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Original Research Article

Morphometric Analysis of Hard Palate and Arch Form in the North – West Rajasthan Population

Monika Vyas[1], Rakesh Mani[2], Khushboo Joshi[3], Rajiv Narayan Purohit[4]

[1]Tutor, Department of Anatomy, American International Institute of Medical Sciences, Udaipur
[2]Senior Professor, Department of Anatomy, Sardar Patel Medical College, Bikaner
[3]Assistant Professor, Department of Anatomy, American International Institute of Medical Sciences, Udaipur
[4]Assistant Professor, Department of Dentistry, Sardar Patel Medical College, Bikaner

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Corresponding author: Dr. Khushboo Joshi3
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Abstract

Background: The hard palate plays a vital role in chewing, speech, and in separating the oral and nasal cavities. Variations in its shape and dimensions hold considerable clinical importance for orthodontics, prosthodontics, and cleft palate treatment. However, there is limited information on the morphology of the palate in the North-Western population of Rajasthan

Aim: To analyse the morphometric features of the hard palate and arch form in individuals from North-West Rajasthan population.

Materials and Methods: This cross-sectional study included 200 participants (100 males and 100 females) aged 18–25 years with complete permanent dentition and Class I malocclusion. Maxillary casts were prepared, and various parameters—including inter-canine width, inter-molar width, arch perimeter, palatal depth, length, and width—were measured using a digital caliper. Palatine Height Index (PHI), Palatine Index (PI), and Arch Form Index (AFI) were calculated. Correlation and regression analyses were performed.

Results: The average palatal width was 34.05 ± 3.11 mm, palatal length 46.11 ± 3.40 mm, and palatal depth at the molar region 22.53 ± 2.10 mm. Most participants displayed a tapered arch form (80%), a high palate (80%), and a narrow palate (67.5%). Regression analysis revealed that arch perimeter was significantly associated with all palatal measurements, while arch form was mainly influenced by canine and molar depth.

Conclusion: Individuals from North-West Rajasthan predominantly have a high and narrow palate with a tapered arch form. These findings provide essential baseline data useful for orthodontic, prosthodontic, and surgical interventions.

Keywords: Hard Palate, Arch Form, Palatine Index, Morphometry And Maxillary Arch.

Introduction

The palate forms the roof of the oral cavity and separates it from the nasal cavity. Structurally, it is divided into two parts: the hard palate at the front and the soft palate at the back. The hard palate constitutes nearly four-fifths of the entire structure, while the soft palate makes up the posterior one-fifth.

Functionally, the hard palate supports mastication, speech, and swallowing. Its anterior portion is formed by the palatine processes of the maxilla, while the posterior part is formed by the horizontal plates of the palatine bones. These bones join at the median and transverse palatine sutures, creating a cruciform junction. Information concerning maxillary arch dimensions in human populations is important to clinicians in orthodontics, prosthodontics, and oral surgery. [1] The hard palate is regarded as an important part of the human skull, which contributes to the separation of the oral and nasal cavity. [2] The palate is considered to be a key anatomical structure that determines the skeletal pattern due to its position and morphology. The hard palate is well preserved in human remains and its sutures are a well-known feature allowing to estimate an individual's age.

The maxillary arch form, described in terms of width, length, and depth, influences dental alignment and prosthetic design. The length, depth and width of the palate have considerable importance in treatment planning. [3] All the Maxillary impressions made up of dental stone with bases made of alginate. The dental arches in

the incisor region increased upto 9 years and in the other regions of the jaws up to 11 to 13 years after that there is little change occur. Typically, the tissues of the face develop from either side and fuse in the midline.

Palatal morphology is influenced by several factors, including ethnicity, genetics, facial type, and environmental conditions such as diet. Brachycephalic individuals tend to have broader arches, dolichocephalic individuals usually have longer or narrower arches, while mesocephalic individuals exhibit an intermediate form.

Every ethnic group and population have its own unique facial and cranial form.

Hard palate plays an important role in articulation of speech and therefore any morphological variations in the bony palate is of great clinical significance and it will also help in the administration of local anaesthesia and also in palatal surgeries. [4]

Furthermore, indices such as the palatine index are useful, as a high and narrow palate is often associated with syndromic conditions like Apert syndrome, Turner syndrome, and Down syndrome. In adults, the incisive fossa is represented by junction between primitive and permanent palate which may be altered in condition like cleft palate.

During the election of artificial teeth assessment of palatal depth and arch form are very important factors. The arch form acts as a crucial part of the oral cavity as it affects.

Despite its significance, little information is available regarding palatal morphology in the North-Western Rajasthan population. This study aims to provide baseline morphometric data for this group, which will be valuable in both clinical and research settings.

