ORIGINAL ARTICLE

Quantitative Evaluation of Buccal Cortical Bone in Maxillary Posterior Region on Cleft and Non-Cleft Side in Cleft Lip and Palate Patients; A Three-Dimensional Cone Beam Computed Tomography Study

Huma Khan, Amjad Mahmood

Department of Orthodontics Margalla Institute of Health Sciences, Rawalpindi

Abstract

Objective: The study aimed to evaluate the buccal cortical bone thickness in the maxillary posterior region on both cleft and non-cleft sides of patients with unilateral cleft lip and palate (CLP) and to identify the optimal site for mini-implant placement, which is critical for the success of orthodontic treatments in these patients.

Methodology: Cone-beam computed tomography (CBCT) scans of 30 patients with unilateral cleft lip and palate (aged 16–26 years) were analyzed. Buccal cortical bone thickness was measured at four vertical levels (2, 4, 6, and 8 mm) from the cementoenamel junction in three interradicular regions: between first and second premolars (P–P), second premolar and first molar (P–M), and first and second molars (M–M). Paired and independent t-tests and one-way ANOVA were used to compare thickness between cleft and non-cleft sides, and among regions.

Results: Cortical bone thickness increased with height from the CEJ, with the greatest thickness observed at 8 mm. The non-cleft side demonstrated significantly greater thickness than the cleft side at 2 mm, 4 mm, and 6 mm ($p < 0.05$). The P–M region exhibited the highest mean thickness among the three regions, though differences between regions were not statistically significant ($p = 0.508$). The only region showing a significant cleft vs. non-cleft difference was P–P ($p = 0.012$). Intraobserver reliability was excellent (ICC = 0.976–0.988).

Conclusion: Cortical bone was thicker at greater vertical heights and on the non-cleft side at most levels. The posterior maxilla at 6 mm or 8 mm from the CEJ on the non-cleft side appears to be the most favorable site for mini-implant placement. Both vertical level and side-specific anatomy should be considered during treatment planning in cleft patients.

Keywords: Cleft lip and palate, maxillary posterior region, buccal cortical bone, mini-implants, cone beam computed tomography (CBCT), orthodontic treatment.

Introduction

Cleft lip and palate is one of the most common congenital craniofacial birth defects. Patients of cleft lip and palate require complex orthodontic treatment involving biomechanical and anchorage planning. Orthodontic treatment is required to align teeth and to correct crossbites prior to secondary alveolar bone grafting in cleft patients. For this purpose, mini-implants are often used which are important for an optimal skeletal anchorage and are used to perform complex tooth movements without impairing side effects on adjacent teeth.[1]

The use of mini-implants in orthodontics is increasing due to their role in eliminating anchorage loss during orthodontic tooth movements. Mini-implants have several advantages, i.e., minor surgery, increased patient comfort, immediate loading, and lower cost.[2,3] The mini-implants provide absolute anchorage for the tooth movement.[4] The stability of mini-implants depends on many factors such as clinical management, oral hygiene, maxillary or mandibular location, cortical bone thickness, insertion torque, location, age and soft-tissue management.[5] One of the most important factors in the primary stability of mini-implants is cortical bone thickness.[6] The mini-implants are usually inserted in the buccal cortical bone and palate.[7] Cortical bone has a higher modulus of elasticity as compared to cancellous bone, making it more resistant to deformation and superior for anchorage. It has been reported that even as small as 0.5 mm differences in cortical bone thickness can have a major impact on success rates.[8] Many studies have demonstrated that a thickness of more than 1mm increases the success rate of mini-implants.[9]

Few studies have compared the thickness of cortical bone in the anterior region on cleft side and non-cleft side and found that the cortical bone is thin around the cleft area, which may become a problem during orthodontic treatment.[10] One such study measured the bone thickness around the central incisor and canine adjacent to cleft region in unilateral cleft lip and palate patients using cone bean computed tomography (CBCT) and found that the mean value (1.69 mm ±1.19 mm) at canine for the thickest bone region was 4mm vertically away from alveolar crest on the cleft side, while on the non-cleft side mean value was (1.65 mm ±0.55 mm).[11] Another study also proved that the teeth adjacent to the cleft region are covered by a thin cortical bone plate on the buccal aspect.[12] However, current literature is deficient in studies providing information about cortical bone thickness in posterior regions. Posterior maxillary regions are mainly used for insertion of mini-implants in cleft lip and palate patients and based on the amount of information available in literature, it can be

Corresponding Author:
Huma Khan
Department of Orthodontics Margalla Institute of Health Sciences, Rawalpindi
Email: khan_huma93@hotmail.com

Received: 14th October, 2024
Revised: 20th November, 2024
Accepted: 7th December, 2024
DOI: https://doi.org/10.52442/jrcd.v5i2.100

reasonably assumed that cleft side might have deficient bone as compared to non-cleft side and thus require a need to investigate the sites for mini-implant placement to fulfill the needs of anchorage.

