Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(3), 2140-2145 | ISSN:2251-6727

Impact of Altered Implant Dimensions on Periodontal Bone Anchorage in Immediate Molar Implants. - A Cross-sectional Analysis using Virtual Implants and Digital Imaging.

(Altered Implant dimensions and Bone anchorage in Immediate molar Implants)

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(Received: 16 March 2025 Revised: 20 April 2025 Accepted: 15 June 2025)

KEYWORDS

Immediate molar implants, bone anchorage, implant length and diameter, implant stability, altered implant dimensions, bone to implant contact.

ABSTRACT:

Aim: The objective of this study was to evaluate the Periodontal bone thickness (Bucco-lingual, Mesio-distal and Apical) and to elucidate the precise correlations between bone quality and quantity with alterations in the length and diameter of immediately placed virtual molar implants using Digital Imaging system.

Material methods: Present study includes 60 Cone Beam Computed Tomography (CBCT) images, where virtual implants of various lengths (8.5, 11.5 & 13.5 mm) and diameters (4.7, 5.8 & 7 mm) were categorized (L1 to L3 and D1 to D3) groups and analysed for implant periodontal bone support at buccal and lingual cortical plate, mesial and distal interdental bone support and as well apical bone anchorage.

Results: Virtual implant placement results showed highest apical bone support (1.35mm ± 1.67mm) for longer implants (L3 – 13.5mm) and wider implant groups (D3 – 7mm) showed complete coronal cortical bone support buccally (2.55mm ± 0.81mm) and lingually (1.95mm ± 0.98mm), interdental bone anchorage mesially (1.20mm ± 0.51mm) and distally (1.05mm ± 0.59mm).

Conclusion: The results of this study indicate that, in order to maximise periodontal bone anchoring on all surfaces and minimise the need for adjuvant bone grafting methods, wider and longer implants should be used when placing immediate molar extraction cases.

Introduction

To satisfy the ideal goals of the implant dentistry, the presence of sufficient bone in ideal qualities volume is the most important of prerequisites (1). The alveolar process which houses and supports the teeth socket consists of an external cortical plate, alveolar bone proper (compact bone) and a cancellous trabecular bone in between the two bony layers. The palatal and lingual bony plates are thicker when compared with the buccal areas. The buccal bone plate is made mainly of bundle bone and tends to resorb faster than lingual bone (2).

The concept of implant placement immediately in post-extraction site is often preferred as it allows preservation of the socket walls, favours aesthetics and shortens treatment and only one surgical intervention. A potential disadvantage with this type of treatment modality of immediate implants could be the mismatch between the implant surface and the socket wall since dental roots do not have a regular circular shape. Therefore, gaps may be present after implantation (3). These bony gaps between implant surface and socket wall gets resolved during healing with time but the bony walls show substantial reduction in width, hence although during immediate implant placement there is early hard tissue fill of the marginal defect, but this newly formed marginal bone may in part be lost (4). To address these potential problems, implant manufacturers have designed fixtures having various tapered shapes with different length and diameters for use with sockets of varying dimensions (5). Bone width availability as measured at the crest is the

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JCHR (2025) 15(3), 2140-2145 | ISSN:2251-6727

distance between the buccal and the lingual plates (6). The increase in length of implants helps in more engagement of bone wall and thereby enhances the primary stability. For every 1 mm increase in diameter results in 20% to 30% increase in the surface area, thereby effectively increasing diameter results in decreasing the crestal stress. Hence it's the diameter of the implant rather than length which plays a very critical role for success (7). Literature reports high success rates under various loading conditions with the use of ultra-wide dental implants for immediate placement (8,9).

A study by Ferrus J. et al reported that the wider the buccal bone, the more pronounced the fill of the buccal void (median 100% gap fill) and less vertical resorption in sockets with thicker buccal crest (10). Another finite element study by Xi Ding et al. revealed reduction of stress and strain on crestal bone following increasing the diameter and length of implants more significantly than the diameter (11). The use of regular diameter implants has been vastly investigated and reported in the literature, but the significance and influence of use of different diameter implants and ultra-wide diameter on the cortical bone and implant survival and prognosis is little known. However, limited information is available on the hard and soft tissue alterations around immediately placed molar implants. A multidimensional assessment of the available osseous tissue is necessary for optimal treatment planning to ensure longevity and function of implant supported prosthesis (12).

The objective of this study was to evaluate the Periodontal bone thickness (Bucco-lingual, Mesio-distal and Apical) and to elucidate the precise correlations between bone quality and quantity with alterations in the length and diameter of immediately placed virtual molar implants.

Material and Methods: The institutional ethics committee approved this cross-sectional descriptive study. For diagnostic reasons, a total of Sixty CBCT Digital Imaging and Communications in Medicine (DICOM) data were acquired from Digital Library of College of Dentistry, Buraidah. In determining the sample size, the previously reported 83% mean agreement was taken into account, with a 95% significance level and 80% two-tailed test power(13,14). A total of nine groups with 60 molar sites were identified for each group analysis(Table 1). The following conditions were met for a tooth to be considered for inclusion: mandibular molar teeth to be fully erupted (except for the third molar), closed root apices with a root length of 10 mm and an inter-root apex distance of 3 to 7 mm and every tooth to be in a normal position(15). The following conditions were excluded: mandibular tooth crowding or ectopic eruption, periapical radiolucency, periodontal disease, or any other pathology; and incomplete or hazy pictures.