Material and Method

This cross-sectional study was conducted in the Department of Anatomy in collaboration with the Dental Department of Sardar Patel Medical College, Bikaner, and Rajasthan. A total of 200 individuals were included, consisting of 100 males and 100 females. The Study was approved by Institutional Ethics committee.

Inclusion Criteria

- Complete permanent dentition fully erupted to the occlusal plane aged from 18 to 25 years.
- No extraction
- No fracture and jaw surgery
- Class I malocclusion.
- No previous orthodontic treatments
- No congenital and developmental abnormalities

Exclusion Criteria

- Class II or Class III malocclusion cases.
- History of extracted permanent teeth.
- History of significant respiratory and allergic problems.
- Crowding
- Spacing
- Missing teeth
- Parafunctional habits like thumb sucking, tongue thrusting.

Measurements

Maxillary arch measurements:

a) **Inter-molar width:** Distance between mesiobuccal cusp tips of the maxillary first molars, measured with a digital caliper. {figure A}

b) **Inter-canine width:** Distance between cusp tips of the maxillary canines.{figure B}

c) **Arch perimeter:** Obtained by summing five segments measured along the dental arch: from the mesial aspect of the first molar to the distal aspect of the canine on each side, from the canine to the central incisor on each side, and between the distal surfaces of the central incisors.

Palatal measurement

a) Palatal depth [height]: Measured vertically from the mid-palatal suture. Two depths were recorded: molar depth (distance between the occlusal planes at the mesiobuccal cusps of first molars to the mid-palatal suture) and canine depth (distance between the occlusal planes at the canine tips to the mid-palatal suture). {figure C}

b) Palatal length: Distance between the contact point of the central incisors and the most posterior point of the maxillary first molars. {figure D}

c) Palatal width: Distance between the palatal gingival sulci of the first molars on either side. {figure E}

Indices: Palatine Height Index (PHI): In order to assess the height of the palate at the molar, the calculation was performed using the PHI formula below [Orthodontics: Diagnosis and Management of Malocclusion and Dentofacial Deformities Kharbanda] [5]

$$\text{Index of Palatine Height} = \frac{\text{Palatal height}}{\text{Palatal Width}} \times 100$$

Average index value = 42%

Arch Form Index (AFI): The arch form for all study casts will be determined by measuring each of the inter-canine width (ICW), canine depth (CD), inter-molar width (IMW), and molar depth

(MD). Based on these observations, the arch form ratio is calculated depending on the AFI formula as illustrated in the following equation.

$$\text{Arch Form Index Formula} = \frac{\text{CD}}{\text{ICW}} \times \frac{\text{IMW}}{\text{MD}}$$

Cast is classified into three categories, namely square, ovoid, and tapered, derived from their ratio as explained below.

Arch form ratio will be obtained in accordance to the study by Budiman and colour atlas of oral disease: [6,7]

a. Square Form – if arch ratio is <45.30%
b. Tapered Form – if arch ratio is more than 53.37%
c. Oval Form – is arch ratio is between 45.30% and 53.37%

Palatine Index (PI): it is calculated through the use of the specific formula adopted by Khatiwada et al and colour atlas of oral disease. [7,8]

$$\text{Palatine Index Formula} = \frac{\text{Palatal length}}{\text{Palatal Width}} \times 100$$

PI means the ratio of the palatine width to the palatine length which is expressed as a percentage.

(1) If PI is less than 79, the palate is narrow.

(2) If PI is between 80 and 84.9, the hard palate is intermediate in width.

(3) If PI is 85 or more, the hard palate is broad.

Statistical Analysis: Data analysis will be carried out by using Microsoft Excel and Suitable Statical Software. t- Test is used to compare different variables.

Result and Discussion

The average palatal width was 34.05 ± 3.11 mm, palatal length 46.11 ± 3.40 mm, and palatal depth at the molar region 22.53 ± 2.10 mm. Most participants displayed a tapered arch form (80%), a high palate (80%), and a narrow palate (67.5%). Regression analysis revealed that arch perimeter was significantly associated with all palatal measurements, while arch form was mainly influenced by canine and molar depth. In the present study, the majority of subjects had a high palate (80%), a narrow palatal form (67.5%), and a tapered maxillary arch (80%). These findings emphasize the predominance of high and constricted palates in the North-West Rajasthan population. All the results of present study were depicted in following tables:

Table 1: Descriptive statistics of different variables

Variables	No.	Min.	Max.	Mean	SD
Inter-molar width(mm)	200	44.00	56.00	50.32	2.86
Inter-canine width(mm)	200	29.50	38.50	34.63	2.35
Palatal depth at molar area(mm)	200	19.00	28.00	22.53	2.10
Palatal depth at canine area(mm)	200	8.00	13.50	11.25	1.73
Palatal length(mm)	200	40.00	52.00	46.11	3.40
Palatal width(mm)	200	28.20	43.05	34.05	3.11
Arch perimeter(mm)	200	66.00	86.00	77.89	5.77
Palatine Height Index	200	50.00	84.85	66.69	8.25
Palatine Index	200	62.50	94.15	74.00	6.33
Arch form	200	31.00	90.00	67.37	16.36

Table 1 summarizes the descriptive statistics of the recorded variables.

