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Evaluation of Bone Graft Need in Edentulous Posterior Sites: A CBCT Retrospective Study

Abstract

Objective
This retrospective study investigates the necessity for bone graft augmentation in edentulous posterior sites, focusing on the lower premolar and molar regions.

Materials and Methods
Using Cone Beam Computed Tomography (CBCT) imaging from patients treated at Umm Al-Qura University between 2019 and 2022, to evaluates bone conditions that influence dental implant placement. Digital software was employed to plan implant placement with a prosthetically driven approach. Measurement of buccal and lingual bone thickness at the coronal and middle aspect of the implant was done. Measurement less than 1mm was considered an indication for the need of bone augmentation.

Results
A total of 74 CBCT scans were evaluated, representing 100 missing teeth. Premolars constitute 23% (n=23), and molars constitute 77% (n=77) of the teeth site evaluated. A significant number of sites required bone grafting due to insufficient buccal bone thickness, with 80% of implants having <1mm bone thickness. 91% of premolar implants and 89.6% of molar implants lacked adequate buccal bone. More premolars needed guided bone regeneration (GBR) than molars ($p<0.0001$). Overall, 80% of implants needed bone grafts, with females showing a slightly higher need ($p>0.05$). Lingual bone thickness was adequate.

Conclusion
Number of edentulous posterior sites, specifically in the lower premolar and molar regions, necessitate bone graft augmentation for successful implant placement. Pre-surgical planning using digital software and CBCT imaging is crucial to assess bone accurately and determine the need for bone augmentation.

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Keywords

Bone graft , Edentulous site, Guided bone regeneration , Dental implant.

INTRODUCTION

After tooth extraction, significant changes in bone volume, including loss of height and width, typically occur, with notable differences between the maxilla and mandible and between anterior and posterior sites (1, 2). Schropp et al. estimated that two-thirds of the hard and soft tissue changes occur in the first three months. The authors reported 50% of crestal width is lost during a 12-month period (3). The amount of bone loss after extraction depends on many factors, such as facial bone wall thickness, angulation of the tooth, and the anatomy at the various tooth sites (4). In addition, tooth loss and bone resorption have a negative impact on the facial structure as they result in face collapse and complicated prosthesis fitting. It also prevents implant placement in the optimal prosthetic position and necessitates supplementary procedures, such as bone grafting or sinus augmentation (5, 6).

To achieve optimal outcomes in dental implant procedures, the dimensions of the implant must be carefully selected based on the available bone. Ideally, a buccal bone plate thickness of 1-2 mm is recommended to ensure adequate soft tissue support and prevent the resorption of the buccal bone, thereby minimizing the risk of peri-implant soft-tissue recession (7). For instance, a minimum buccolingual width of 6 mm is advised to accommodate a 4 mm implant crestal diameter, ensuring sufficient bone thickness for long-term stability and success (8). Other considerations, such as bone height, directly influence the choice of implant length and crown height. In cases where the bone is insufficient, techniques like bone grafting or sinus augmentation may be necessary to create a site suitable for implant placement, particularly in the anterior maxillary region (9, 10).

The selection of implant diameter and length, when combined with advanced planning and surgical techniques, is crucial for achieving successful outcomes in the posterior region, which is typically subjected to higher occlusal forces and often presents with reduced bone height and width. Careful consideration is necessary to ensure implant stability, longevity, and functionality (11, 12). ITI guidelines advocate for the use of wide-diameter implants (⩾ 4.5 mm) in the posterior region to better manage the increased occlusal forces and enhance primary stability (13). These wider implants are particularly recommended when bone width permits, ensuring a minimum of 1.5 mm of bone remains on the buccal and lingual sides to mitigate the risk of peri-implant bone loss (14). While standard-diameter implants (3.75-4.2 mm) may also be utilized in this area, it is imperative to ensure there is sufficient bone support and that occlusal forces are appropriately distributed (11). Implants with a length of 10 mm or greater are typically preferred in the posterior region due to their enhanced surface area, which promotes better osseointegration and biomechanical stability (12). However, in cases where vertical bone height is limited, such as in proximity to the maxillary sinus or the inferior alveolar nerve, shorter implants (6-8 mm) are considered a viable alternative (13).

