10.5937/bjdm2602067D

BALKAN JOURNAL OF DENTAL MEDICINE

ISSN 2335-0245

Correlation Between Maxillary Dental Arch Width and Morphometric Characteristics of the Incisive Papilla

SUMMARY

Background: *The relationship between the morphometric characteristics of the incisive papilla and dental arch width represents an important aspect in assessing anatomical and prosthetic relationships in the anterior maxilla. The aim of this study was to examine the correlation between maxillary dental arch width and morphometric characteristics of the incisive papilla (length, width, shape).* ***Materials and Methods:*** *A total of 180 subjects of both sexes, aged 20–40 years, with complete dentition and different skeletal classes were included in the study.* ***Results:*** *The results indicate that the transverse dimensions of the maxillary dental arch (13–23, 14–24, and 16–26) are significantly associated with the morphological parameters of the palate and the incisive papilla. The width of the incisive papilla emerged as the most significant predictor in all regression models, confirming its importance as a stable anatomical landmark in prosthetic rehabilitation of edentulous patients. The shape of the incisive papilla did not show a statistically significant influence on dental arch width, nor was there a significant interaction between sex and papilla shape.* ***Conclusion:*** *The width of the incisive papilla represents the most significant predictor of the transverse dimensions of the maxillary dental arch. This correlation has important implications in prosthodontics for understanding individual anatomical variations and improving clinical practice.*

Keywords: incisive papilla, maxilla, dental arch, morphometry, prosthodontics

Amela Đonlagić,[1]*Alma Kamber,[1] Lejla Berhamović,[1] Emir Berhamović,[1] Sanela Strujić - Porović,[1] Alma Gavranović Glamoč,[1] Lejla Kazazić,[1] Selma Alić - Drina,[2]

[1] Faculty of Dentistry, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[2] Dental Clinical Center, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

ORIGINAL PAPER (OP)
Balk J Dent Med, 2026;67-73

Introduction

In modern dentistry and craniofacial morphology, increasing importance is being placed on the detailed analysis of the dimensions and relationships of the anatomical structures of the oral cavity to improve diagnostic, orthodontic, and prosthetic procedures. The maxillary dental arch represents a complex anatomical and functional structure whose shape, width, and length are determined by the interaction of genetic, developmental, and functional factors. Variations in dental arch width, particularly intermolar and intercanine width, have a significant influence on occlusion, smile aesthetics, and the stability of orthodontic treatment[1,2]. The development of digital technologies, including three-dimensional model analysis, has further emphasized the importance of precise dental arch measurements in clinical practice[3].

Particular attention has been directed toward the relationship between the incisive papilla and the dimensions of the dental arch. Previous studies have demonstrated that the distance between the incisive papilla and the maxillary central incisors varies according to the shape and width of the dental arch, suggesting a functional and morphological association between these structures[4]. The incisive papilla is a well-defined anatomical landmark located in the anterior region of the hard palate, immediately posterior to the maxillary central incisors. Classical studies have shown that the position of the maxillary central incisors can be determined relative to the incisive papilla with relatively high accuracy, making this landmark particularly valuable in the prosthetic rehabilitation of completely edentulous patients[5]. However, although the incisive papilla is generally considered a stable anatomical reference point, numerous studies have reported considerable individual variation in its morphometric characteristics, including its shape, size, height, and relationship to adjacent structures[6]. More recent investigations have confirmed that factors such as gingival thickness and the morphology of the anterior teeth may influence the morphology of the incisive papilla, further limiting its application as a universal reference parameter[7]. Contemporary studies in forensic dentistry have also highlighted the incisive papilla as an individually variable anatomical structure with potential value in human identification[6].

Despite numerous studies investigating either dental arch dimensions or the characteristics of the incisive papilla separately, there remains a limited number of studies that comprehensively examine the relationship between these variables, particularly within the context of contemporary digital morphometric analysis. Therefore, investigating the association between maxillary dental arch width and the morphometric characteristics of the incisive papilla may contribute to a better understanding of individual anatomical variation and support the advancement of clinical practice.

Aim of the Study

The aim of this study was to evaluate the relationship between maxillary dental arch width and the morphometric characteristics of the incisive papilla, including its length, width, and shape.

Materials and Methods

This study was conducted at the Department of Prosthodontics, Faculty of Dentistry, University of Sarajevo. The sample comprised 180 subjects (students and patients) from the Bosnian and Herzegovinian population, including both sexes and aged 20–40 years. All participants had complete dental arches and represented different skeletal classes.