The mean inter-molar width was 50.32 ± 2.86 mm, while the mean inter-canine width measured 34.63 ± 2.35 mm. The average palatal depth was 22.53 ± 2.10 mm at the molar region and 11.25 ± 1.73 mm at the canine region. The mean palatal length and width were 46.11 ± 3.40 mm and 34.05 ± 3.11 mm, respectively. The mean arch perimeter was 77.89 ± 5.77 mm.

The average Palatine Height Index (PHI) was 66.69 ± 8.25, while the mean Palatine Index (PI) was 74.00 ± 6.33. The mean Arch Form Index (AFI) value was 67.37 ± 16.36.

Table 2: Correlation of 3D palatal measurements with Arch Form and Arch Perimeter

Palatal Measurements	Correlation with Arch Form and Arch Perimeter	
Palatal Depth molar	-0.36	-0.90
Palatal Depth canine	0.83	0.53
Palatal width	0.46	0.58
Palatal length	0.16	0.56
Palatine height index	-0.58	-0.47
Palatine index	0.33	0.12

A positive correlation was observed between arch form and Canine depth with a medium positive correlation between arch form and Palatine height index. In regard to the arch perimeter, a strong negative correlation was found with Molar depth and a medium positive correlation with each of Canine depth, palatal width, and palatal length (Table 2).

Table 3: Multiple Regression analysis of Arch perimeter (as dependent variable) and palatal variables

Variables	Unstandardized Coefficients		Standardized Coefficients	T	P
	B	Std. Error	Beta		
Palatal Depth molar	-1.05	0.216	-0.382	-4.86	0.000
Palatal Depth canine	0.673	0.273	0.203	2.46	0.015
Palatal width	0.398	0.158	0.215	2.52	0.013
Palatal length	0,934	0.158	0.551	5.9	0.000

Results of the multiple regression analysis reveal that all dimensions of the palate were significantly associated with arch perimeter as shown in Table 3.

Table 4: Multiple Regression analysis of Arch form (as dependent variable) and palatal variables

Variables	Unstandardized Coefficients		Standardized Coefficients	T	P
	B	Std. Error	Beta		
Palatal Depth molar	-0.028	0.002	-0.435	-12.24	0.000
Palatal Depth canine	0.069	0.003	0.9	24.24	0.000
Palatal width	0.001	0.002	0.025	0.645	0.521
Palatal length	-0.002	0.002	-0.62	-1.47	0.145

Molar depth and Canine depth were significantly associated with the arch form (Table 4)

Table 5: Frequency and percentage of different variables of the study sample

Variables		N	%
Arch Form	Square	25	12.5
	Oval	15	7.5
	Tapered	160	80.0
Palatine Height Index	Low palate	0	0
	Medium palate	40	20.0
	High palate	160	80.0
Palatine Index	Narrow	135	67.5
	Intermediate	50	25.0

As shown in Table 5, the distribution of arch forms revealed that 80% of subjects had a tapered arch, 12.5% had a square arch, and 7.5% had an oval arch.

With respect to palatal height, all subjects exhibited a high palate (80%) or medium palate (20%), with no cases of low palate.

According to the Palatine Index, 67.5% of individuals had a narrow palate, 25% had an intermediate palate, and only 7.5% had a broad palate.

Different populations and ethnic groups exhibit variable dental arch dimensions and characteristics. The study depends on the important aspect of establishing a set of norms on various arches, and palatal parameters present significant clinical considerations in various disciplines in dentistry. Evaluation of palatal dimensions provides clinically important insights for orthodontics, prosthodontics, orthognathic surgeries, cleft palate repair, and even sleep apnea management. Since dental arch dimensions differ across ethnic groups, documenting region-specific data is essential for accurate diagnosis and treatment planning.

1. **Palatal width:** The mean palatal width in this study (34.05 mm) was smaller compared to the 40.63 mm reported by Khatiwada et al. [8] (2020) in a Nepalese population. This suggests regional variability, with the present sample showing narrower maxillae. Gender differences were observed, with males having a wider palate than females.

2. **Palatal length:** The mean palatal length (46.11 mm) was greater than that reported by Khatiwada et al. [8] (2020) (41.58 mm). In our study, males displayed significantly longer palates, indicating sexual dimorphism.