Pre-surgical assessment using tools such as cone-beam computed tomography (CBCT) allows for accurate evaluation of the available bone volume, helping clinicians select the appropriate implant size and plan for necessary bone augmentation procedures. This meticulous approach to implant planning is essential for reducing surgical complications, enhancing safety, and achieving favorable long-term outcomes (15, 16). There is limited data regarding how frequently bone augmentation is needed to achieve adequate implant position and the prevalence of needed graft horizontal versus vertical in the Saudi population. This study aims to assess the thickness of buccal and lingual bony plates around digitally placed standard implants at lower edentulous sites and to identify the need for bone augmentation (BA) techniques during the placement of implants in lower premolar and molar sites.

MATERIAL AND METHODS

Study Design and Sample

This retrospective study was conducted using archived CBCT records of patients seeking treatment at Umm Al-Qura University between 2019 and 2023. The collected sample size was for healthy adult patients aged above 18 years and have at least one sextant with missing mandibular premolar or molar. Unclear CBCT and fully edentulous patients were excluded. CBCT analyses were collected and analyzed by one trained investigator. CBCT images and digital planning of the implants. The same machine is used to take all CBCT scans (i-CAT Vision Q System set at 120 kVp and 37.07 mAs, acquisition time 26.9 sec and assessed using ICAT Vision viewer, (version 1.9.3.13). The CBCT transferred as DICOM files to BlueSkyPlan®" software from Blue Sky Bio, which allowed for implant planning. Axial, coronal, and sagittal images were used for the digital planning of implant placement. A crown from the software library was placed in the missing area, and then a standard implant was placed according to the ideal prosthetic position. First, the inferior alveolar never pathway and mental foramina were traced, and a 2mm safety zone was considered around the neurovascular bundles. ITI recommendation was followed for selecting the ideal implant size and position (17). A standard diameter implant (4.8 for molar sites and 4.1 for premolar sites) and a standard length of 10 mm was planned. If the 10 mm length violated the 2 mm safety zone for the inferior alveolar, an 8 mm implant length was never selected. Implants were placed 1.5