The objective of this study was to evaluate mean buccal cortical bone thickness in maxillary posterior region on cleft and non-cleft side and to determine the best site for insertion of mini-implants.

Methodology

This cross-sectional study was conducted in the Department of Orthodontics, Margalla Institute of Health Sciences, Rawalpindi. A total of 30 participants were included.

The sample size was calculated using the WHO Calculator 7.1 (Confidence Level: 95%, Absolute Precision: 0.5). The sampling technique employed was non-probability consecutive sampling.

Patients diagnosed with unilateral cleft lip and palate (right or left) and aged between 16 and 26 years were included in the study, while those with syndromes or a history of trauma were excluded. Ethical approval was obtained from the Ethics Review Committee of Margalla Institute of Health Sciences (ERC No. HK/126/21). CBCT scans were collected from a radiology center in Islamabad, ensuring anonymization and assigning serial numbers to maintain confidentiality.

CBCT scans were analyzed using Planmeca Romexis Viewer software (version 6.0) and buccal cortical bone thickness was measured in the maxilla at four different vertical levels (2, 4, 6, and 8mm) from the cementoenamel junction (CEJ) (Fig 1). Areas that were measured are between first and second premolar (P-P), between second premolar and first molar (P-M), and between first and second molar (M-M). Measurements were taken on both cleft and non-cleft sides. The axial view of the software was rotated so that the vertical reference line is at the center of the two teeth where buccal cortical thickness between them was to be measured, and the horizontal reference line was between the two teeth. The sagittal view was oriented so that vertical reference line is bisecting the interradicular space (Fig 1,2).

Fig 1: Measurement were done at 4 level (2mm, 4mm, 6mm, 8mm) from cementoenamel junction.

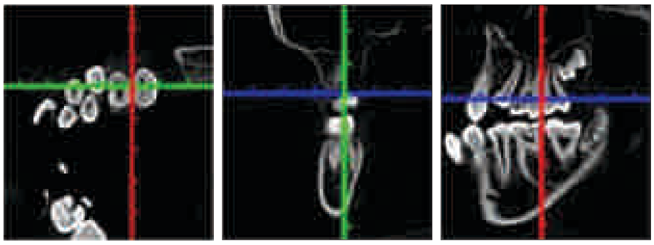

Fig 2: Orientation of CBCT

All CBCTs were coded and results were analyzed using IBM® Statistical Package for the Social Sciences (SPSS®) version 26.0. The results of the study were analyzed using various statistical tests. Descriptive statistics were calculated for age, gender, and cortical bone thickness. Gender distribution was presented as frequencies and percentages, while age was described using mean and standard deviation. Paired samples t-tests were conducted for each region (P-P, P-M, M-M) at all measured heights (2mm, 4mm, 6mm, 8mm), comparing cleft and non-cleft thickness within the same individuals. Independent samples t-tests were performed for each height level, comparing cleft and non-cleft thickness across all regions. A One-Way ANOVA was used to assess differences in mean cortical bone thickness among the three anatomical regions (P-P, P-M, M-M), regardless of side. To ensure reliability, 10 randomly selected sites were re-measured after two weeks to assess intraobserver reliability.

Result

The study included a total of 30 participants, consisting of 13 males (43.3%) and 17 females (56.7%). The age of participants ranged from 16 to 26 years, with a mean age of 21.33 years (Standard Deviation SD = 2.89) (Table1 and 2).

Table 1: Gender Distribution

Gender	Frequency (n)	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Male	13	43.3	43.3	43.3
Female	17	56.7	56.7	100.0
Total	30	100.0	100.0	100.0

Table 2: Age Distribution

Variable	N	Minimum Age	Maximum Age	Mean Age	Standard Deviation
Age (years)	30	16.00	26.00	21.33	2.89

The descriptive analysis was done to assess the mean cortical bone thickness across different regions (P-P, P-M, M-M), heights (2mm, 4mm, 6mm, 8mm), and sides (cleft vs. non-cleft). The results include mean values, standard deviations, and statistical comparisons.

The non-cleft side exhibited a higher mean in the P-P region (Mean = 0.4750, SD = 0.2287) compared to the cleft side (Mean = 0.3317, SD = 0.3407), with this difference reaching statistical significance ($p = 0.012$). In the P-M and M-M regions, the mean differences were not statistically significant ($p = 0.655$ and $p = 0.109$, respectively) (Table 3) (Fig 3).