Subjects with fixed prosthodontic restorations, a history of orthodontic treatment, or parafunctional habits were excluded. Ethical approval was obtained from the Ethics Committee of the Faculty of Dentistry, University of Sarajevo (No. 09-874-6/12; December 27, 2012), and written informed consent was obtained from all participants.

Impressions of the maxilla were taken using an alginate material, then disinfected and poured in type IV dental stone (Heraeus Kulzer). On the resulting study casts, the crowns of all teeth were sectioned to the level of the interdental papilla using a universal milling machine (E-Schiff-B, 7647 0968 WSWA/II, Germany).

Study models were photographed using a digital camera (Nikon D7000 with an AF-S DX NIKKOR 18–105 mm f/3.5–5.6G ED VR lens) from a standardized distance of 50 cm. During photography, the models were placed on millimeter paper to ensure calibration and standardization of measurements. The obtained images were then transferred to a computer for further analysis.

Image analysis was performed using the Digimizer software package (version 4.2.1; MedCalc Software bvba, Belgium). Using this software, the center of each tooth was determined. The following linear distances were measured: between the centers of the right and left canines, between the centers of the right and left first premolars, and between the centers of the right and left first molars. Additionally, the dimensions of the incisive papilla (length and width) were determined, and its morphological shape was defined.

Statistical analysis was conducted using descriptive statistical methods (mean, standard deviation, minimum and maximum values), alongside inferential techniques, including correlation and multiple regression analyses. The level of statistical significance was set at $p < 0.05$. All analyses were performed using SPSS statistical software (version 17).

Results

The results of the analysis of the relationship between the width of the maxillary dental arch and the morphometric characteristics of the incisive papilla are presented in the following tables.

The general linear model evaluating the effects of sex, incisive papilla shape, and their interaction on the 13–23 distance was not statistically significant ($F(5,174) = 1.078$; $p = 0.374$). The model explained only 3.0% of the variance in intercanine width ($R^2 = 0.030$; adjusted $R^2 = 0.002$), indicating very limited explanatory power of the examined variables. Consistent with these findings, no statistically significant effects were observed for sex ($p = 0.061$), incisive papilla shape ($p = 0.780$), or the interaction between sex and incisive papilla shape ($p = 0.787$). These results suggest that neither sex nor the shape of the incisive papilla, individually or in combination, significantly influences the distance between the right and left maxillary canines in the studied sample (Table 1).

Table 1. Dependent Variable:13-23

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	172.795[a]	5	34.559	1.078	0.374
Intercept	345041.160	1	345041.160	10764.042	0.000
SexMF	114.353	1	114.353	3.567	0.061
ShapeIP	15.941	2	7.970	0.249	0.780
GenderMF*Shape IP	15.385	2	7.692	0.240	0.787
Error	5577.566	174	32.055		
Total	423645.086	180			
Corrected Total	5750.361	179			

a. R Squared = 0.030 (Adjusted R Squared = 0.002)

In the analysis of the 14–24 distance, the general linear model did not reach statistical significance (F (5,174) = 1.218; p = 0.303), indicating that the combined set of predictors did not significantly improve the explanation of variability in first premolar width. The proportion of explained variance was low ($R^2 = 0.034$; adjusted $R^2 = 0.006$), further confirming the limited overall contribution of the examined variables.

Despite the non-significant overall model, sex emerged as the only statistically significant individual predictor (p = 0.046), suggesting a measurable difference in first premolar width between males and females. In contrast, neither incisive papilla shape (p = 0.454) nor its interaction with sex (p = 0.853) showed any significant effect. Taken together, these results indicate that while a sex-related difference is present for this measurement, the overall predictive value of the model remains weak, and most of the variability in 14–24 distance is likely determined by other unaccounted factors (Table 2).

Table 2. Dependent Variable:14-24

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	243.263[a]	5	48.653	1.218	0.303
Intercept	427886.615	1	427886.615	10709.327	0.000
S	162.129	1	162.129	4.058	0.046
SexMF					
ShapeIP	63.345	2	31.672	0.793	0.454
GenderMF*Shape IP	12.729	2	6.365	0.159	0.853
Error	6952.096	174	39.955		
Total	527852.555	180			
Corrected Total	7195.359	179			

a. R Squared = 0.034 (Adjusted R Squared = 0.006)

For the dependent variable 16–26, the general linear model was not statistically significant (F (5,174) = 0.976; p = 0.434). The model explained only 2.7% of the variance in dental arch width (R^2 = 0.027; adjusted R^2 = -0.001), indicating a negligible explanatory contribution of the examined factors.

