

Assessment of Buccal Plate Thickness in Maxillary and Mandibular Posterior Dentition using Cone Beam Computed Tomography

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ABSTRACT

Introduction: Adequate buccal plate thickness sustains alveolar bone remodelling without significant peri-implant bone resorption, thereby, preventing peri-implant bone defects like fenestrations and dehiscences, and maintaining the integrity of overlying soft tissues.

Objective: To assess the buccal plate thickness in the maxillary and mandibular posterior dentition using cone beam computed tomography (CBCT).

Methods: An analytical cross-sectional study was conducted in the Department of Periodontology and Oral Implantology, Kantipur Dental College Teaching Hospital and Research Centre, from 2021 December to 2023 July. After ethical approval, CBCT scans obtained from 60 participants in the age range of 21-49 years, selected through non-probability convenience sampling, fulfilling all the inclusion and exclusion criteria, were retrospectively analysed for buccal plate thickness at three measurement points, 1 mm, 3 mm, and 5 mm from the crest, with an additional measurement from cemento-enamel junction (CEJ) to the crest, on 1,440 roots, using Carestream (CS) 3D imaging software version 3.5.18. The data were then compared between jaws, measurement points, sides, and genders using SPSS v.20 software.

Results: In the maxilla, the thinnest buccal plate was presented by mesiobuccal root of first molar at 1 mm, and by first premolar at 3 mm and 5 mm, while the thickest buccal plate was presented by mesiobuccal and distobuccal roots of second molar at 5 mm, and at 1 mm and 3 mm respectively. In the mandible, first premolar had the thinnest buccal plate while distobuccal root of second molar had the thickest buccal plate at all three measurement points.

Conclusions: The study presented the tendency of buccal plate to increase in thickness from anterior to posterior, and from coronal to apical along the roots, in both jaws. No significant differences could be determined between right and left sides, or between genders.

Keywords: Bone substitutes; cone beam computed tomography; implants; mandible; maxilla.

INTRODUCTION

Buccal bone plate is a component of the alveolar process which is immensely associated with the development and eruption of teeth, and is very responsive to changes that occur in the dental structures it supports. Major remodelling is an inevitable and a well-documented phenomenon after tooth extraction, and is mainly a consequence

of the disappearance of bundle bone. Anatomically, buccal bone plate is relatively thinner than its palatal or lingual counterpart, and therefore is prone to significant remodelling.^{1,2}

The integrity and volume of hard tissue envelope surrounding implants is essential for the ideal prosthetic reconstruction and stability of the overlying soft tissues, which influence long-term function and aesthetics.^{1,3} Despite the earlier claims on prevention of post-extraction bone resorption with immediate implants, it has now been demonstrated that buccal bone plate can be expected to undergo bone remodelling and subsequent dimensional alterations after implant placement as well.^{4,5}

Cone beam computed tomography (CBCT), although

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may show some artefacts in the presence of metals, the accuracy and reliability for linear and angular measurements are reported to be high, thereby making it a reliable diagnostic option for linear evaluation measurements of structures associated with dental and maxillofacial imaging, such as preoperative assessment for dental implant surgery.⁶⁻¹⁰

There are several investigations on the buccal plate thickness in the anterior maxilla calculated by clinical as well as CBCT analyses.^{11,12} Despite the equal dominance and preference of performing implant surgery in the posterior regions of the jaws, however, there are only a few studies which have calculated buccal plate thickness in the posterior dentition.¹³⁻¹⁶ Therefore, the present study aimed to determine this anatomic variable in the maxillary and mandibular dentition, using CBCT, in Nepali population.

METHODS

This analytical cross-sectional study was conducted at Kantipur Dental College Teaching Hospital and Research Centre, Kathmandu, Nepal. The study population included the patients visiting the Department of Periodontology and Oral Implantology and Department of Oral Medicine and Radiology, who fulfilled all the inclusion and exclusion criteria. The participants were selected using non-probability convenience sampling. Inclusion criteria included full mouth CBCT images obtained using the same machine and general adjustment settings from patients over the age of 20 years who had all the