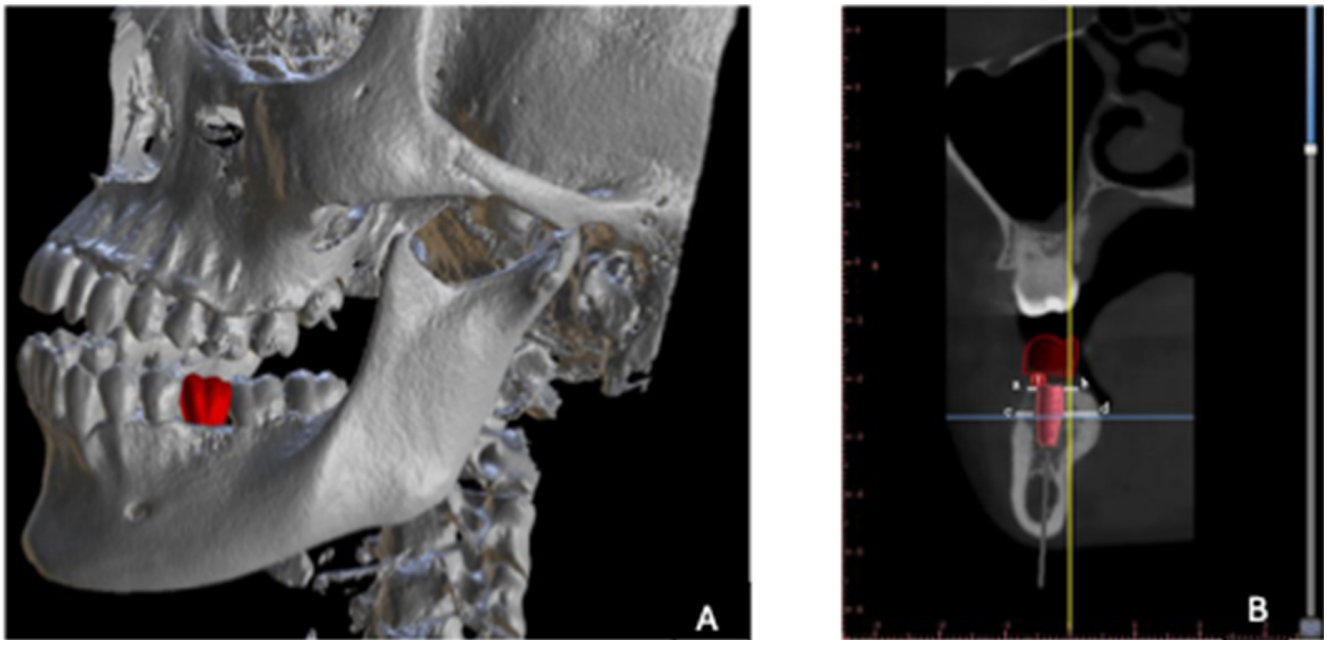

Fig. 1 Implant planning was carried out using "BlueSkyPlan® software. **A:** First prosthetic planning was performed, and a standard implant size was placed following ITI guidelines. **B:** Measurement taken in sagittal view. a: Buccal bone thickness at the coronal aspect of the implant. b: Lingual bone thickness at the coronal aspect of the implant. c: Buccal bone thickness at middle (5mm) of the implant. d: Lingual bone thickness at middle (5mm) of the implant

mm from the adjacent teeth and 2mm deeper than the cementoenamel junction of adjacent teeth.
The following measurements, in millimeters (mm), were evaluated on the sagittal section (Fig. 1): Buccal bone thickness at the implant head, Buccal bone thickness at the middle of the implant (5mm mark), Lingual bone thickness at the implant head, Lingual bone thickness at the middle of the implant (5mm mark). Bone augmentation was considered needed when the bone thickness measurement was less than 1mm.

RESULTS

A total 100 missing teeth sites form 74 CBCT scans were evaluated. 48.6 % (n=36) of the sample were males with an average age of 39.7 ±12 years and 51.4 % (n=38) were females with an average age of 37.2 ± 12 years. There was no statistical difference between male and females' participants. Of the sites evaluated, premolars constitute 23% (n=23) of the teeth and molars 77% (n=77). Details on the samples evaluated is presented in Table 1.
The average B bone thickness in the coronal aspect was 0.32 + 0.65mm. On the premolar sites, the average bone thickness was 0.13±0.33mm, while on the molar sites, the average bone thickness was 0.44 ± 0.78mm (Table 2). No significant difference in bone thickness was detected between males and females.
Ninety-one percent (n=21) of implants placed in premolar sites and 89.6% (n-69) of implants placed in molars showed either no buccal bone or thin bony plates (<1mm) on the buccal aspects of the implants. Overall, 80 % (n=80) of the implants evaluated had bone thickness <1mm on the coronal buccal aspect. Only 20 % (n=20) had adequate buccal bone thickness (>1mm) on the coronal aspect. Of those, only 2 (8.7%) premolars and 18 (23 %) molars.
Evaluating the buccal bone at the mid-point of the implants, 38% (n=38) had less than one mm of bone thickness on the buccal aspect. 78% (n=18) and 26% (n=20) implants placed at premolars and molars sites, respectively, had <1mm of buccal bone thickness at the middle point of the implant.
In terms of needing horizontal bone augmentation at the buccal aspect, 50.6% (n=39) of molars need augmentation on the coronal aspect only, while 87% (n-20) need augmentation along the buccal aspect.
For the premolars, 78 % (n=18) needed buccal augmentation along the buccal aspect, and only three implants were needed along the coronal aspect. Significantly more premolars sites needed GBR than molars ($p < 0.00001$) (Table 2).
Thus, the overall percentage of implants that need bone grafts is 80 % (42 % coronal and 38 % all over)
More females needed bone grafts compared to males, but the difference was not statistically significant (Of those who need coronal GBR 22 females and 20 males and of those who needed GBR 24 female 14 male).
For the lingual aspect, the average lingual bone thickness was 2.66 ±1.5 mm. (2.8 ±1.7mm and 2.6 ± 1.5 mm for premolars sites and molar, respectively ($p>0.05$).
Fifty-two percent of implants were placed in supra

