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IMMEDIATE IMPLANT PLACEMENT IN THE MANDIBULAR POSTERIOR REGION COMBINED WITH RIDGE PRESERVATION AND SOCKET SEALING WITH CUSTOM HEALING ABUTMENTS AND DELAYED LOADING PROTOCOL. A RADIOGRAPHIC EVALUATION OF VERTICAL AND HORIZONTAL ALVEOLAR BONE CHANGES

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ABSTRACT

This study aimed to evaluate vertical and horizontal alveolar bone changes after immediate implant placement in the mandibular posterior region combined with ridge preservation and socket sealing with custom healing abutments. **Material and methods:** eighteen immediately placed implants were inserted in sockets of mandibular molar and the space around the implants was filled with Allograft bone material. Socket was sealed with custom healing abutment. Radiographic evaluation of vertical and horizontal alveolar bone changes were performed on CBCT images taken immediately after implant placement (T0), six months (T6) and 12 months (T12). The following distances were measured around the four implants surfaces; 1) P-BIC; from implant platform to the first bone contact, 2) P-T; vertical distance between implant platform and alveolar bone crest, 3) OBS; from buccal and lingual border of bone to the implant surface at the level of the implant platform (OBS0), 2 mm (OBS2), and 4 mm (OBS4) apical to implant platform.

Results: The highest bone loss at P-BIC and P-T distances was noted with distal surface, followed by mesial surface, the lowest was noted was buccal/lingual surfaces. At T6 and T12, Buccal surface recorded significant higher OBS0 bone loss than lingual surface.

Conclusion: Immediate implant placement in the mandibular posterior region combined with ridge preservation and socket sealing with custom healing abutments and delayed loading protocol is a successful treatment and associated with acceptable vertical and horizontal bone loss around implants after one year follow-up.

KEYWORDS: Immediate placement, ridge preservation, socket sealing, custom healing abutment

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INTRODUCTION

The restoration of badly destructed molars with dental implants is a common dental practice with high implant success rate[1]. There is a consensus in the literature that immediate implant placement in extraction sockets in molar region provide several advantages such as reduced treatment time, decreased surgical trauma and preservation of remaining bone[2]. Such treatment proved a high (96.6%7) implant survival rate[3]. It has been reported that ridge preservation with the use of bone grafting biomaterials can minimize bone resorption after extraction and can preserve the contour of the alveolar ridge[4]. Consequently, the combination of implant placement in extraction sockets with alveolar ridge preservation techniques is recommended[2].

To preserve bone and maintain soft tissue contour, atraumatic tooth extraction without raising flap, immediate implant placement, socket grafting, then connection of provisional restoration is recommended[5, 6]. After extraction of molars, large sockets usually develop which need adequate closure of the wound. This may be achieved by buccal releasing flaps. Conversely, the flapless approach is recommended due to reduction of surgical trauma[7]. The socket closure may be performed by bone augmentation material and wide healing abutment. However, optimum emergence profile can be achieved by custom healing abutment that mimic natural gingival contour without elevating flap[8]

It should be noted that immediate loading is not usually performed in the posterior region for several reasons. Firstly, aesthetics is not critical as in anterior region[9].

Secondly, the increased forces of mastication and molar area may discourage the dentists of performing immediate loading to avoid loss of osseointegration[10]. Thirdly, at least 35 Ncm insertion torque is needed to achieve adequate primary stability required for immediate loading which may not be achieved due to limited amount of bone remaining for implant anchorage after tooth extraction[11, 12]. Consequently, delayed loading is usually recommended[13, 14]

Immediate implant placement with bone grafting procedures in the molar region is less critical than aesthetic zone due to thick buccal bone of the socket which reduce the ridge alterations[15, 16]. However, such treatment needs special precautions to fill the large gap between the implant and the socket walls and to ensure adequate primary closure of the socket[17]. To address this issue, several studies advocated the use of custom healing abutment to close large gap after immediate implant placement in extraction sockets and to maintain the contour of the gingival tissues[9, 18-20]. Custom healing abutment can protect the alveolar bone during the healing, maintain the alveolar bone contour, reduce food impaction, protection of bone grafting material, and eliminates the need of second surgery and provisional restoration[9]