posterior teeth, with the exception of third molars. Exclusion criteria included subjects with a history of periodontal surgery, orthodontic therapy or trauma to the face, obvious skeletal abnormalities, periapical pathologies, bone loss more than 4 mm from the CEJ, no detectable buccal plate, and presence of restorations or implants causing excessive scatter in scans. Sample size was calculated using data from the study by Zekry et al.¹³ using the formula: $n = 2 \times (\sigma^2 (Z\alpha + Z\beta)^2) / d^2$; Where, n = required sample size, $Z\alpha = 1.96$ for α at 0.05, $Z\beta = 1.282$ for β at 0.10, Σ = mean of Standard deviation (SD1 + SD2)/2, d = mean difference (mean1-mean2). Thus, $n = 2 \times (0.655)^2 \times (3.242)^2 / (0.57)^2 = 27$ for each group = 54; With 10% permissible error, sample size = 60 (30 males and 30 females).

The protocol for the study was reviewed and approved by the Institutional Review Committee (Reference number: 19/021), Kantipur Dental College Teaching Hospital and Research Centre. Full mouth CBCT images of 60 patients (30 males and 30 females) in the age range of 21-49 years, taken via CS9300 Care Stream using the standardised protocol at 85 kV, 6.3 mA, Voxel size of 300 and 17x13.5 field of view, were collected from the archive and retrospectively analysed over a period of 18 months from 2021 December to 2023 July.

The volume on the curved slicing was oriented to visualise the entire root in one sagittal plane (Figure 1). A reference line was drawn at the mid-root level apico-coronally such that an ideal coronal slice was obtained (Figure 2). A tangent was drawn along

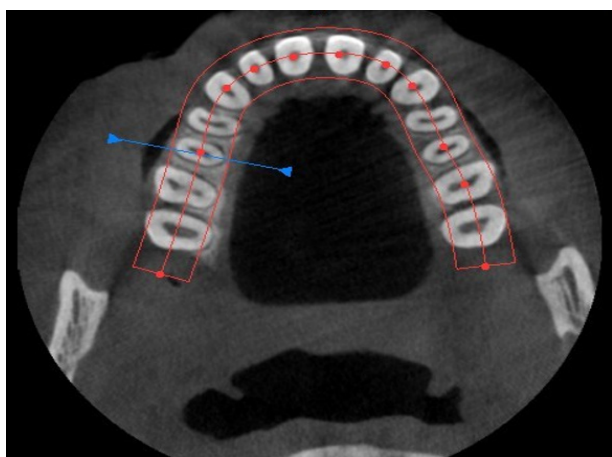


Figure 1: Curved slicing on CS 3D imaging software.

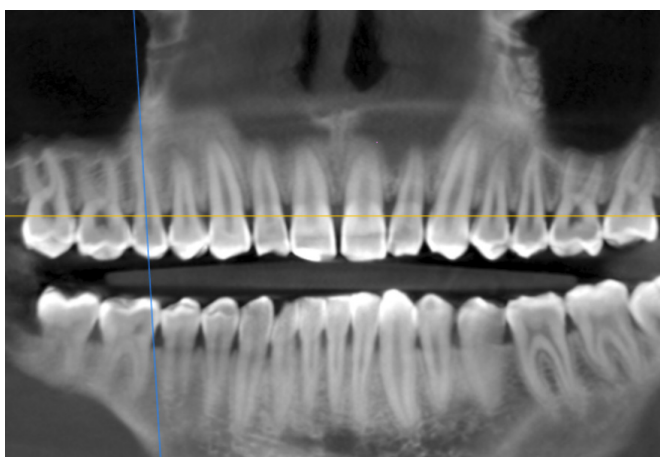


Figure 2: Reference line drawn at the mid-root level apico-coronally such that an ideal coronal slice is obtained.

