Original Article

Evaluation of the Thickness of Cortical Bone in the Maxillary Posterior Region in Subjects with Impacted Maxillary Canine: A Retrospective Study

Aakansha Anthwal[1], Abhishek Singh[1], Umi Mittal[1], Preeti Bhattacharya[2], Ankur Gupta[3]

[1]Post Graduate Student, Department of Orthodontics and Dentofacial Orthopaedics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India, [2]Head, Department of Orthodontics and Dentofacial Orthopaedics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India, 3Professor, Department of Orthodontics and Dentofacial Orthopaedics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India.

ABSTRACT

Introduction: Maxillary canine impaction is a frequent orthodontic concern, often resulting in root resorption, loss of arch length, and alveolar bone changes. Accurate evaluation of buccal cortical bone thickness is essential for planning the placement of temporary anchorage devices (TADs), particularly in such cases. **Aim:** The study aimed to assess cortical bone thickness in patients with unilateral maxillary canine impaction, focusing on interradicular regions between the first and second premolars and between the second premolar and first molar, on both the impacted and non-impacted sides (ISs). **Material and Methods:** Cone-beam computed tomography (CBCT) scans of 31 patients (aged 13–33 years) from Northern India were analyzed. Samples were categorized into Group I (IS) and Group II (non-IS). Cortical bone thickness was measured at 8 mm, 10 mm, 12 mm, and 14 mm from the cementoenamel junction (CEJ) in two interradicular regions: Between interradicular region between the maxillary first premolar and second premolar (IRR PM_1 and PM_2) and interradicular region between the maxillary second premolar and maxillary first molar (IRR PM_2 and M_1). Statistical analysis was performed using an independent *t*-test to compare bone thickness between groups. **Results:** In both groups, cortical bone thickness increased progressively from CEJ to apex, and from anterior to posterior regions. The IRR PM_2–M_1 site consistently showed greater thickness than the IRR PM_1–PM_2 site. Although the non-IS exhibited slightly higher values, inter-group differences were not statistically significant. **Conclusion:** Cortical bone thickness increases posteriorly and apically in the maxilla, with minimal variation between impacted and non-ISs. CBCT provides reliable data for identifying optimal TAD placement sites, aiding precise treatment planning in cases involving impacted maxillary canines.

Key words: TADs, Impacted Canine, Cortical bone thickness

INTRODUCTION

Impaction of the maxillary canine is one of the most commonly encountered orthodontic clinical findings, with a reported prevalence in the general population ranging from 0.9% to 2.2%.[1] It is the third most impacted tooth after maxillary and mandibular third molars, with palatal impaction occurring two to three times more frequently than buccal impaction.[2] Labial impaction often results from limited maxillary arch space, whereas palatal impaction has genetic and guidance-related causes. Impactions can lead to complications such as tooth displacement, resorption, and cyst formation, underscoring the need for regular dental monitoring.[3]

Treatment for impacted canines is complex, often requiring a multidisciplinary approach. The typical procedure involves guiding and aligning the tooth using orthodontic traction via temporary anchorage device (TAD) in conjunction with surgical exposure.[2] TADs have become increasingly popular due to their small size, simple surgical procedure, immediate loading, and multiple insertion sites, especially at inter- and extra-radicular sites such as the infrazygomatic crest (IZC) and buccal shelf.[4]

Anatomically, the IZC is a cortical bone pillar located near the maxilla's zygomatic process.[5] Significant individual variation in the IZC thickness can be due to maxillary sinus pneumatization, maxillary first molar inclination, root morphologies, and the alveolar process height. For orthodontic purposes, it is crucial to comprehend the anatomical variances existing in this location before inserting mini-screws.[6]

In recent times, three-dimensional computed tomography (CT) has become a regular tool for assessment and diagnostics in complex situations.[7] The purpose of this study was to evaluate the

Corresponding Author: Dr. Aakansha Anthwal, Department of Orthodontics and Dentofacial Orthopaedics, Institute of Dental Sciences, Bareilly,Uttar Pradesh, India.
E-mail: anthwal.aakansha@gmail.com

cortical bone thickness in individuals with unilaterally impacted canine cases, focusing on the regions between the maxillary first and second premolars, as well as between the maxillary second premolar and first molar, on both the impacted and non-impacted sides (ISs) by bone mapping using cone beam CT (CBCT) and thus would help in identifying the ideal location for placement of TAD.