The use of customized chairside fabricated healing abutments after tooth extraction to seal the socket was introduced by Finelle et al.[18] to protect the bone graft material and prevent contact of this material to the oral cavity. This approach achieved 100% implant survival rate with a stable soft tissue contour after two years[19]. However, the fabrication of customized healing abutment was made either by injecting flowable composite resin around the ti-base abutments or by CAD/CAM fabrication[19]. The injection of flowable composite resin over the surgical wound may contaminate the bone grafting material. Also, is difficult to control the flow of the resin which come into contact with blood. Moreover, needs further finishing and polishing which may increase chairside time. Furthermore, the presence of blood in the surgical field may affect bonding to ti-base abutments. On the other hand, the CAD/CAM fabrication involves additional steps and costs. Another approach is the use of prefabricated metrics[21]. More recently, several implant manufactures introduced automatic profile generator which is a 3D printed silicone index that can be used to make custom healing abutments of different sizes and emergence profiles corresponding to each extracted tooth.

Reviewing the literature, there is a limited number of studies concerned with the evaluation of vertical and horizontal alveolar bone changes after placement of custom healing abutments for immediate implant placement in extraction socket[3,9]. Moreover, the radiographic evaluation of the automatic profile generator custom healing abutments on alveolar bone height changes was not a concern. Accordingly, this prospective study aimed to evaluate vertical and horizontal alveolar bone changes after immediate implant placement in the mandibular posterior region combined with ridge preservation and socket sealing with custom healing abutments (automatic profile generator).

MATERIALS AND METHODS

Patient cohort

Ten patients (5 males and 5 females, mean age 40±12.9 years) were selected for this study from the patients attending the outpatient clinic of the Oral surgery Department, Faculty of Dentistry Mansoura University to receive eighteen immediately placed implants inserted in the sockets of mandibular molars. The inclusion criteria are 1) minimal age of 20 years, 2) badly decayed or hopeless mandibular molars (first molars or second molars or both) due to caries, fracture, periapical lesion, or failure of endodontic treatment, 3) adequate amount of remaining apical bone after extraction to achieve primary stability of the implants, 4) sufficient mesiodistal and interocclusal space for implant restoration. The exclusion criteria are 1) any systemic disease that compromise implant placement or implant osseointegration, 2) acute periapical or periodontal infections, 3) Any bone fenestrations or dehiscence in the socket, 4) smokers, and 4) pregnancy.

All participants were informed about the treatment protocol and objectives before obtaining informed consents. The study was conducted according to the ethical principles stated in Helsinki declaration. The protocol of the study was reviewed and approved by Dental Research Ethics Committee, Faculty of Dentistry, Mansoura University with an approval serial number (A15061222).

Surgical and prosthetic protocol

For all participants, preoperative cone beam computerized tomography (CBCT) was performed for teeth to be removed to evaluate amount of remaining bone and detect the periapical lesions (fig 1).

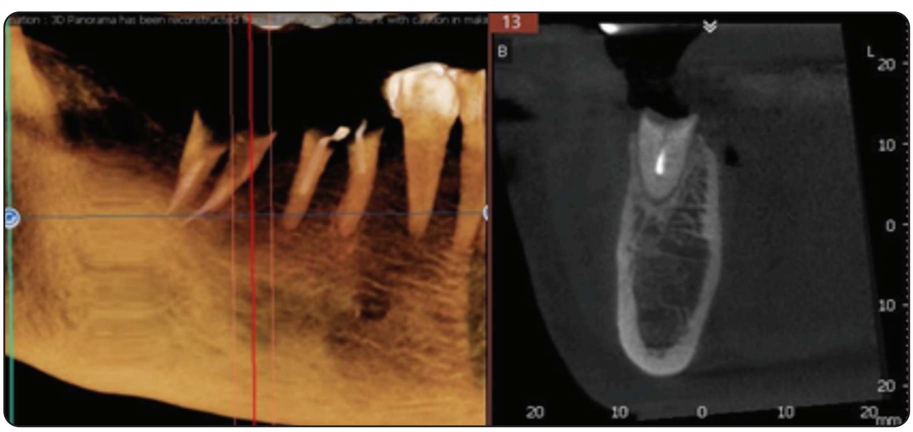

Fig. (1) Preoperative CBCT.