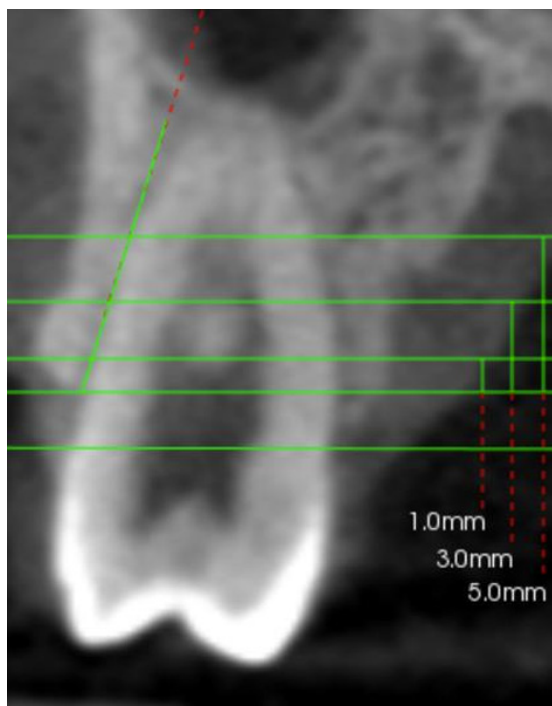


Figure 3: A tangent drawn along the lamina dura of alveolar bone and the thickness of the buccal plate measured perpendicular to the periodontal ligament space of each root at three levels.

the lamina dura of alveolar bone and the thickness of the buccal plate was measured perpendicular to the periodontal ligament (PDL) space of each root at three levels: 1 mm, 3 mm, and 5 mm from the crest. An additional measurement was taken from CEJ to the crest at the mid-root level apico-coronally, so as to validate the inclusion criteria of bone loss no more than 4 mm (Figure 3). In case of molars, the buccal roots were considered separately. The buccal plate thickness was measured at these points on all the buccal roots of maxillary and mandibular posterior dentition using the measurement tools in the software. The measurements were analysed using IBM SPSS Statistics for Windows, version 20 (IBM Corp., Armonk, N.Y., USA). In all the statistical tests, a statistical significance level i.e. p-value was set at $\alpha = 0.05$.

RESULTS

A total of 1,440 roots were evaluated for the study, on CBCT scans from 60 subjects, 30 males and 30 females, with a mean age of 28.57 ± 6.22 years (age range: 21-49 years).

In the maxilla, at 1 mm from the crest, mesiobuccal root of first molar had the thinnest buccal plate. However, at 3 mm and 5 mm measurement points, first premolar presented the thinnest buccal plate. Likewise, the thickest buccal plate at 1 mm and 3 mm from the crest was presented by distobuccal root of second molar while at 5 mm from the crest, mesiobuccal root of second molar had the thickest buccal plate (Figure 4). In the mandible, buccal plate was thinnest for first premolar and thickest for distobuccal root of second molar at all three measurement points (Figure 5).

One way ANOVA test in analysing the buccal plate along the roots of maxillary teeth presented a significant increase in thickness from coronal to apical for second premolar, distobuccal root of first molar, and mesiobuccal and distobuccal roots of second molar (Table 1). Post Hoc (Tukey) test comparing the buccal plate thickness among three measurement points suggested significant increase in buccal plate thickness at 3 mm as compared to 1mm for second premolar, distobuccal root of first molar and mesiobuccal and distobuccal roots of second molar. Similar increase in thickness was

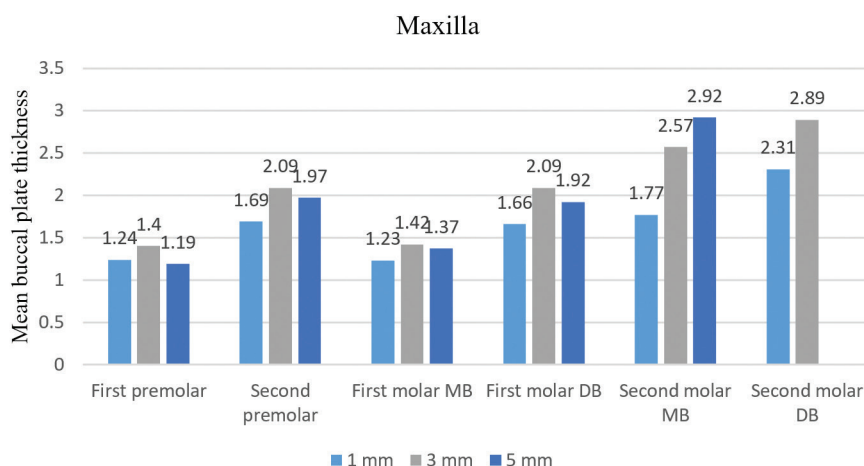


Figure 4: Mean values of buccal plate thickness in the maxillary posterior teeth at various measurement points.