MATERIALS AND METHODS

The CBCT images of cases with unilateral maxillary impacted canines were obtained from different diagnostic imaging centers in the Northern Indian region using the CS9300 Carestream diagnostic system. For this retrospective study, ethical approval of the investigation was obtained from the ethical committee of the Institute of Dental Sciences, Bareilly. Sample size calculation was based on a previous study Paul *et al.*[6] using G Power, version 3.0 software, which yielded a minimum sample size of 31. The inclusion criteria were as follows: (1) patients in the age group between 13 and 33 years, (2) presence of unilateral maxillary impacted canine, (3) full set of erupted teeth with/without the third molars, (4) absence of deciduous maxillary canine, and (5) scans with good imaging definition. The exclusion criteria were as follows: (1) patients having crown/bridge or interproximal caries or restorations, (2) dental agenesis, trauma or tumors, craniofacial abnormalities (cleft lip and palate), and (3) presence of hypo or hyperdontia, and neck-and-head disorders. When all inclusion criteria were applied, samples selected for the study were divided into 2 groups: Group I – IS and Group II – Non-IS. The cortical bone thickness was measured from the cementoenamel junction (CEJ) toward the maxillary sinus floor at different heights, i.e., 8 mm, 10 mm, 12 mm, and 14 mm for both the groups. The measurements were done perpendicular to the buccal surface of the infrazygomatic crest (IZC).[6] Cortical bone thickness was measured on two sites, i.e., interradicular region between the maxillary first premolar and second premolar (IRR PM_1 and PM_2) and interradicular region between the maxillary second premolar and maxillary first molar (IRR PM_2 and M_1) on the impacted and the non-IS [Figure 1].

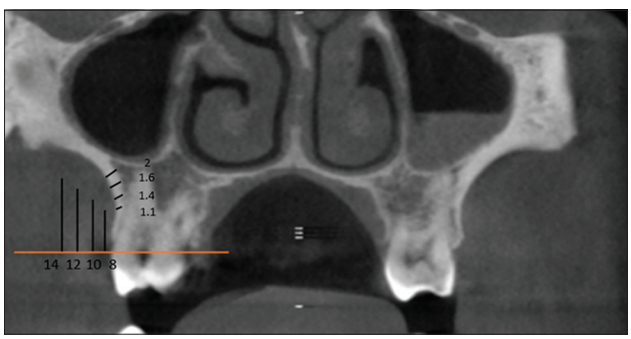


Figure 1: Cortical bone thickness at varying heights

Statistical analysis

Microsoft Word (2021) was used to compile the data. The data collected were analyzed using IBM Statistical Package for the Social Sciences version 20. Alpha error was set at 0.05 and a $P < 0.05$ was considered statistically significant. Descriptive statistics (Mean, Standard deviation) was calculated for total samples. An independent *t*-test was used to compare the mean measurements between the two independent groups.

Table 1: Comparison of cortical bone thickness on various heights at IRR PM_1 And PM_2 and IRR PM_2 and M_1 in Group I (impacted side)

Measurement	Mean	Standard deviation	*P*-value*
8 mm			
IRR PM_1 and PM_2	1.02	0.308	0.680
IRR PM_2 and M_1	1.01	0.298	
10 mm			
IRR PM_1 and PM_2	1.18	0.383	0.716
IRR PM_2 and M_1	1.20	0.424	
12 mm			
IRR PM_1 and PM_2	1.27	0.426	0.580
IRR PM_2 and M_1	1.35	0.458	
14 mm			
IRR PM_1 and PM_2	1.26	0.477	0.586
IRR PM_2 and M_1	1.42	0.415	