Local nerve block anesthesia (4% articaine with adrenaline 1:100000, UbistesinTM, 3M ESPE) was administered for each participant. A flapless atraumatic extraction procedures were performed. Mandibular molars were sectioned using with a high-speed surgical bur, then adequate periotomes were used to separate the gingival tissues from the teeth. Adequate elevators were used to remove the roots separately with great care to avoid damage to buccal and lingual bone plates[22](fig 2a). Adequate curettage and irrigation of the socket was performed to remove any granulation tissues. The initial (pointed) drill was used to make a hole (starting point) in the interradicular bone to avoid slippage of the subsequent the drills in the socket of the remaining roots. The drills of increasing diameters were used to complete the implant osteotomy according to manufacturer instructions. In case of limited interradicular bone volume, drilling was made at the socket of mesial or distal roots. Implants with platform switch (Dentium, South Korea) of adequate diameter (4, 4.5, or 5mm) and length (selected using preoperative CBCT) were inserted in the prepared osteotomies to engage the bone apical to the socket with at least 35 Ncm insertion torque (to gain adequate primary stability). The implant platform was leveled 3mm apical to the buccal gingival margin[7] (fig 2b). The gaps of the socket around the implants were filled with allogenic mineralized cortical bone grafting material (0.5-1mm particle size, Lyoplast, Russia) to preserve the ridge from resorption[23] (fig 2c).

After implant placement, custom healing abutment was fabricated using readymade automatic profile generator (3D printed silicone index, Neobiotech, South Korea) (fig 3). The generator contains several sizes of emergence profiles with different positions of implant platforms. The conventional straight abutment (Dentium South Korea) was inserted into the whole of the generator of adequate size, and the space around the abutments was filled with flowable composite resin. The abutment was removed and screwed to the implant to seal the grafted socket without sutures (fig 4a). The same oral and maxillofacial surgeon performed all surgical procedures. Postoperative medications include; chlorhexidine 0.12% mouthwash twice/day for one week, antibiotics (amoxicillin 1 g twice/day for one week). Anti-inflammatory medications

(Alphintern) and analgesics (Ketolac 10mg) were prescribed 3 times daily for 7 days post surgically. Patients were instructed to use soft diet and perform adequate oral hygiene. Three months later after osseointegration and gingival healing (fig 4b), Open tray impression was made on the implant level, and fixed screw retained monolithic Zirconia crown bonded on the straight abutments.