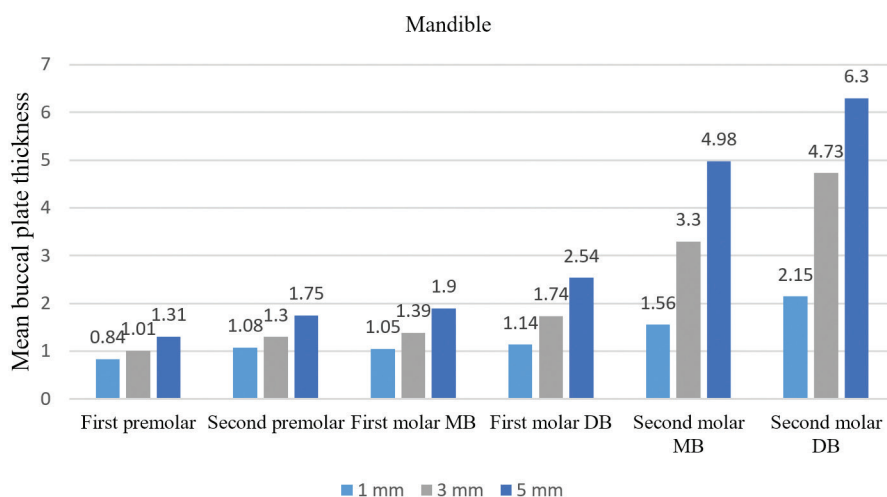


Figure 5: Mean values of buccal plate thickness in the mandibular posterior teeth at various measurement points.

observed for first premolar and the mesiodistal root of first molar, though not significant. The buccal plate thickness increased at 5 mm as compared to 3 mm for distobuccal root of second molar, while it decreased for all other roots. The differences were however not significant. The results suggested a tendency for the buccal plate of maxillary posterior dentition to significantly increase from 1 mm to 3 mm from the crest and then remain somewhat stable thereafter up to 5 mm, in all the teeth except first premolar and mesiobuccal root of first molar. Buccal

plate thickness at 1 mm was lower than at 5 mm for all maxillary roots, except for first premolar, with significantly lower values for the mesiobuccal and distobuccal roots of second molar (Table 2).

Likewise, one way ANOVA test in analysing the buccal plate along the roots of mandibular teeth presented a significant increase in the buccal plate thickness from coronal to apical aspect of the root, for all mandibular posterior teeth (Table 3). Post Hoc (Tukey) test comparing the buccal plate thickness among three

measurement points suggested significant increase in buccal plate thickness at 3 mm as compared to 1 mm, and at 5 mm as compared to 3 mm, except for first and second premolars where the increase from 1 mm to 3 mm was not significant. Buccal plate thickness at 1 mm was significantly lower than at 5 mm in all the roots, suggesting a significant increase in the buccal plate thickness from coronal to apical aspect along the roots in the mandibular posterior dentition (Table 4).

Comparing the thickness of buccal plate among the teeth presented a tendency of buccal plate to increase in thickness from anterior to posterior in both the jaws.

Independent samples t- test to compare the buccal plate thickness of maxillary teeth between genders revealed no statistically significant difference at any measurement point, except at 5 mm for the mesiobuccal root of first molar (p = 0.04) at which buccal plate thickness was greater for males (1.55 ± 0.64 as compared to 1.20 ± 0.72), and at 1 mm for the distobuccal root of first molar (p = 0.01) where the

buccal plate was thicker for females (1.80 ± 0.52 as compared to 1.52 ± 0.37). For the mandibular teeth, no significant difference could be seen for any tooth at any measurement point.

Comparison between the right and left sides of the maxilla revealed buccal plate to be significantly thicker on the left side at 1 mm measurement point for mesiobuccal root of first molar (1.29 ± 0.43 as compared to 1.16 ± 0.45), at 3 mm (2.18 ± 0.82 as compared to 2.005 ± 0.77) and 5 mm (2.04 ± 0.92 as compared to 1.90 ± 0.96) measurement points for second premolar, and at all three measurement points for first premolar (1.35 ± 0.38 as compared to 1.14 ± 0.34 at 1 mm, 1.51 ± 0.60 as compared to 1.29 ± 0.61 at 3 mm, and 1.28 ± 0.58 as compared to 1.11 ± 0.64), and distobuccal root of first molar (1.74 ± 0.52 as compared to 1.58 ± 0.57 at 1 mm, 2.25 ± 0.91 as compared to 1.93 ± 0.82 at 3 mm, and 2.03 ± 0.95 as compared to 1.82 ± 0.98 at 5 mm). However, no significant difference between the right and left sides could be observed at any measurement point along the root of any tooth in the mandible.