No statistically significant effects were observed for sex (p = 0.059), incisive papilla shape (p = 0.577), or their interaction (p = 0.964), further confirming the lack of meaningful influence of these variables on the 16–26 arch width (Table 3).

In this study, the distances between the right and left canines, first premolars, and first molars were treated as dependent variables, while PL, HNR - HNL, IP – L, IP - W, age, sex, and the shape of the incisive papilla were included as independent variables. Although all listed independent variables were considered in the initial analysis, only those that contributed most significantly to the prediction of the dependent variables (13–23, 14–24, and 16–26) were retained for further analysis based on statistical criteria.

Table 3. Dependent Variable: 16-26

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	319.550[a]	5	63.910	0.976	0.434
Intercept	665840.134	1	665840.134	10164.341	0.000
SexMF	236.293	1	236.293	3.607	0.059
ShapeIP	72.376	2	36.188	0.552	0.577
GenderMF*Shape IP	4.852	2	2.426	0.037	0.964
Error	11398.298	174	65.507		
Total	821519.689	180			
Corrected Total	11717.848	179			

a. R Squared = 0.027 (Adjusted R Squared = -0.001)

For the dependent variable 13–23 (distance between the right and left maxillary canines), the width of the incisive papilla exhibited the highest positive regression coefficient (B = 0.796), suggesting that a 1 mm increase in papilla width is associated with an average increase of 0.796 mm in the intercanine distance (Table 4). For the dependent variable

Table 4. Multiple linear regression model for intercanine width (13–23)

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	5.721	2.506		2.283	0.024		
	PL	0.371	0.051	0.517	7.318	0.000	0.459	2.177
	HNR- HNL	0.231	0.047	0.346	4.863	0.000	0.453	2.207
	IPW	0.796	0.317	0.126	2.512	0.013	0.909	1.100

Abbreviations: PL - length of the palate, HNR-HNL distance between the right and left hamular notches, IPL - length of the incisive papilla, IPW - width of the incisive papilla

14–24 (distance between the right and left maxillary first premolars), the width of the incisive papilla demonstrated the strongest positive effect among the examined predictors (B = 1.439), with a statistically significant association ($p < 0.05$). These findings suggest that a 1 mm increase in papilla width corresponds to an average increase of 1.439 mm in the interpremolar distance (Table 5).

Table 5. Multiple linear regression model for interpremolar width (14–24)

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	4.777	2.739		1.744	0.084		
	PL	0.429	0.056	0.511	7.700	0.000	0.432	2.316
	HNR- HNL	0.321	0.052	0.412	6.220	0.000	0.435	2.297
	IPL	-0.367	0.183	-0.120	-2.000	0.048	0.526	1.901
	IPW	1.439	0.416	0.195	3.461	0.001	0.599	1.671
	IPS	-1.243	0.441	-0.138	-2.822	0.006	0.799	1.251

Abbreviations: PL - length of the palate, HNR-HNL distance between the right and left hamular notches, IPL - length of the incisive papilla, IPW - width of the incisive papilla, IPS - shape of the incisive papilla

For the dependent variable 16–26 (distance between the right and left maxillary first molars), the width of the incisive papilla demonstrated the highest positive regression coefficient (B = 1.531), suggesting that an increase in papilla width is associated with a corresponding increase in the intermolar distance (Table 6).

Table 6. Multiple linear regression model for intermolar width (16–26)

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	3.331	2.766		1.204	0.231		
	PL	0.436	0.056	0.416	7.755	0.000	0.432	2.316
	HNR- HNL	0.562	0.052	0.577	10.785	0.000	0.435	2.297
	IPL	-0.503	0.185	-0.132	-2.719	0.008	0.526	1.901
	IPW	1.531	0.420	0.166	3.647	0.000	0.599	1.671
	IPS	-1.044	0.445	-0.093	-2.346	0.021	0.799	1.251

Abbreviations: PL - length of the palate, HNR-HNL distance between the right and left hamular notches, IPL - length of the incisive papilla, IPW - width of the incisive papilla, IPS - shape of the incisive papilla

Discussion

The results of this study indicate that the transverse dimensions of the maxillary dental arch[13–23, 14–24, and 16–26] are significantly associated with the morphological parameters of the palate and the incisive papilla. In particular, the width of the incisive papilla emerged as the most significant predictor in all regression models, confirming its importance as a stable anatomical landmark in the prosthetic rehabilitation of edentulous patients[8-10]. This finding is further supported by the study by Hotta Y, which, although methodologically different, provides indirect evidence of a relationship between hard palate morphology and dental arch dimensions. The incisive papilla is described as a stable anatomical reference point within the geometric organization of the maxillary arch, suggesting that the dental arch should not be viewed as an isolated structure, but rather as part of a broader craniofacial morphological system[11].