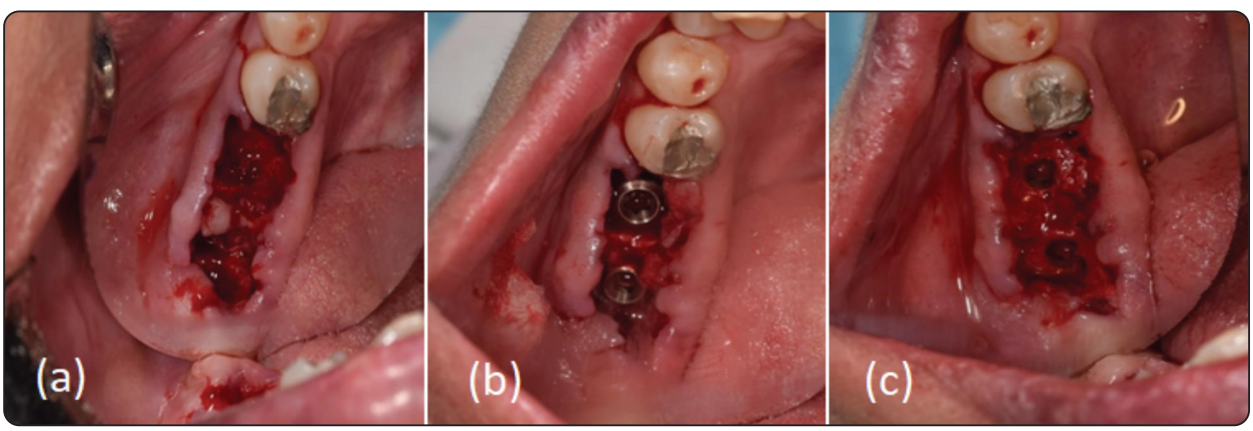

Fig. (2) Surgical procedures; a; atraumatic teeth extraction, b; implant insertion, c) application of bone grafting material around the implants

Fig. (3) Fabrication of custom healing abutment

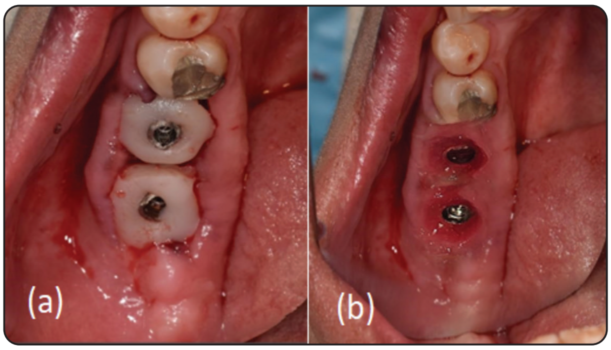

Fig. (4) Custom healing abutment in patient mouth; a) Fixation of custom healing abutment to implant fixtures, b) gingival healing and emergence profile before impression making.

Radiographic evaluation of vertical and horizontal alveolar bone changes

Radiographic evaluation of vertical and horizontal alveolar bone changes were performed on cone-beam computed tomography (CBCT, i-CAT device; Imaging

Sciences Intl) images taken immediately after implant placement (T0) and six months (T6) and 12 months (T12) later[7]. Scan parameters were standardized to deliver low radiation dose (5 mA, 120 kV, voxel size of 0.30 mm, the acquisition time of 4.8 seconds, a field of view =6 cm high × 8 cm wide). Using the accompanying software (On-Demand), all measurements were performed by the same dentist who was familiar with On-Demand software using the following landmarks (fig 5): implant platform (P), first bone to implant contact (BIC), alveolar bone crest (T), outer border of the bone (OB), and the surface of implant (S). The following distances were measured; 1) PBIC; the distance from implant platform to the first bone contact (Vertical bone height changes), 2) P-T; the vertical distance between implant platform and the alveolar bone crest (positive value indicates that alveolar bone crest is coronal to the implant platform, while negative value indicates that the crest is apical to the platform), 3) OBS; distance from buccal and lingual border of the bone to the implant surface at the level of the implant platform (OBS0), 2 mm (OBS2), and 4 mm (OBS4) apical to implant platform (horizontal bone height changes). P-IBC, and P-T were measured at buccal, lingual, mesial and distal surfaces of each implant. OBS were measured at buccal, and lingual surfaces only. To detect vertical and horizontal bone loss, the distances measured at T6 and T12 were subtracted from distances measured at T0.

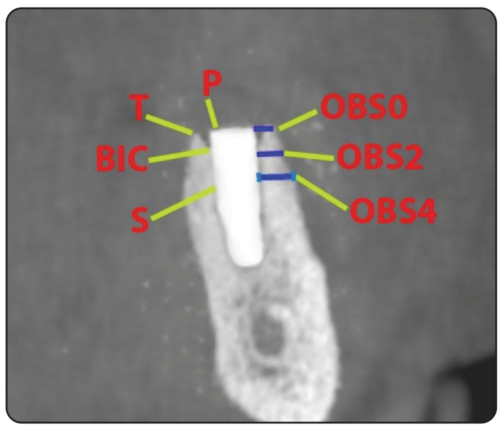

Fig. (5) Measurement of vertical and horizonal alveolar bone changes on the crosssectional images of the CBCT.