The first molar of the mandible was aligned in all three planes of the DICOM image software. For every group of implants, measurements of the Bucco-lingual cortical bone distance, mesio-distal interdental bone distance and apical bone thickness were made in the sagittal and cross section views (Table 1). The purpose of the study was concealed from the certified observers when taking bone measurements. Prior to the start of the image evaluation and training sessions, there was a calibration session. The cases were debated until an agreement was reached despite disagreements. 25% (15 CBCT pictures) of the sample were chosen at random and reanalysed by two observers using the Intraclass Correlation Coefficient to test inter- and intra-observer reliability.

Table 1: Implant groups with dimension measurement criteria incorporated

Group	Implant dimensions*	Measurements included
D1-L1	4.7 D – 8.5 L	Mesial Interdental Gap Defect at Crest (M1)
D1-L2	4.7 D – 11.5 L	Mesial Interdental Gap Defect at Tip (M2)
D1- L3	4.7 D – 13.5 L	Distal Interdental Gap Defect at Crest (D1)
D2- L1	5.8 D – 8.5 L	Distal Interdental Gap Defect at Tip (D2)
D2-L2	5.8 D – 11.5 L	Buccal Cortical Bone Thickness at Crest (B1)
D2-L3	5.8 D – 13.5L	Buccal Cortical Bone Thickness at Tip (B2)

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JCHR (2025) 15(3), 2140-2145 | ISSN:2251-6727

D3-L1	7 D – 8.5 L	Lingual Cortical Bone Thickness at Crest (L1)
D3-L2	7 D – 11.5 L	Lingual Cortical Bone Thickness at Tip (L2)
D3-L3	7 D – 13.5 L	Implant tip - Inferior Alveolar Nerve Level (IAN)
		Apical 4 wall Bone Support for Implant (AB)

*(D = Diameter, L= Length)

The SPSS v. 11.5 program (SPSS Inc., Chicago, IL, USA) was used to enter all the parameter data (mean and standard deviation) analysis descriptive statistics. To do a comparison analysis between the groups, one-way analysis of variance was followed by a Post hoc Tukey test, with $P < 0.05$ being deemed statistically significant.

Results:

As seen in "Table 2" of the results, Mesial Interdental Gap Defect at Crest (M1) for standard diameter (D1-L1, D1-L2, D1-L3) was 2.30 ± 0.64 mm. For wide diameter implant (D2- L1, D2-L2, D2-L3) it was 1.50 ± 0.59 mm and for ultra-wide Implants (D3-L1, D3-L2, D3-L3) it was 1.20 ± 0.51 mm. Distal Interdental Gap Defect at Crest (D1) was 2.25±0.43, 1.55 ± 0.50, 1.10 ±0.59 mm respectively standard, wide and ultra-wide diameter implants. The result is statistically significant between standard with wide and ultra-wide groups ($p< 0.00$) in mesial and distal interdental bone at the crest. However, the results between wide and ultra-wide implants were not statistically significant.

Table 2: Measurements (Mean and Standard Deviation) of Periodontal Bone support around implant groups.

	M1	M2	D1	D2	B1	B2	L1	L2	IAN	AB
D1-L1	2.25±0.63	2.40±0.67	2.25±0.43	2.90±0.77	2.35±0.48	3.20±0.75	2.10±0.4	3.60±0.9	10.10±2.1	-4.25±1.62
D1-L2	2.30±0.64	1.80±0.88	2.25±0.43	2.45±1.2	2.35±0.48	3.55±074	2.10±0.4	3.40±0.9	7.20±2.06	-1.10 ±1.56
D1-L3	2.30±0.64	0.75±0.89	2.25±0.43	1.40±1.85	2.30±0.79	3.85±0.86	2.15±0.3	2.85±0.8	5.15±2.03	1.45 ±1.37
D2-L1	1.45±0.59	1.90±0.54	1.55±0.50	2.25±0.77	2.00±0.45	2.65±0.66	1.80±0.6	3.40±1.0	10.10±2.1	-3.90 ±2.30
D2-L2	1.50±0.59	1.40±0.81	1.55±0.50	1.90±1.25	2.00±0.45	3.20±0.93	1.70±0.4	2.90±1.0	7.20±2.01	-1.00 ±1.43
D2-L3	1.50±0.59	0.35±0.73	1.55±0.50	1.00±1.32	1.95±0.50	3.30±0.96	1.70±0.4	2.40±1.0	5.00±2.02	1.95 ±2.23
D3-L1	1.20±0.51	1.30±0.64	1.05±0.59	1.45±0.74	1.30±0.56	2.15±0.73	1.30±0.5	2.55±1.0	10.05±2.1	-4.00 ±2.33
D3-L2	1.20±0.51	0.75±0.95	1.10±0.54	1.65±1.12	1.30±0.56	2.55±081	1.30±0.5	2.40±0.9	7.20±2.11	-.90 ±1.35
D3-L3	1.20±0.51	0.10±0.78	1.05±0.59	1.70±1.01	0.35±0.58	2.55±0.81	1.25±0.5	1.95±0.9	5.00±2.02	1.35± 1.67