IRR PM_1 and PM_2: Interradicular region between the maxillary first premolar and second premolar), IRR PM_2 and M_1: Interradicular region between the maxillary second premolar and maxillary first molar. Independent *t*-test; *indicates significant difference at $P \leq 0.05$

Table 2: Comparison of cortical bone thickness on various heights at IRR PM_1 and PM_2 And IRR PM_2 and M_1 In group II (non-impacted side)

Measurement	Mean	Standard deviation	*P*-value*
8 mm			
IRR PM_1 and PM_2	1.07	0.286	0.659
IRR PM_2 and M_1	1.05	0.362	
10 mm			
IRR PM_1 and PM_2	1.17	0.336	0.355
IRR PM_2 and M_1	1.22	0.494	
12 mm			
IRR PM_1 and PM_2	1.29	0.407	0.423
IRR PM_2 and M_1	1.38	0.471	
14 mm			
IRR PM_1 and PM_2	1.30	0.484	0.414
IRR PM_2 and M_1	1.47	0.439	

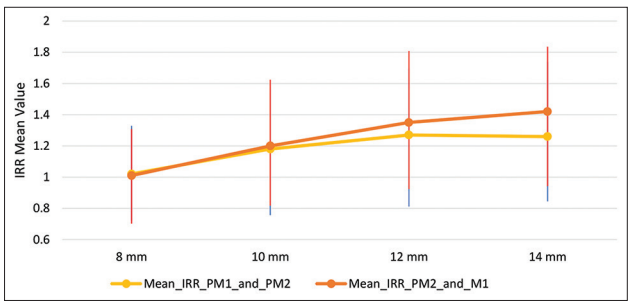
IRR PM_1 and PM_2: Interradicular region between the maxillary first premolar and second premolar, IRR PM_2 and M_1: Interradicular region between the maxillary second premolar and maxillary first molar. Independent *t*-test; *indicates significant difference at $P \leq 0.05$

OBSERVATION AND RESULTS

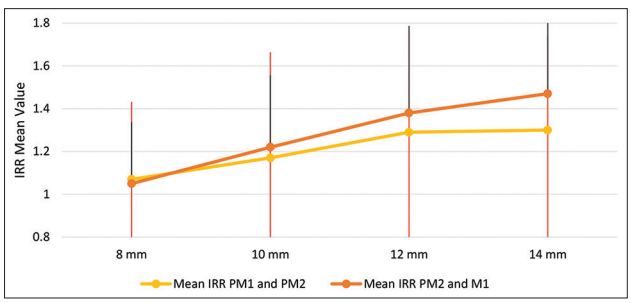
Independent *t*-test was used to compare the mean measurements between the two sites: The 1st and 2nd premolar, and the 2nd premolar and 1st molar, at various heights, as well as to compare the mean cortical bone thickness on the IS with the non-IS.

Tables 1 and 2 show the intragroup comparison of cortical bone thickness between two sites, i.e., at IRR PM_1 and PM_2 and IRR PM_2 and M_1. On the IS [Table 1], cortical bone thickness increased gradually from the CEJ toward the apex, i.e., from 8 mm to 14 mm at both sites. IRR PM_2–M_1 consistently showed greater thickness than IRR PM_1–PM_2 at all levels, with a more pronounced increase apically; however, the difference between the two sites was not statistically significant [Graph 1]. On the non-IS [Table 2], a similar trend was observed, with thickness increasing from CEJ to apex in both regions, and IRR PM_2–M_1 being thicker than IRR PM1–PM2 throughout. Again, no statistically significant difference was found between the two sites [Graph 2].