Statistical analysis

The SPSS software version 22 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Shapiro Wilk Test of normality was used to determine normal distribution of collected data. Descriptive statistics of bone loss values was presented as mean± standard deviation. The data was parametric and met the normal distribution. One-way analysis of variance (one-way ANOVA) was used to compare distances between implant surfaces (buccal, lingual, mesial and distal surfaces) followed by Tukey test for pairwise comparisons, while paired samples t-test was used to compare distances between T12 and T6. The significance level was set at p<.05.

RESULTS

A total of 18 implants are inserted in 10 patients. The implant survival rate was 100% and no implant failures occurred. The periimplant soft tissue show adequate signs of healing with good emergence profile without signs of inflammation or infection. All patients attended the follow-up visits without dropouts due to the short evaluation period.

Comparison of P-BIC distance (the distance from implant platform to first bone to implant contact) between implant surfaces and between observation times is demonstrated in table 1. At T6 and T12, there was a significant difference in P-BIC bone loss between the implant surfaces. The highest bone loss at P-BIC distance was noted with distal surface, followed by mesial surface, then buccal surface and the lowest was noted was lingual surface. There was no significant difference in P-BIC bone loss between mesial and distal surface or between buccal and lingual surface. For all implant surfaces P-BIC bone loss at T12 was significantly greater than P-BIC bone loss at T6.

Comparison of P-T distance (the distance from implant platform to alveolar bone crest) between implant surfaces and between observation times is demonstrated in table 2. At T6 and T12, there was a significant difference in P-T bone loss between the implant surfaces. The highest bone loss at P-BIC distance was noted with distal surface, followed by mesial surface, then lingual surface and the lowest was noted was buccal surface. There was no significant difference in P-BIC bone loss between mesial and distal surface or between buccal and lingual surface. For all implant surfaces P-T bone loss at T12 was significantly greater than P-T bone loss at T6.

TABLE (1) Comparison of P-BIC distance between implant surfaces and between observation times

	T6 X±SD	T12 X±SD	Paired samples t-test
Mesial	.70±.10a	1.05±.20a	.001*
Distal	.82±.12a	1.15±.22a	.002*
Buccal	.19±.03b	.30±.03b	.032*
Lingual	.15±.04b	.25±.07b	.022*
One Way ANOVA	.012*	.010*	

X; mean, SD; standard deviation. * p is significant at 5%. Different letters in the same column indicate significant difference between each 2 implant surfaces (Tukey, p<.05), while the same letters indicate no difference.

TABLE (2) Comparison of P-T distance between implant surfaces and between observation times

	T6 X±SD	T12 X±SD	Paired samples t-test
Mesial	1.82±.63a	2.11±.66a	.011*
Distal	1.90±.71a	2.23±.78a	.019*
Buccal	1.41±.50b	1.78±.54b	.022*
Lingual	1.50±.52b	1.89±.53b	.032*
One Way ANOVA	.038*	.029*	

X; mean, SD; standard deviation. * p is significant at 5%. Different letters in the same column indicate significant difference between each 2 implant surfaces (Tukey, p<.05), while the same letters indicate no difference.

Comparison of OBS bone changes (the distance from outer cortex to implant surface) at level of platform (OBS0), 2 mm below the platform (OBS2), and 4mm below the platform (OBS4) between implant surfaces and between observation times is demonstrated in table 3. At T6 and T12, there was a significant difference in OBS0 bone loss between buccal and lingual surfaces. Buccal surface recorded significant higher OBS0 bone loss then lingual surface. At T6 and T12, there was no significant difference in OBS2 or OBS4 between buccal and lingual implant surfaces. For buccal and lingual surfaces, OBS0, OBS2, and OBS4 bone loss at T12 was significantly greater than OBS0, OBS2, and OBS4 bone loss at T6.