Mesial Interdental Gap Defect at Tip (M2) varied according to the change in diameter and length of the implant where D1-L1 showed 2.4±0.67mm, D1-L2 showed 1.8 ± 0.88mm, D3-L3 had 0.75±0.89mm proximity to the interdental bone. Similarly, Wide and ultra-wide showed the same pattern mesially and distally (Table 2) except for, ultra-wide-longer (D3-L3) is -0.10±0.77mm proximity to the interdental bone mesially.

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JCHR (2025) 15(3), 2140-2145 | ISSN:2251-6727

The minus sign indicates implant tip engaging the interdental bone with no gap defect between implant and bone.

For Buccal Cortical Bone Thickness at Crest (B1), the standard diameter implant showed 2.35±0.48mm, wide diameter showed 2.00±0.45mm and ultra-wide showed 1.35±0.58mm proximity to the cortical bone respectively. On the lingual side (L1) the standard diameter implant showed 2.1±0.44 mm, wide diameter showed 1.70±0.46mm and ultra-wide showed 1.3±0.56mm proximity to the cortical bone respectively. Similarly, the Cortical Bone Thickness at Tip of implant, both in the buccal and lingual aspect (B2 and L2) proximity to the buccal cortical plate varied according to the change in diameter and length of the implant with ultra-wide and longer implants showing more closeness to the cortical plates buccally and lingually (Table 2) indicating chances of perforation if angulation is not defined. Mean measurements of distance from implant tip to the inferior alveolar nerve showed, regular length implant (L1) was 10.10±2,14 mm, long implant (L2) was 7.20 ±2.06 mm and for L3 implants was 5.15 ± 2.01 mm from the inferior alveolar nerve respectively. Results for apical bone anchorage (AB) revealed the longer implants (L3) had greater 4-wall bone support (D1-L3 1.45 ±1.37, D2-L3 1.95 ±2.23, D3-L3 1.35± 1.67) as compared to 8.5mm (L1) and 11.5 mm(L2) lengths (Table 2), indicating longer the length, significant apical bone support.

Discussion: In this study we assessed the stability and dimensions of implant on radiographic condition. The changes in diameter and length and its effect on implant anchorage. Our study showed that increasing the implant length enhances the apical four wall bone support especially in teeth with divergent roots. These findings are like the results of Ueno et al(16), where they mentioned longer implants enhanced 40-50% more osseointegration as compared to shorter implants. Esposito M et al(17) suggested that implants placed minimum 3mm apical to root tips enhanced the apical bone anchorage and hence apical primary stability. Increasing the length of implant also favours increasing the surface area of implant to bone osseointegration, Bone to implant contact (BIC) and crown to implant ratio as compared to shorter implants(18,19). Findings of Bateineh (2017) and Silva R (2020) showed longer implants are indicated in compromised Bone quality to achieve better implant stability(20,21). According to our results, while increasing the implant length, the clinicians also must take precautions with complications of lingual plate perforations, haemorrhage and invasion of anatomic vital structures. Gaudio et al in their case reports (22) stated the potential risk of profuse lingual hematoma and lingual plate perforation with longer implants in mandibular anterior region.

In our study, as the diameter of implants increased, the buccal and lingual bone anchorage increased as well the gap defect mesially and distally decreased. Ultra-wide implants showed highest periodontal bone anchorage since both mesially and distally implant engaged interdental bone for its support and thus, these implants did not require any bone grafts to fill the defects around them(23–25).

In this study longer and wide implants gained best results in terms of bone support apically, Bucco-lingually, and Mesio-distally with most prudent anchorage for immediate molar implants(26). These findings were previously supported by many authors for increasing primary stability of immediate molar implants(17,27,28).

In our study virtual implant were places where, the post-surgical bone loss during healing of implant-bone interface was not considered. To overcome these limitations, long term clinical trials will help getting actual bone support post implant placement.

Conclusion: The current study's findings suggest using wider and longer implants in immediate molar placement in order to maximize periodontal bone anchoring on all surfaces and reduce the need for adjuvant bone grafting techniques. Simultaneously, in cases where there is insufficient bone height and width, case selection plays a critical role in minimizing post-operative difficulties for longer and wider implants.

Funding: Present study was self-funded. No external funding was taken.

Conflict of Interest: There is no Conflict of interest between the authors.

Regulatory Statement

This study was conducted as per the STROBE guidelines for experimental studies. For analyzing the retrospective patient data, institutional ethical approval was obtained from IRB of College of Dentistry in Alrass, Qassim University (DRC/008FA/20).

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JCHR (2025) 15(3), 2140-2145 | ISSN:2251-6727

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