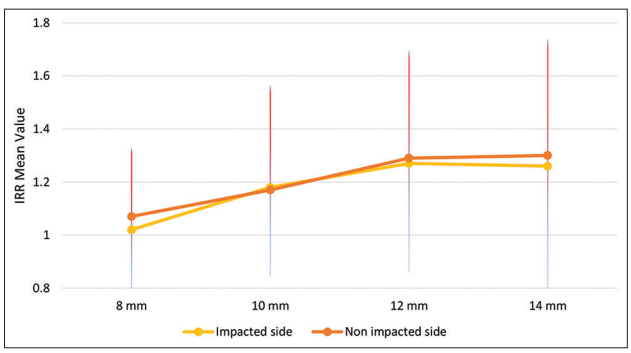
Inter-group comparison between the impacted and non-ISs at IRR PM_1–PM_2 [Table 3] showed slightly greater cortical bone thickness on the non-IS at all heights, except at 10 mm where the IS was thicker. The differences were statistically insignificant [Graph 3]. At IRR PM_2–M_1 [Table 4], the non- IS had slightly higher cortical bone thickness at all measured heights, but no statistically significant difference was noted [Graph 4].



Graph 1: Comparison of cortical bone thickness on various heights at IRR PM_1 And PM_2 and IRR PM_2 and M_1 in Group I (impacted side).



Graph 2: Comparison of cortical bone thickness on various heights at IRR PM_1 and PM_2 And IRR PM_2 and M_1 In group II (non-impacted side).



Graph 3: Comparison of cortical bone thickness between group I (impacted side) and group II (non-impacted side) on various heights at IRR PM_1 and PM_2.

DISCUSSION

Impaction can be defined as the inability of the teeth to erupt into the dental arch during the regular growing stage.[8] Tooth eruption is a physiological process that affects normal alveolar bone development, while impaction may prevent the local growth of alveolar bone.[2]

Numerous researches have attempted to ascertain if a correlation exists between the occurrence of impacted canines and skeletal and dentoalveolar dimensions of the maxilla. A meta-analysis by Gudelevičiūtė *et al.*,[2] determined the skeletal and dentoalveolar dimensions in patients with palatally impacted canines using CBCT. Results showed that only the change in the first premolar width was statistically significant in terms of dentoalveolar characteristics.[2]

The present study determined the cortical bone thickness in individuals with unilaterally impacted canine cases, focusing on the regions between the maxillary first and second premolars, as well as between the maxillary second premolar and first molar, on both the impacted and non-ISs by bone mapping using CBCT.

In the present study, the intra-group comparison on the IS revealed that the cortical bone thickness gradually increased

Table 3: Comparison of cortical bone thickness between group I (impacted side) and group II (non-impacted side) on various heights at IRR PM_1 and PM_2.

Two-sample *t*-test (independent *t*-test)	Cortical Bone thickness at IRR PM_1 and PM_2			
Measurement	Group	Mean	Standard deviation	*P*-value
8 mm	Impacted	1.02	0.308	0.627
	Non-impacted	1.07	0.286	
10 mm	Impacted	1.18	0.383	0.642
	Non-impacted	1.17	0.336	
12 mm	Impacted	1.27	0.426	0.793
	Non-impacted	1.29	0.407	
14 mm	Impacted	1.26	0.477	0.787
	Non-impacted	1.30	0.484	

IRR PM_1 and PM_2: Interradicular region between the maxillary first premolar and second premolar. Independent t-test

Table 4: : Comparison of cortical bone thickness between group I (impacted side) and group II (non-impacted side) on various heights at IRR PM2 and M1. IRR PM2 and M1.