The obtained results indicate that an increase in the width of the incisive papilla leads to a proportional increase in the width of the dental arch, with this relationship being most pronounced in the molar region[16–26], followed by the premolar region[14–24], and least pronounced in the canine region[13–23]. These findings are consistent with contemporary morphological and clinical studies, which suggest that the posterior segments of the maxilla more accurately reflect the overall skeletal dimensions of the palate, whereas the anterior segment is more influenced by esthetic and functional factors[8 - 10].

The highest regression coefficient across all models was observed for the width of the incisive papilla, indicating its consistent and clinically significant effect. These results are consistent with recent studies that support the use of the incisive papilla as a reliable anatomical landmark for determining tooth position, particularly in complete dentures and implant-prosthodontic rehabilitation[9, 12–14].

In contrast, the shape of the incisive papilla did not show a statistically significant effect in any of the models ($p > 0.05$). This may be explained by the fact that papilla shape is highly susceptible to individual variability, thereby limiting its reliability as a quantitative parameter[15]. This finding is supported by recent studies, which emphasize that the morphological classification of the incisive papilla is less clinically relevant compared to its linear dimensions[12,14]. However, findings by Avhadia et al. suggest a consistent geometric relationship between the incisive papilla and the anterior dental arch, reporting that the intercanine line frequently passes through the center of the papilla regardless of arch form. This partially supports the present findings, indicating that while a relationship exists, its predictive strength remains limited[16]. Unlike papilla shape, which is assessed subjectively, its linear dimensions—particularly width—represent an objectively measurable parameter, providing greater statistical strength and clinical applicability.

Additionally, the interaction between sex and the shape of the incisive papilla did not exhibit a statistically significant effect, suggesting that this relationship remains stable irrespective of demographic variation. Comparable findings have been reported in the literature, where no significant association between sex and the morphological characteristics of the incisive papilla has been observed. This may be attributed to the fact that papilla morphology is mainly governed by local anatomical and functional determinants rather than by sex[6,15,17].

From a clinical perspective, the findings of this study have direct relevance to the fabrication of complete dentures. Precise determination of dental arch width based on anatomical landmarks contributes to enhanced stability, retention, and esthetic outcomes of prosthodontic rehabilitation. The incisive papilla has long been recognized in the literature as a reliable landmark for positioning anterior teeth, while recent studies have extended its application to posterior segments as well [13,15,18,19].

Modern digital approaches, including three-dimensional analyses and artificial intelligence–based models, underscore the increasing importance of accurate identification of anatomical structures in dentistry[20,21]. In this context, the incisive papilla is frequently used as a reference point for standardization in 3D digital analysis of the maxillary arch, confirming its role as a key geometric landmark. The use of 3D methodologies further highlights the complexity of dental arch morphology, demonstrating that its shape is best described through multiple interacting parameters rather than a single anatomical determinant[22].

Although the available literature does not provide relevant studies that directly examine the relationship between dental arch width and the morphometric characteristics of the incisive papilla, there are studies that confirm an association between the incisive papilla and the position of anterior teeth as well as intercanine width, which may suggest an indirect relationship with overall dental arch width[21,23].

The limitations of this study include the use of two-dimensional images due to possible image distortions, positioning of the model on millimeter paper, and the limited representation of anatomical structures compared to modern three-dimensional digital methods such as intraoral scanning or CBCT analyses. These factors may affect measurement precision and potentially reduce the accuracy of quantitative analysis, which should be considered when interpreting the results and applying them in a broader clinical context.

Conclusion

Based on the findings of this study, it can be concluded that the width of the incisive papilla is the most significant predictor of the transverse dimensions of the maxillary dental arch. The linear dimensions of the incisive papilla exhibit greater predictive value than its morphological shape, which did not show statistical significance.

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Received on May 18, 2026
Revised on June 29, 2026
Accepted on July 7, 2026

Conflict of Interest: The authors declare that they have no conflict of interest.
Financial Disclosure Statement: The authors received no financial support for the research, authorship, and/or publication of this article.
Human Right Statement: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the Faculty of Dentistry, University of Sarajevo (Approval No. 09-874-6/12; December 27, 2012), and written informed consent was obtained from all participants prior to their inclusion in the study.
Animal Rights Statement: N/A

Correspondence

Assoc. Prof. Amela Đonlagić, PhD
Faculty of Dentistry, University of Sarajevo
Bolnička 4 Sarajevo, Bosnia and Herzegovina
Mob. 0038761364190 Email: ameladz@yahoo.com