Table 1: One way ANOVA test for comparison of buccal plate thickness at various measurement points in the maxilla.

Variables (Maxilla)	1 mm (Mean ± SD)	3 mm (Mean ± SD)	5 mm (Mean ± SD)	p-value
Second molar mesiobuccal	1.77 ± 0.47	2.57 ± 0.78	2.92 ± 0.94	<0.05
Second molar distobuccal	2.31 ± 0.65	2.89 ± 0.87	2.90 ± 1.01	<0.05
First molar mesiobuccal	1.23 ± 0.38	1.42 ± 0.65	1.37 ± 0.70	0.18
First molar distobuccal	1.66 ± 0.47	2.09 ± 0.78	1.92 ± 0.91	0.007
Second premolar	1.69 ± 0.79	2.09 ± 0.76	1.97 ± 0.90	0.024
First premolar	1.24 ± 0.31	1.40 ± 0.57	1.19 ± 0.55	0.068

Table 2: Post Hoc (Tukey) test for comparison of buccal plate thickness at various measurement points in the maxilla.

Variables (Maxilla)	1 mm versus 3 mm	3 mm versus 5 mm	1 mm versus 5 mm
Second molar mesiobuccal	<0.05	0.0	<0.05
Second molar distobuccal	0.001	0.99	<0.05
First molar mesiobuccal	0.18	0.91	0.37
First molar distobuccal	0.005	0.43	0.13
Second premolar	0.02	0.70	0.14
First premolar	0.21	0.06	0.84

Table 3: One way ANOVA test for comparison of buccal bone thickness at various measurement points in the mandible.

Variables (Mandible)	1 mm (Mean ± SD)	3 mm (Mean ± SD)	5 mm (Mean ± SD)	p-value
Second molar mesiobuccal	1.56 ± 0.61	3.30 ± 1.38	4.98 ± 1.68	<0.05
Second molar distobuccal	2.15 ± 0.99	4.73 ± 1.67	6.30 ± 1.56	<0.05
First molar mesiobuccal	1.05 ± 0.32	1.39 ± 0.66	1.90 ± 0.90	<0.05
First molar distobuccal	1.14 ± 0.37	1.74 ± 0.65	2.54 ± 1.05	<0.05
Second premolar	1.08 ± 0.31	1.30 ± 0.58	1.75 ± 0.88	<0.05
First premolar	0.84 ± 0.31	1.01 ± 0.42	1.31 ± 0.72	<0.05

Table 4: Post Hoc (Tukey) test for comparison of buccal bone thickness at various measurement points in the mandible.

Second molar mesiobuccal	<0.05	<0.05	<0.05
Second molar distobuccal	<0.05	<0.05	<0.05
First molar mesiobuccal	0.018	<0.05	<0.05
First molar distobuccal	<0.05	<0.05	<0.05
Second premolar	0.14	<0.05	<0.05
First premolar	0.17	0.005	<0.05

DISCUSSION

Major bone remodelling is an inevitable, and in fact, a well-documented phenomenon after tooth extraction, and is mainly a consequence of the disappearance of bundle bone.^{1,2,17} Such remodelling predisposes alveolar ridge to significant resorption, leading to challenges in implant placement, both in healed ridges and in fresh extraction sockets.¹ Bone resorption is more pronounced in the buccal aspect as compared to the lingual aspect. Moreover, thick buccal plate presents a higher chance of preservation of ridge contour while thin buccal plate presents a higher chance of significant bone resorption. This could be attributed to the presence of both lamellar and bundle bone in a thick buccal bone plate, where lamellar bone supports the ridge even when bundle bone disappears.¹⁸