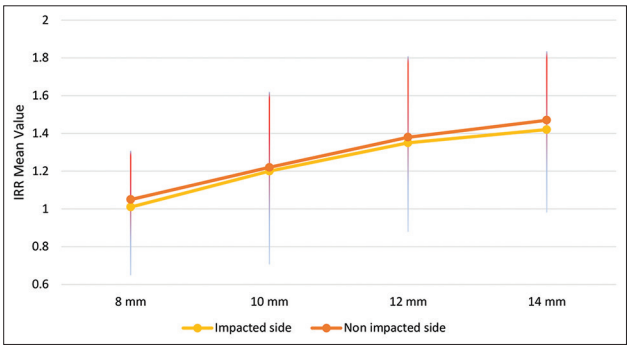
Independent samples *t*-test (two-sample *t*-test)	Cortical bone thickness at IRR PM_2 and M_1			
Measurement	Group	Mean	Standard deviation	*P*-value
8 mm	Impacted	1.01	0.298	0.647
	Non-impacted	1.05	0.362	
10 mm	Impacted	1.20	0.42	0.825
	Non-impacted	1.22	0.494	
12 mm	Impacted	1.35	0.458	0.703
	Non-impacted	1.38	0.471	
14 mm	Impacted	1.42	0.415	0.574
	Non-impacted	1.47	0.439	

IRR PM_2 and M_1: Interradicular region between the maxillary second premolar and maxillary first molar. Independent t-test

from 1.02 to 1.26 on moving from the CEJ towards the apex at IRR PM_1 and PM_2. A similar trend was seen at IRR PM_2 and M_1, where the bone thickness increased from 1.01 to 1.42. Intra-group comparison on the non-IS showed that the cortical bone thickness increased from 1.07 to 1.30 at IRR PM_1 and PM_2 site on moving apically from the CEJ. A similar pattern was seen at IRR PM_2 and M_1 site where the cortical bone thickness increased from 1.05 to 1.47. However, the difference between the means of both sites at different heights was found to be statistically insignificant. The results of our investigation were consistent with those of Farnsworth *et al.*,[9] who reported that the cortical bone tended to be thicker the farther it was from the alveolar crest.[9] On the contrary, Fayed *et al.*[10] demonstrated that the buccal cortical bone thickness in the maxilla followed a certain pattern. It increased on progressing apically from the CEJ to 4-mm level and then started to decline at 6-mm level.[10]

In the present study, the intergroup comparison of the impacted and the non-IS at various heights from the CEJ showed that the cortical bone thickness was slightly greater on the non-IS compared to the IS at all heights. However, the differences observed at all heights were statistically insignificant. This was in agreement with the study conducted by Tadinada *et al.*,[11] who concluded that the alveolar bone dimensions were significantly less on the IS than the non-IS.[11] Sharhan *et al.*,[3] revealed that with the exception of the arch depth, maxillary unilateral or bilateral canine impaction was linked to smaller maxillary basal dimensions.[3]

The present study also revealed that the cortical bone thickness increased on progressing from the anterior to the posterior region of maxilla which was in accordance with the study conducted by Baumgaertel and Hans,[12] who reported that the buccal cortical bone was thinnest in the anterior sextants of both the jaws and progressed gradually toward the posterior.[12] Chen *et al.*,[7] attributed that the increase in the posterior region can be due to increased masticatory strain and frequency. As a result, diverse



Graph 4: Comparison of cortical bone thickness between group I (impacted side) and group II (non-impacted side) on various heights at IRR PM_2 and M_1. IRR PM_2 and M_1.

biological adaptations and biting pressures lead to different bone structures.[7]

This study underscored the significance of understanding buccal cortical bone thickness at various sites, as this knowledge aids clinicians in determining if the dentoalveolar dimensions and quality of the surrounding bone are related to the impacted canine.

CONCLUSION

Statistically insignificant increase in the cortical bone thickness from the CEJ toward the apex at the interradicular region between PM_1 and PM_2 and between PM_2 and M_1 on both the impacted and non-IS was observed.

The cortical bone thickness in the interradicular region between PM_2 and M_1 is greater than the interradicular region between PM_1 and PM_2 at all heights on both the impacted and non-IS. The difference was statistically insignificant. The cortical bone thickness was found to be increasing as we move from the anterior to the posterior region of the maxilla.

At both the interradicular region, the thickness of the cortical bone is slightly higher on the non-IS than the IS at all heights.

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