	Total	Male (%)	Female (%)
Number	74 (100%)	36 (48.6)	38 (51.4)
Age	38.2 +12.0 y	39.7 +12 y	37.2 +12 y
Teeth			
Premolar	23	6 (26)	14 (60.8)
Molar	77	38(49)	25 (32.4%
Bone Thickness			
Buccal bone thickness (mean + SD)	0.32 + 0.65mm	0.4 +0.70mm	0.34 + 0.73 mm
lingual Bone thickness (mean + SD)	2.66 +1.51mm	0.72+1.05 mm	0.98 + 1.45 mm
Implant size			
4.8*10	70	26 (37)	30 (42)
4.8*8	7	3 (42.8)	4 (57)
4.1*10	21	7 (33)	13 (62)
4.1*8	2	0	2 (100)
Need Buccal augmentation (coronal only)	42	20 (47.6)	22 (52)
Need Buccal augmentation	38	14 (36.8)	24 (63)

No statistical difference between male and females participant regarding the need for bone graft augmentation

Tab. 1

	Overall (n=100)	Premolar (n=23)	Molar (n=77)
Buccal bone thickness (mean + SD)	0.32 + 0.65mm	0.13+0.33mm	0.44 + 0.78mm
Need Buccal augmentation (coronal only) n (%)	42 (42)	3 (13)	39 (50)
Need Buccal augmentation n (%)	38 (38)	18 (78) *	20 (26)
lingual Bone thickness (mean + SD)	2.66 +1.51mm	8 +1.7mm	2.6 + 1.5 mm

** significant different between premolars and molars in need for buccal bone augmentation p < 0.00001*
Abbreviation : (CBCT) Cone beam computed tomography

Tab. 2

crestal position, 73% (n=17) premolars, and 45% (n=35) molars, indicating a vertical discrepancy between the edentulous area and the adjacent teeth.
Only five molar sites had a significant bone deficiency, so standard implant placement was not possible.

DISCUSSION

Dental implants are a unique tooth replacement solution that not only restores function but also helps prevent bone resorption by mimicking the natural function of tooth roots. The concept of implant placement being primarily guided by prosthetic considerations is well-supported. Thus, the design of the prosthesis should determine the ideal position, angulation, and depth of the implant to ensure optimal outcomes (8). It is well established that bone loss is a major consequence of tooth loss, significantly impacting subsequent treatment options (1, 3). This study focuses on evaluating the thickness of the buccal and lingual bony plates thickness around digitally placed implants in the lower edentulous sites and assessing the necessity for bone augmentation procedure during the placement of implants in the lower premolar and molar regions.
This study shows that most implants placed at

extracted lower premolars and molars sites have less than 1mm of buccal bone thickness. Most of the Implant at premolar sites had no bone in the coronal and middle; on the other hand, most molar sites had no bone at the coronal site, leading to implant thread exposure. This indicated that more than 50.6 % of molars and 78% of premolar sites need additional procedures, such as guided bone regeneration with or without implant placement, for successful implant treatment.

Similar findings were reported in the literature evaluating different populations. A retrospective study conducted by Cha et al. (2016) evaluated the frequency and types of bone grafts required during dental implant placement. The study analyzed 792 sextants, including both anterior and posterior sites in the upper and lower jaws. The results indicated that approximately 50.3% of the sextants necessitated bone grafting, with a higher prevalence observed in the anterior maxilla compared to other sites. However, 29 % of implants placed lower posterior sextant required GBR (18).

In comparison, the present study focused exclusively on lower posterior edentulous sites, specifically premolars, molars and assessed the surgical site during implant placement rather than before. The findings align with Cha et al.'s, particularly in the need for bone augmentation in specific regions(18).