The mean horizontal bone loss after tooth extraction has been reported to be about 1.3 to 1.4 mm. Therefore, in order to avoid buccal bone loss, the bone thickness should be at least 2 mm.¹⁹ Several studies have advocated the crestal buccal plate thickness of ≥2 mm at the time of implant placement as a prerequisite for successful biological and aesthetic outcomes.¹⁹⁻²² One of such studies by Nohra et al. showed that implants which initially presented buccal bone thickness of < 2 mm exhibited eight times greater vertical bone loss when compared to implants that displayed buccal bone thickness of ≥2mm.²² Likewise, Qahash et al. showed that sites with ridge width of <2 mm had significantly greater buccal bone resorption following immediate implant placement and suggested the width of buccal bone to be at least 2 mm for the alveolar bone level to be maintained.²¹ Furthermore, it has been advised that once initial bone healing and remodelling have taken

place, the implants are to be osseointegrated and circumferentially embedded in vital bone, thereby necessitating an adequate buccal plate thickness at the time of implant placement.²²

In the maxilla, at 1 mm measurement point, only the distobuccal root of second molar showed buccal plate thickness of >2 mm. None of the roots, however, presented with <1 mm of buccal plate thickness at this point. The buccal plate thickness increased when measured at 3 mm from the crest, with second premolar, and mesiobuccal and distobuccal roots of first and second molars presenting buccal plate thickness of >2 mm. Further apically along the root at 5 mm measurement point, only the roots of second molar revealed bone thickness of >2 mm.

In the mandible, at 1 mm measurement point, only the distobuccal root of second molar presented with >2 mm of buccal plate thickness, while first premolar presented with buccal plate thickness of 2 mm. The buccal plate thickness increased when measured at 3 mm from the crest, where only the mesiobuccal and distobuccal roots of second molar had buccal plate thickness of >2 mm. Further apically along the root at 5 mm measurement point, mesiobuccal and distobuccal roots of second molar, and distobuccal root of first molar revealed bone thickness >2 mm.

Therefore, considering buccal plate thickness of 2 mm as a threshold, the geometric means of all the posterior teeth except the second molars, presented a trend towards requiring ridge preservation. These findings are similar to those shown by Temple et al.¹⁴

The present study suggested a tendency for the buccal plate of maxillary posterior dentition to significantly increase in thickness from 1 mm to 3 mm from the crest along the root and then remain somewhat stable thereafter up to 5 mm. The buccal plate of mandibular posterior dentition, however presented a tendency to significantly increase from 1 mm to 3 mm and 3 mm to 5 mm along the root. Moreover, the thickness of buccal plate was significantly lower at 1 mm than at 5 mm measurement points for all the posterior teeth except for the maxillary first premolar where the buccal plate was thicker, though not significantly, at 1 mm as compared to 5 mm. These findings were in accordance to those obtained by Temple et al.¹⁴ where mandibular posterior dentition presented significant

increase in buccal plate thickness from coronal to apical, along the root. Similar trend of statistically significant increase in buccal bone thickness from coronal to apical along the roots of maxillary and mandibular posterior dentition was presented by Kolte et al.¹⁵ However, in contrast to the present study, analysis of maxillary dentition by Temple et al.¹⁴ demonstrated significant decrease in buccal plate thickness of maxillary posterior dentition from coronal to apical, along the root, except for second molars.

Comparing the thickness of buccal plate among the teeth presented a tendency of buccal plate to increase in thickness from anterior to posterior in both the jaws, and this finding was in accordance with the study by Temple et al.¹⁴

Comparison of buccal plate thickness between right and left sides of both jaws did not present significant difference, except for maxillary premolars and mesiobuccal root of maxillary first molar which presented thicker buccal plate on the left side. No significant difference in the buccal plate thickness could be seen between genders except for the mesiobuccal and distobuccal roots of maxillary first molar where the buccal plate was thicker for males and females respectively. These findings were similar to those presented by Zekry et al in 2014.¹³

CONCLUSIONS

The results of this study have presented a tendency of buccal plate to increase in thickness from anterior to posterior along the jaws and from coronal to apical along the roots in both jaws. Significant effect of tooth, measurement points along the root, and jaw, on buccal plate thickness could be observed. No significant difference in buccal plate could be observed however, between right and left sides or between genders. Because of this profound effect of jaw on the buccal plate thickness, the study suggested that tooth alone without bearing in mind, the jaw, could not be reliable for treatment planning. Moreover, considering buccal plate thickness of 2 mm as a prerequisite, the geometric means of all the posterior teeth except the second molars, presented a trend towards requiring ridge preservation.

Conflict of Interest: None.

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