the incisive papilla and the hamular notch [15]. In the present study, multiple regression analyses confirmed a similar result, and the hamular distance contributes significantly (Beta = 0.162, p <0.026) to the estimation of the width of the anterior maxillary teeth, unlike the other three predictors. However, when a simple linear regression examined the individual influence of predictors, the present study found the opposite results, a weak correlation of the width of teeth and the hamular distance, and a moderate correlation between the width of teeth and the length between the incisive papilla and the hamular notch. The hard palate length is another possible intraoral reference distance with boundary points, the center of the incisive papilla and the palatine fovea remaining constant after tooth loss. Previous studies have shown that the average values of this distance are not significantly different in dentate and edentate subjects, and also that through its measurement, the original value of the length of the upper central incisor can be estimated [43]. According to the present study results, four examined dimensions of the hard palate were significantly different in the mean value from the width of the anterior maxillary teeth, and the hard palate length was the most similar, with a mean difference of 0.51 ± 0.45 millimeters. The present study founded a statistically significant moderate positive linear relationship between the hard palate length and the anterior teeth width. Compared to other predictors, hard palate length would be a better guideline than the hamular distance but weaker than the distance between the incisive papilla and the hamular notch. Similar studies examining the relationship between the hard palate length and the width of the anterior maxillary teeth are lacking in the literature.

Conclusion

Within the limitations of this study, the following conclusions can be drawn:

1. There is a significant positive correlation between all evaluated dimensions on the hard palate and the anterior maxillary teeth width, and the multiple linear regression model provides a more reliable prediction of the original value of the width of the anterior maxillary teeth compared to the simple linear regression models constructed in this study.

2. Determination of the width of the artificial anterior maxillary teeth by measurement of the hard palate dimensions can be used as the initial step or combined with other methods for the selection of anterior teeth in denture construction. Some other parameters must be examined since the combined influence of the four evaluated hard palate dimensions can explain at most 19% of the variability of maxillary anterior teeth width in our subjects, which is insufficient for a reliable prediction.

Declaration of interest

There is not any conflict of interest for all authors, between the authors, or for any organization.

References:

1. Sun YC, Sun R, Deng KH, Wang Y, Zhou YS. Research and Development of Digital Design and Fabrication of Complete Denture. Zhonghua Kou Qiang Yi Xue Za Zhi. 2018;53(1):60-65.

2. Oreški NP, Čelebić A, Petričević N. Assessment of esthetic characteristics of the teeth and surrounding anatomical structures. Acta Stomatol Croat. 2017;51(1):22-32.

3. Jain AR, Nallaswamy D, Ariga P, Ganapathy DM. Determination of correlation of width of maxillary anterior teeth using extraoral and intra-ral factors in Indian population: a systematic review. World J Dent. 2018;9(1):68-75.

4. Ravikumar C, Jain AR. Reliability of pterygomaxillary notch in determination of width of maxillary anterior in Indian and Malaysian po-pulation. Drug Invention Today. 2018; 10(4): 525-530.

5. Ibrahimagić L, Čelebić A, Jerolimov V, Seifert D, Kardum-Ivić M, Filipović I. Correlation between the size of maxillary frontal teeth, the width between alae nasi and the width between corners of the lips. Acta Stomatol Croat. 2001;35(2):175-179.

6. Attokaran G, Shenoy K. Correlation between Innercanthal Distance and Mesiodistal Width of Maxillary Anterior Teeth in a Thrissur, Kerala, India, Population. J Contemp Dent Pract. 2016;17(5):382-387.

7. A L-Kaisy N, Garib BT. Selecting maxillary anterior tooth width by measuring certain facial dimensions in the Kurdish population. J Prosthet Dent. 2016;115(3):329-334.