Table 3: Cortical Bone Thickness by Region on Cleft and Non-Cleft Side

Region	Cleft Side (Mean ± SD)	Non-Cleft Side (Mean ± SD)	P-Value
P-P	0.3317 ± 0.3407	0.4750 ± 0.2287	0.012
P-M	0.4683 ± 0.3496	0.4300 ± 0.3836	0.655
M-M	0.3517 ± 0.3005	0.4550 ± 0.2334	0.109

To determine whether cortical bone thickness differed significantly across the three regions irrespective of cleft involvement, a One-Way ANOVA was performed. The results revealed no statistically significant difference among the regions (P-P, P-M, M-M) when averaged across sides ($p = 0.508$). This indicates that region alone does not significantly influence cortical bone thickness, and the observed differences are more likely due to side-specific anatomical variations (Table 4)

Table 4: One-Way ANOVA – Comparison of Cortical Bone Thickness Across Regions

Region	Mean Thickness (mm)	Standard Deviation
P-P	0.4058	0.4371
P-M	0.4492	0.5523
M-M	0.4033	0.4583
ANOVA P-Value		0.508

Independent t-tests were conducted at each height (2mm, 4mm, 6mm, 8mm) to determine if there were significant differences between the cleft and non-cleft sides. At each height, the non-cleft side exhibited greater mean cortical bone thickness compared to the cleft side. The difference was statistically significant at 2mm, 4mm, and 6mm ($p < 0.05$), with the largest difference seen at 8mm, though it was not statistically significant ($p = 0.591$). This trend suggests that increased height from the CEJ may offer improved bone support, especially on the non-cleft side. 0.6933 ± 0.5400 (Table 5) (Fig 3).

Table 5: Cortical Bone Thickness by Height on Cleft and Non-Cleft Side

Region	Cleft Side (Mean ± SD)	Non-Cleft Side (Mean ± SD)	P-Value
2 mm	0.2844 ± 0.4375	0.4222 ± 0.5292	0.046
4 mm	0.3911 ± 0.4380	0.4267 ± 0.4534	0.004
6 mm	0.3044 ± 0.4652	0.5244 ± 0.4797	0.004
8 mm	0.3022 ± 0.3826	0.6933 ± 0.5400	0.591

The intra-observer reliability of the measurements was analyzed with an Intraclass Correlation Coefficient (ICC) of 0.976 (95% CI: 0.907–0.994) for single measures and 0.988 (95% CI: 0.951–0.997) for average measures, both showing statistical significance ($p < 0.001$). These results indicate high consistency in measurements.

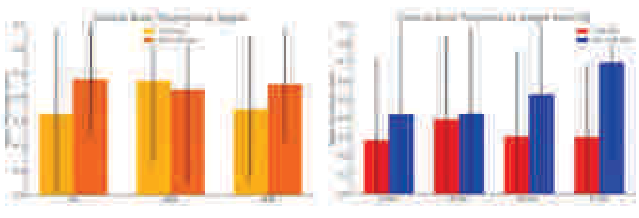

Fig 3: Critical Bone Thickness by Region and Height

Discussion

The present study aimed to evaluate the buccal cortical bone thickness in the maxillary posterior region on both cleft and non-cleft sides in patients with unilateral cleft lip and palate and to identify the optimal site for mini-implant placement.

The findings provide valuable insights into the cortical bone thickness distribution, which is critical for the success of orthodontic treatment involving mini-implants in cleft patients.

The results demonstrated that cortical bone thickness increased with vertical height from the cementoenamel junction (CEJ), which aligns with previous studies that have reported thicker cortical bone in more apical regions of the maxilla.13 This finding is clinically significant, as it suggests that mini-implant placement at greater vertical heights may provide better primary stability due to increased cortical bone thickness. Notably, thickness differences between cleft and non-cleft sides were more pronounced at lesser heights i.e., at 2 mm, 4 mm, and 6 mm, while the distinction became less significant at greater heights. This may suggest a leveling effect in bone quality as the measurement moves further from the alveolar crest, offering potential clinical value for implant stability in higher regions regardless of cleft involvement.

Among the regions analyzed, the P-M region had the highest mean cortical bone thickness, followed by the P-P and M-M regions, although these differences were not statistically significant. This pattern is consistent with findings from Chaves Gómez et al. and Vasoglou et al., who reported greater cortical bone thickness in the premolar-molar region of the posterior maxilla, identifying it as a favorable site for mini-implant placement based on CBCT evaluation.14,15 The lack of significant differences among the P-P, P-M, and M-M regions indicates that clinicians may have flexibility in choosing the insertion site based on other factors, such as root proximity and soft tissue considerations. When comparing the cleft and non-cleft sides region-wise, only the P-P region showed a significant difference, with greater thickness on the non-cleft side.