3. **Palatal depth:** The average palatal depth at the molar region (22.53 mm) was greater than values reported in other populations. While some earlier studies found no sex-related difference in palatal depth, our data showed generally higher

measurements in males. Variations in depth may be attributed to genetic, environmental, or pathological factors such as nasal obstruction or prolonged mouth breathing.

4. Arch form: A tapered arch was the most common type in this population, consistent with findings in Chhattisgarh populations1 but contrasting with Sudanese populations [9], where oval arches were more prevalent.

5. Arch Perimeter: With reference to what was stated in the results, all dimensions of the palate were significantly associated with the arch perimeter. On the other hand, a strong correlation of arch perimeter was reported with Molar depth and a medium correlation with Canine depth, palatal width, and palatal length. Furthermore, in another study on the Iraqi population by Khidair in 2001 [10] no correlation was found between arch perimeter and palatal depth. At the same time, a moderate correlation of maxillary perimeter with palatal width was demonstrated by Khidair in 2001 which was in concordance with the present study. Different ethnic groups, sample size, different landmarks, and measurement devices with a different age group of the study sample may be behind these controversies.

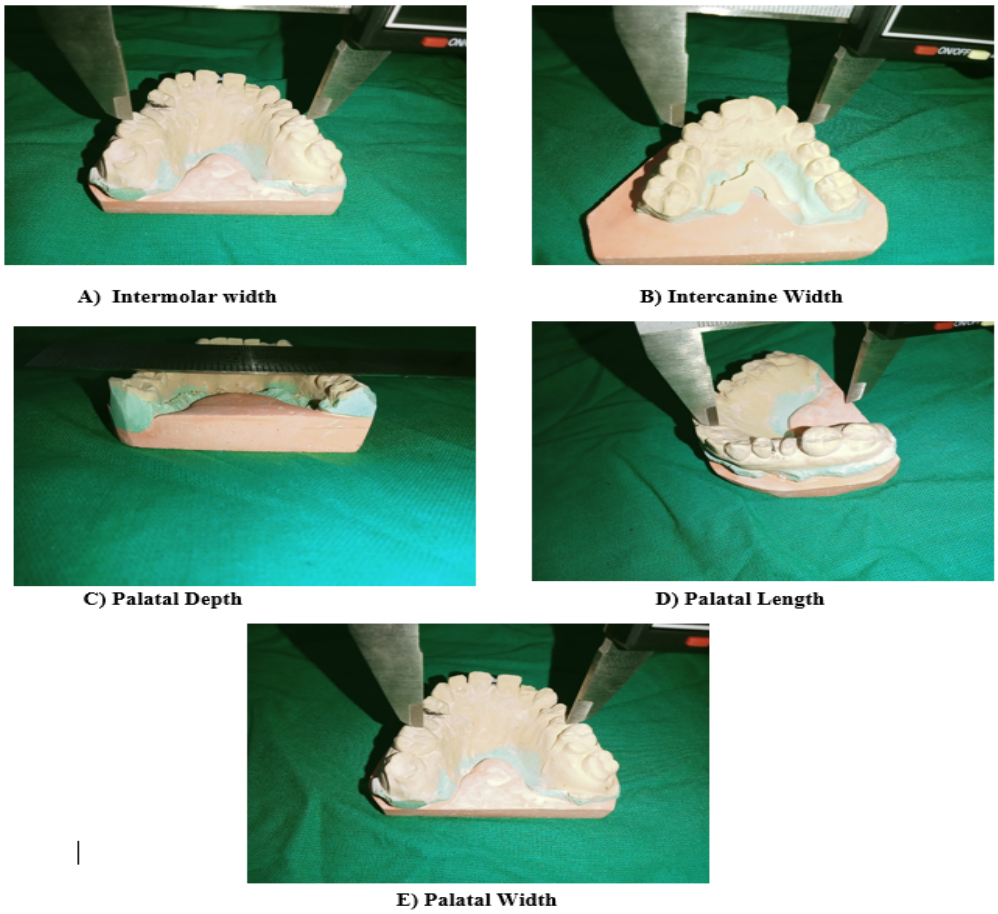

Figure 1:

Conclusion

Morphometric knowledge of the hard palate has significant clinical applications across various dental disciplines, including orthodontics, prosthodontics, orthognathic surgery, and cleft palate management.

In the present study on the North-West Rajasthan population:

- The majority of individuals were found to have a high, narrow palate and a tapered arch form.
- A positive correlation was observed between arch form and canine depth.
- For arch perimeter, a strong negative correlation was observed with molar depth, while medium positive correlations were noted with canine depth, palatal width, and palatal length.

These findings underline the uniqueness of palatal morphology in this regional population. Establishing such normative data is important for improving diagnostic accuracy, treatment planning, and prosthetic and orthodontic outcomes.

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