8. Mishra MK, Singh RK, Suwal P, Parajuli PK, Shrestha P, Baral D. A comparative study to find out the relationship between the inner inter-canthal distance, interpupillary distance, inter-commissural width, inter-alar width, and the width of maxillary anterior teeth in Aryans and Mongoloids. Clin Cosmet Investig Dent. 2016;8:29-34.

9. Bissasu M. Pre-extraction records for complete denture fabrication: a literature review. J Prosthet Dent. 2004;91(1):55-58.

10. Liao P, Fan Y, Nathanson D. Evaluation of maxillary anterior teeth width: A systematic review. J Prosthet Dent. 2019;122(3): 275-281.e7.

11. Abdullah MA. Inner canthal distance and geometric progression as a predictor of maxillary central incisor width. J Prosthet Dent. 2002;88(1):16-20.

12. Al Wazzan KA. The relationship between intercanthal dimension and the widths of maxillary anterior teeth. J Prosthet Dent. 2001;86(6): 608-612.

13. Hasanreisoglu U, Berksun S, Aras K, Arslan I. An analysis of maxillary anterior teeth: facial and dental proportions. J Prosthet Dent. 2005;94(6): 530-538.

14. Kern BE. Anthropometric parameters of tooth selection. J Prosthet Dent. 1967;17(5): 431-437.

15. Baker PS, Morris WJ, Lefebvre CA, Price GA, Looney SW. Relationship of denture cast measurements to width of maxillary anterior teeth. J Prosthet Dent. 2011;105(1):44-50.

16. Zlatarić DK, Kristek E, Celebić A. Analysis of width/length ratios of normal clinical crowns of the maxillary anterior dentition: correlation between dental proportions and facial measure-ments. Int J Prosthodont. 2007;20(3):313-315.

17. Melilli D, Calandra F, Messina P, Scardina GA. A new system for choosing the form and size of complete denture anterior teeth. Dent Hypotheses. 2016;7(4):147-151.

18. Ibrahimagić-Šeper L, Selimović E. Analysis of the correlation between some antropometric parametars of the face and the teeth in reconstruc-tive removable prosthodontics. Med Glas. 2005;2(1):29-33.

19. Gomes VL, Gonçalves LC, Costa MM, Lucas Bde L. Interalar distance to estimate the combined width of the six maxillary anterior teeth in oral rehabilitation treatment. J Esthet Restor Dent. 2009;21(1):26-36.

20. Miranda GA, D'Souza M. Evaulating the reliability of the interalar width and intercommissural width as guides in selection of artificial maxillary anterior teeth: A clinical study. J Interdiscip Dentistry. 2016;6(2):64-70.

21. Isa ZM, Tawfiq OF, Noor NM, Shamsudheen MI, Rijal OM. Regression methods to investigate the relationship between facial measurements and widths of the maxillary anterior teeth. J Prosthet Dent. 2010;103(3):182-188.

22. Gomes VL, Gonçalves LC, do Prado CJ, Junior IL, de Lima Lucas B. Correlation between facial measurements and the mesiodistal width of the maxillary anterior teeth. J Esthet Restor Dent. 2006;18(4):196-205.

23. Banu R, Dandekeri S, Shenoy KK, Shetty S, Bhat V, Ragher M. An In Vivo Study to Compare and Evaluate the Correlation of the Facial Measurements with the Combined Mesiodistal Width of the Maxillary Anterior Teeth between Males and Females. J Pharm Bioallied Sci. 2017;9(Suppl 1):S127-S131.

24. Ellakwa A, McNamara K, Sandhu J, et al. Quantifying the selection of maxillary anterior teeth using intraoral and extraoral anatomical landmarks. J Contemp Dent Pract. 2011;12(6): 414-421.

25. Strajnić L, Vuletić I, Vucinić P. The significance of biometric parameters in determining anterior teeth width. Vojnosanit Pregl. 2013;70(7):653-659.

26. Deogade SC, Mantri SS, Sumathi K, Rajoriya S. The relationship between innercanthal dimension and interalar width to the intercanine width of maxillary anterior teeth in central Indian population. J Indian Prosthodont Soc. 2015;15(2):91-97.