The slightly thicker cortical bone on the non-cleft side, particularly at 2 mm, 4 mm, and 6 mm from the CEJ, may reflect the inherent bone deficiency associated with the cleft defect. This finding is consistent with previous studies that have reported thinner cortical bone around the cleft region, which could pose challenges for mini-implant stability.16

However, the absence of a significant difference at 8 mm from the CEJ suggests that the bone deficiency may be less pronounced in more apical regions, providing a potential site for mini-implant placement in cleft patients.

The results of this study are consistent with prior research that has highlighted the importance of cortical bone thickness for mini-implant stability. For instance, studies have shown that cortical bone thickness of at least 1 mm is associated with higher success rates for mini-implants . A study by Marquezan et al 17 investigated the relationship between cortical bone cortical bone thickness in the posterior maxilla using CBCT and reported that thicker cortical bone in the apical regions was associated with higher mini-implant stability. The current findings also corroborate previous reports of thinner cortical bone in the cleft region, which may compromise mini-implant stability. However, this study adds to the literature by providing detailed measurements of cortical bone thickness in the posterior maxilla, a region that has been less studied in cleft patients.

The findings of this study have important clinical implications for orthodontic treatment planning in cleft patients. Clinicians should consider placing mini-implants at greater vertical heights (e.g., 6 mm or 8 mm from the CEJ) to take advantage of the thicker cortical bone in these regions. Additionally, the non-cleft side may be a more favorable site for mini-implant placement, particularly at lower vertical heights. However, the choice of insertion site should also consider other factors, such as root proximity, soft tissue thickness, and the specific biomechanical requirements of the case.

This study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study was conducted at a single center, and the results may not be representative of other populations. Third, the study did not evaluate other factors that may influence mini-implant stability, such as insertion torque, bone density, and soft tissue management. Future studies with larger sample sizes and multicenter designs are needed to validate these findings and explore additional factors that may impact mini-implant success in cleft patients.

Future research should focus on evaluating the long-term success rates of mini-implants placed in different regions and at different vertical heights in cleft patients. Additionally, studies should investigate the impact of other factors, such as bone density, insertion torque, and soft tissue management, on mini-implant stability. Furthermore, comparative studies between cleft and non-cleft patients could provide additional insights into the unique challenges associated with mini-implant placement in cleft patients.

Conclusions

Cortical bone thickness increased with vertical distance from the cementoenamel junction, with the thickest bone observed at 8 mm. The non-cleft side demonstrated significantly greater cortical bone thickness than the cleft side at 2 mm, 4 mm, and 6 mm. No significant differences in thickness were observed among the three posterior regions (P-P, P-M, M-M), although the P-M region had the highest overall mean thickness. The apical region on the non-cleft side appears to offer the most favorable site for mini-implant placement in patients with unilateral cleft lip and palate. Clinicians should consider both vertical height and cleft-side asymmetry when selecting mini-implant insertion sites.