Additionally, a study by Mateo et al. (2023) analyzed 106 CBCT scans and 201 edentulous sextants for the need for horizontal and vertical bone augmentation (19). Similar to the current study, they utilized digital implant planning across anterior, posterior maxilla, and mandible sites. Their results showed that 63.68% of sextants required bone augmentation, and 51.8 % of lower posterior sextants needed bone graft. Horizontal bone augmentation was the most prevalent type, with 48% of the sextants needing it, and twenty-nine sextants of the posterior mandible required horizontal bone augmentation. However, unlike our study, the investigator did not differentiate between molar and premolar sites. Moreover, their study identified a statistically significant difference in the need for supplementary techniques among women (19). In this study, more females needed bone grafting than males, but the differences were not significant.

The thickness of the buccal bone plays a critical role in the long-term success and stability of dental implants (14). In the posterior region, the thickness of the buccal bone plays a vital role in protecting against peri-implant bone resorption, especially when considering the anatomical challenges posed by the proximity of the sinus in the maxilla and the inferior alveolar nerve in the mandible (20). A systematic review by Miyamoto et al. concluded that thicker buccal bone, specifically 2 mm or greater, is essential to prevent crystal bone loss and maintain soft tissue stability around posterior implants (21). In relation to our findings, it is evident that maintaining an adequate buccal bone thickness during posterior implant placement is critical for long-term stability. Our data showed that most of the implant was placed in insufficient buccal bone support. Therefore, they are expected to have a higher rate of bone loss and complications over time.

Implants placed in healed sites must ensure that the implant is circumferentially embedded in the vital bone at the completion of bone healing (22). For that, evaluation of hard tissue after implant placement has several benefits as it allows the surgeon to directly visualize and evaluate the bone and determine the need for grafting. In addition, better control in implant placement (23). Flapless implant surgery, while advantageous in reducing surgical time and postoperative discomfort, is associated with several potential complications that require careful consideration. One of the primary issues is the increased risk of inaccurate implant placement. This can result in mispositioned implants, particularly in areas with limited bone volume or proximity to vital structures such as the maxillary sinus or inferior alveolar nerve (24). Damage to adjacent anatomical structures, especially in cases where preoperative planning or imaging is insufficient (25).

Furthermore, the flapless technique has been linked to an increased risk of peri-implantitis due to insufficient soft tissue adaptation around the implant (17). Infection rates may also be higher in flapless procedures(26). Implant failure and soft tissue recession can be higher than those for traditional flap techniques, particularly in anatomically challenging cases (27). Flapless surgery is only recommended when sufficient bone width and height, adequate keratinized soft tissue, and no significant tissue undercuts (28).

The use of CBCT combined with digital planning software is strongly recommended to accurately predict surgical outcomes and determine whether additional procedures may be necessary. Pre-assessment of available bone and the need for grafting can be done using CBCT and interactive software (29). The implant surgeon can choose between different diameters and lengths of implants and select the ideal one. These tools are becoming valuable tools for implant planning that help in reducing complications, enhancing surgical safety, and evaluating available bone volume to select appropriate implant dimensions (16, 30).

This study has many limitations, such as CBCT not allowing for soft tissue evaluation. It is crucial to consider adjusting the implant position in relation to both the soft tissue and bone structure to achieve optimal functional and aesthetic outcomes (31). The depth of the implant plays a significant role not only in aesthetics but also in biomechanical stability. In this study, the crown was planned according to a

prosthetically driven position, and the implant was placed 2 mm below the adjacent cemento-enamel junction (CEJ). However, in situations where there is limited bone height, adjustments in the implant depth and angulation may be necessary.

In summary, the majority of edentulous posterior sites required additional bone graft augmentation prior or adjunct to implant placement. Thorough evaluation and meticulous planning of these sites are critical to ensure successful outcomes in implant dentistry.

CONCLUSION

This study demonstrates that over half of the extracted sites require additional grafting procedures prior to implant placement. Therefore, a thorough evaluation and assessment of the bone using tomography, such as CBCT and digital planning, are essential to ensure appropriate planning and successful implant integration.

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Conflict of interest

The authors declare no conflict of interest exist.

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