TABLE (3) Comparison of OBS distance between implant surfaces and between observation times

	T6 X±SD	T12 X±SD	Paired samples t-test
OBS0			
Buccal	.52±.22	.83±.35	.023*
Lingual	.23±.18	.45±.23	.036*
Independent t-test	.033*	.002*	
OBS2			
Buccal	.16±.07	.28±.10	.001*
Lingual	-.18±.08	-.25±.09	.004*
Independent t-test	.125	.237	
OBS4			
Buccal	.11±.04	.17±.08	.022*
Lingual	-.12±.05	-.19±.07	.029*
Independent t-test	.351	.098	

X; mean, SD; standard deviation. * p is significant at 5%. Different letters in the same column indicate significant difference between each 2 implant surfaces (Tukey, p<.05), while the same letters indicate no difference. Negative values indicated bone gain

DISCUSSION

In a systematic review, the authors concluded that implant success criteria should include creation of natural looking soft tissue contour around the implant[24]. This can be performed by using adequately manufactured custom healing abutment. Hu, et al. recommended that healing abutment should have highly polished and smooth surface and the reduced manufacturing time[7]

In this study, the use of automatic profile generator (3D printed silicone index) for fabrication of custom healing abutments provides several advantages. Firstly, can be performed chairside at time of extraction by using either flowable composite or PMMA material quickly and efficiently, therefore it saves time. Secondly, it produces smooth gingival surface of healing abutment due to contact of the resin material to the smooth surface of the silicone index. Thirdly, it is fabricated outside patient mouth out of the surgical field. Consequently, it minimizes contamination of the bone grafting material, and prevent the contact of blood to the abutment which may affect the bonding capacity of the resin to the abutment. Fourthly, it is available in different sizes and emergence profiles which accommodate the position of the implant (in the center of abutment or in the mesial or distal portion of the abutment). Therefore, the clinician can easily choose the size of the abutment that corresponded to the desired emergence profiles. Moreover, it minimizes several steps, save time and cost compared to CAD/CAM designed abutments which is usually fabricated from expensive material (for example PEEK) and needs to be prepared in the laboratory before surgical appointment.

We used CBCT for monitoring vertical and horizontal alveolar bone changes as it allows visualization of buccal and lingual bone changes and provide a third dimension that cannot be obtained by the conventional periapical radiographs [25, 26]. To minimize the effect of radiation dose on the patient, the field of view was limited to the extracted teeth only, and scanning the parameters were adjusted to minimize the effect of radiation dose. The use of CBCT in monitoring alveolar bone changes around the implants was advocated in several studies[7,22,27,28]. One year follow-up was used as it has been reported that most of bone remodeling occurred around immediately placed implants happened with the first year after implant insertion and no extensive bone loss occurred thereafter[3].

At all implant surfaces, vertical bone loss (P-BIC) did not exceed 1.2mm in the first year. This value was located within the normal range of bone resorption that is reported in the literature[29-32]. Similarly, in a retrospective study[3], the authors reported stable vertical bone loss at all investigated implant surfaces following immediate implant placement in extraction sockets and replacement of socket sealing abutments. Also, Cheng et al.[33] demonstrated a stable vertical bone dimension for immediate implant in posterior region when combined with bone grafting (deproteinized bovine bone mineral). This could be attributed to the overfilling of the socket by bone grafting material which also fill the gap distance around the implant and allow it to properly osteointegrate[34]. Moreover, the minimal invasive tooth extraction by using flapless approach without reflecting the flap reduced trauma to mucoperiosteum and reduce bone loss[3]. Additionally, the closure of the socket by custom healing abutment reduces contamination of bone graft, reduce infection exposures to microbiota in the oral cavity, provide adequate support for gingival tissue and consequently reduce bone loss[35]. It worthy mentioned that the smooth gingival surface of the custom abutment facilitate healing, reduce bacteria colonization and reduce bone loss as it has been reported that irregularities and roughness of the healing abutments allows bacteria to survive longer because they can be protected from removal forces or oral hygiene measures[36]. Furthermore, the use of implant design with platform switch provides better stability of marginal bone and minimize vertical bone resorption[37]