References

1. Moscarino S, Scholz J, Bastian A, Knaup I, Wolf M. Bone and soft tissue palatal morphology and potential anchorage sides in cleft palate patients. Ann Anat 2019;224:41–6. https://doi.org/10.1016/j.aanat.2019.02.005.
2. Abu Al-Melh MM, Al-Anzi AN. Knowledge of undergraduate dental students toward orthodontic skeletal temporary anchorage devices at Kuwait University. BMC Med Educ 2020;20.
3. Yu WP, Tsai MT, Yu JH, Huang HL, Hsu JT. Bone quality affects stability of orthodontic miniscrews. Sci Rep 2022;12. https://doi.org/10.1038/S41598-022-06851-Y.
4. Singh J, Singh S, Gupta A, Nayak S, Vatsa R, Priyadarshni P. Comparative Evaluation of Primary Stability of Two Different Types of Orthodontic Mini-Implants. J Pharm Bioallied Sci 2021;13:S128–31. https://doi.org/10.4103/JPBS.JPBS_604_20.
5. Leo M, Cerroni L, Pasquantonio G, Condò SG, Condò R. Temporary anchorage devices (TADs) in orthodontics: review of the factors that influence the clinical success rate of the mini-implants. Clin Ter 2016;167:70–7. https://doi.org/10.7417/CT.2016.1936.
6. Pan CY, Liu PH, Tseng YC, Chou ST, Wu CY, Chang HP. Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. J Dent Sci 2019;14:383–8. https://doi.org/10.1016/J.JDS.2019.06.002.
7. Al Amri MS, Sabban HM, Alsaggaf DH, Alsulaimani FF, Al-Turki GA, Al-Zahrani MS, et al. Anatomical consideration for optimal position of orthodontic miniscrews in the maxilla: a CBCT appraisal. Ann Saudi Med 2020;40:330–7. https://doi.org/10.5144/0256-4947.2020.330.
8. Holmes PB, Wolf BJ, Zhou J. A CBCT atlas of buccal cortical bone thickness in interradicular spaces. Angle Orthod 2015;85:911–9. https://doi.org/10.2319/082214-593.1.
9. Jia X, Chen X, Huang X. Influence of orthodontic mini-implant penetration of the maxillary sinus in the infrazygomatic crest region. Am J Orthod Dentofacial Orthop 2018;153:656–61. https://doi.org/10.1016/J.AJODO.2017.08.021.
10. Parveen S, Shetty R, Husain A, Mascarenhas R, D'Souza N, Shetty N. Three-dimensional assessment of alveolar bone thickness in individuals with nonsyndromic unilateral complete cleft lip and palate. J Cleft Lip Palate Craniofacial Anomalies 2018;5:106. https://doi.org/10.4103/JCLPCA.JCLPCA_11_18.
11. Ercan E, Celikoglu M, Buyuk SK, Sekerci AE. Assessment of the alveolar bone support of patients with unilateral cleft lip and palate: a cone-beam computed tomography study. Angle Orthod 2015;85:1003–8. https://doi.org/10.2319/092614-691.1.
12. Garib DG, Yatabe MS, Ozawa TO, Filho OG da S. Alveolar bone morphology in patients with bilateral complete cleft lip and palate in the mixed dentition: cone beam computed tomography evaluation. Cleft Palate-Craniofacial J Off Publ Am Cleft Palate-Craniofacial Assoc 2012;49:208–14. https://doi.org/10.1597/10-198.
13. Ono A, Motoyoshi M, Shimizu N. Cortical bone thickness in the buccal posterior region for orthodontic mini-implants. Int J Oral Maxillofac Surg 2008;37:334–40. https://doi.org/10.1016/J.IJOM.2008.01.005.

14. Chaves Gómez A, Grageda Núñez E, Uribe Querol E. «Safe» areas with more bone quantity for inter-radicular mini-implant placement in the buccal cortical of the upper maxilla in periodontally compromised patients. Rev Mex Ortod 2015;3:e148–53. https://doi.org/10.1016/J.RMO.2016.03.040.

15. Vasoglou G, Apostolopoulos K, Vasoglou M. Optimal Buccal Site for Mini-Implant Placement on Attached Gingiva of Posterior Maxilla: A CBCT Study. Appl Sci 2023, Vol 13, Page 7099 2023;13:7099. https://doi.org/10.3390/APP13127099.

16. Parveen S, Shetty R, Husain A, Mascarenhas R, D'Souza N, Shetty N. Three-dimensional assessment of alveolar bone thickness in individuals with nonsyndromic unilateral complete cleft lip and palate. J Cleft Lip Palate Craniofacial Anomalies 2018;5:106. https://doi.org/10.4103/JCLPCA.JCLPCA_11_18.

17. Marquezan M, Mattos CT, Sant'Anna EF, De Souza MMG, Maia LC. Does cortical thickness influence the primary stability of miniscrews?: A systematic review and meta-analysis. Angle Orthod 2014;84:1093. https://doi.org/10.2319/093013-716.1.

18. Li S-F, Xu F-Y, Xue M-R, Wu X-P, Park H-S, Bing L. Micro-Implanted-Anchorage Safety: Cortical Bone Thickness in the Maxillary Posterior Region of Skeletal Class II Malocclusion Seguridad en el Micro-implante de Anclaje: Espesor del Hueso Cortical en la Región Posterior del Maxilar en Maloclusión de Clase Esquelética Tipo II. Int J Morphol 2018;36:1002–6.

How to cite this article?

How to Cite this article: Khan H, Mehmood A. Quantitative evaluation of buccal cortical bone in maxillary posterior region on cleft and non-cleft side in cleft lip and palate patients; A three-dimensional Cone Beam Computed Tomography study. J Rehman Coll Dent 2024;5(2): 6-10

Author Contributions

1. Huma Khan- Conceptualization, Literature review, Methodology, Data Collection, and Original Draft
2. Amjad Mehmood - Data interpretation and Data Analysis