27. Sayed ME, Porwal A, Al-Faraj NA, Bajonaid AM, Sumayli HA. Evaluation of the Current Techniques and Introduction of a Novel Approach for Estimating Maxillary Anterior Teeth Dimensions. J Contemp Dent Pract. 2017;18(7):541-548.

28. Deogade SC, Mantri SS, Saxsena S, Daryani H. Correlation between Combined Width of Maxillary Anterior Teeth, Interpupillary Distance and Intercommissural Width in a Group of Indian People. Int J Prosthodont Restor Dent. 2014;4(4):105-111.

29. Varjão FM, Nogueira SS. Intercommissural width in 4 racial groups as a guide for the selection of maxillary anterior teeth in complete dentures. Int J Prosthodont. 2005;18(6):513-515.

30. al-el-Sheikh HM, al-Athel MS. The relationship of interalar width, interpupillary width and maxillary anterior teeth width in Saudi population. Odontostomatol Trop. 1998;21(84):7-10.

31. Ferrario VF, Sforza C, Dellavia C, Schmitz JH. Harmonic analysis of facial profiles: a 10-year evaluation. Int J Adult Orthodon Orthognath Surg. 2001;16(1):54-60.

32. Guldag MU, Büyükkaplan US, Sentut F, Ceylan G. Relationship between pterygomaxillary notches and maxillary anterior teeth. J Prosthodont. 2010;19(3):231-234.

33. Kumar M, Kumar G, Kumar Singh T, Maula D. Relationship between Pterygomaxillary Notches, Maxillary Anterior Teeth and Dental Arch: An in vivo study. Sch J App Med Sci. 2019;7(7):2322-2328.

34. Ferrario VF, Sforza C, Dellavia C, Colombo A, Ferrari RP. Three-dimensional hard tissue palatal size and shape: a 10-year longitudinal evaluation in healthy adults. Int J Adult Orthodon Orthognath Surg. 2002;17(1):51-58.

35. The Glossary of Prosthodontic Terms: Ninth Edition. J Prosthet Dent. 2017;117(5S):e1-e105.

36. Petričević N, Čelebić A, Baučić M, Antonić R. Importance of Hamular Distance for Calculation of the Width of Maxillary Anterior Teeth. Acta Stomat Croat. 2005;39(3):285-290.

37. Petricević N, Katunarić M, Mehulić K, Simeon P, Rener-Sitar K, Celebić A. Selection of appropriate artificial frontal teeth size using dimensions of hard palate. Coll Antropol. 2006;30(3):573-577.

38. Shivaji JM, Vaidya P, Thippanna RK, Wadhwa R, Wadhwa A, Gandhi P. An Innovative Method to Determine the Width of Maxillary Anterior Teeth with the Help of Measurements Obtained from the Master Cast. J Contemp Dent Pract. 2018;19(12):1487-1492.

39. Shukri NMM, Jain AR. The correlation of bizygomatic width and ridge relationships in determination of width of maxillary anterior teeth. Drug Invent. Today. 2018;10(5):728-734.

40. Larasati AA, Gita F, Indrasari M. Measuring Anatomical Landmark Structures to Determine the Width of Maxillary Anterior Teeth. J Int Dent Med Res. 2018;11(1):169-174.

41. McGee GF. Tooth placement and base contour in denture construction. J Prosthet Dent. 1960;10(4):651–657.

42. Harper RN. The Incisive Papilla: The Basis of a Technic to Reproduce the Positions of Key Teeth in Prosthodontia. J Dent Res. 1948;27(6): 661–668.

43. Ibrahimagić–Šeper L, Čelebić A, Selimović E, Petričević N. The length between incisive papilla and foveola palatine for determination of the length of the central upper artificial incisors. Med Glas. 2005;2(2):75-79.