The highest bone loss at P-BIC and P-T distances was noted with distal surface, followed by mesial surface, the lowest was noted was buccal/lingual surfaces. In line with this observation, Hu et al.[7] reported reduced bone loss at P-BIC and P-T distances at buccal and lingual implant surfaces compared to mesial and distal surfaces. This could be attributed to the thick buccal and lingual bone which behaves as a protecting "bone shield" [3] and the large gap distance between the socket walls and the implant. The large gap distance facilitates filling of the socket by new bone compared to the thin gap at mesial and distal sites which may reduce bone loss[38, 39]. In line with this explanation, reported that the bone thickness and the gap size are considered critical factors that affect ridge alteration after immediate placement into extraction sockets[15]. On the other hand, the minimal thickness of bone at mesial and distal aspects enhanced bone remodeling and bone resorption at these areas. Additionally, the traumatic manipulations of mesial and distal areas during the tooth extraction by application of dental elevators may increase bone remodeling[40]. The increased vertical bone loss at mesial and distal aspects was in line with the results of another study[7] in which the authors attributed the increased bone loss to the poor marginal adaptation of the gingival tissue to the abutments at these areas which may increase leakage of bone grafting material, and bacterial leakage from saliva that might hinder osteogenesis[41]

At T6 and T12, Buccal surface recorded significant higher OBS0 bone loss than lingual surface. A similar finding was noted in another study[7] in which the authors reported that buccal bone recorded significant (25%) reduction of horizontal bone at the level of implant platform than lingual aspect which showed only 14% reduction. Also, Alexopoulou et al. [3] reported 1.25±2.21 mm horizontal bone loss in the most cervical portion of molar areas which was greater in maxillary implant sites when compared to mandibular sites. Similarly, Tallarico et al. [42] found significant horizontal bone loss at the most cervical region (at level of implant platform) and implant was immediately placed in extraction socket combined with rigid preservation using a bone grafting material in the posterior areas. In our study, bone formation was noted in the lingual aspects (denoted by negative sign). This observation also similar to the finding of Hu et al. [7] and it may be attributed to the newly formed bone by effect of grafting material.

There was no significant difference in OBS2 or OBS4 between buccal and lingual implant surfaces. In line with this observation, another study[3] reported stable periimplant bone below the level of the implant platform and denoted significant horizontal bone loss in the most coronal portion (at the level of the implant platform). In contrast to this finding, other studies found horizontal bone loss after immediate implant placement in extraction socket[33,42]. The limited horizontal bone loss observed in this study and even new bone formation on the lingual aspects may be attributed to the use of custom healing abutment which is supposed periimplant soft tissue[3], enhance guided bone regeneration[43] provides a mechanical closure of the socket, provides an undisturbed environment, for new bone formation without exposure to oral environment[3].

For all implant surfaces P-BIC, P-T, OBS0, OBS2, and OBS4 bone loss at T12 was significantly greater than P-BIC, P-T, OBS0, OBS2, and OBS4 bone loss at T6. The increased vertical and horizontal bone loss at T12 compared to T6 in could be attributed to the bone response to healing, reorganization and increased stresses caused by the implant loading[44]. Similarly, several studies showed increased bone loss after extraction and immediate implant placement from baseline to 12 months after implant insertion[45,46].

From the results of this study, it could be summarized that the use of a custom healing abutment for immediate implant placement in extraction sockets combined with rigid preservation using bone grafting material did not jeopardize the bone healing and can limit bone remodeling after extraction. However, the limitations of this study includes; the small patient sample, the lack of control group which include conventional healing abutment, and the presence of metal artifacts from the titanium of the implant body which may affect the accuracy of measurements in the CBCT images[27]. Consequently, future randomized controlled clinical trials with sufficient sample size are recommended to compare bone changes between custom healing abutments and conventional healing abutments.

CONCLUSION

Immediate implant placement in the mandibular posterior region combined with ridge preservation and socket sealing with custom healing abutments is a successful treatment and associated with acceptable vertical and horizontal bone loss around implants after one year follow-up.

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