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Evaluation of Alveolar Bone Loss under Immediate Dentures Fabricated with Spatial Modelling Technique - A Descriptive Study

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ABSTRACT

Objective: The objective of this study was to assess the height and width of alveolar bone, before and after insertion of immediate dentures fabricated via the Spatial Modeling Technique, for patients destined for implant prostheses. **Study Design:** Prospective observational study with a pre-post intervention analysis. **Settings:** Department of Prosthodontics, Institute of Dentistry, CMH Lahore Medical College, Lahore Pakistan. **Duration:** Six months from January 01, 2021 to June 30, 2021. **Methods:** On a sample of 240 subjects, alveolar bone height and width were evaluated via CBCTs as per specified landmarks. Immediate dentures were fabricated via the Spatial Modeling cast modification technique, teeth were extracted, and dentures were inserted in subjects. 3 months post extraction, alveolar bone height, and width were evaluated via CBCT on the same landmarks. Mean loss of alveolar bone was noted. **Results:** The mean change in height pre and post-extraction was 0.13 ± 0.14. The mean change in width was 2.95 ±1.24. **Conclusion:** Functional stimulation and protection provided by immediate dentures may result in improved preservation of alveolar bone as compared to bone healing without immediate dentures. Conservative cast modification technique for fabrication of immediate dentures may lead to decreased post-extraction alveolar bone loss in height and width. Increased conservation in labial and lingual reduction in the Spatial Modelling technique may further reduce alveolar bone loss. The selection of a flangeless design of immediate dentures may further preserve alveolar bone width. **Clinical Relevance:** This study may help in the treatment planning of patients who desire future implants. It may also help in the objective selection of cast modification techniques for patients desiring immediate replacement of teeth.

Keywords: *Immediate dentures, Tooth extraction, Cone beam computed tomography.*

INTRODUCTION

Tooth extraction leads to loss in height and width of alveolar bone with an average rate of 0.5–1.0% per year.[1,2] Alveolar bone loss during the first 12 months post-extraction may result in 11 - 22% of loss in height and 29 - 63% of loss in width, whereas approximately two-thirds of the ridge is lost during the first 3 months after tooth extraction.[2,3,4] Loss of a tooth also results in disuse atrophy due to lack of stimulation and natural bone remodeling.[2,3,5]

The objective of prosthodontics service is the provision of esthetics and function to an edentulous patient. An immediate denture is provided immediately after tooth extractions, and it facilitates patient adaptation to prostheses and protection of tooth sockets through clot stabilization.[6,7,8,9] A decrease in post-extraction alveolar bone resorption is reported following immediate denture placement, making it a suitable interim prosthesis in future candidates for implant prostheses.[7,8,9]

Immediate dentures can be fabricated through various techniques of cast modification, i.e., Kelly,[10] Jerbi,[11] Standard,[11] etc. Aggressive cast modification techniques may increase dimensional changes in alveolar bone post-insertion.[6,7,8,9] Extensive alveolar ridge resorption under immediate dentures is reported due to aggressive cast modification.[8] Spatial Modelling Technique with minimum cast modification is preferred.[10,11] This technique is based on estimating the dimensions of the alveolar bone and gingival sulci of natural teeth.[11]

Multiple imaging modalities are used to assess alveolar bone levels.[12,13] Two-dimensional modalities for evaluating alveolar bone height include periapical,

bitewings, and orthopantomograms.[12,13,14] Cone Beam Computed Tomography (CBCT) is the gold standard required to assess quantitative levels of bone, bone density, and bone defects with a three-dimensional view.[13,14] Use of CBCT inflicts decreased radiation to patients compared to traditional CT scans.[13,14] CBCT also provides a user-friendly 3-dimensional reconstruction of the images for both the patient and the dentist.[12,13,14,15]

Comprehensive treatment planning demands three-dimensional pre and post-insertion considerations of bone levels. Preservation of bone is now one of the foremost considerations for patients destined for extractions, whether fixed or removable replacements are planned.[7] No study has been conducted that quantitatively evaluated the alveolar bone loss occurring after specific cast modification techniques for immediate dentures. The present study aims to assess the height and width of alveolar bone levels after the insertion of immediate dentures fabricated via the Spatial Modeling Technique for patients destined for implant prostheses. This study may help in the treatment planning of patients who want to get implant replacements at a date that is distant from teeth extraction. It may also help in objectively selecting cast modification techniques for patients desiring immediate teeth replacement.

METHODS

A sample size of 240 subjects was calculated at a 95% confidence interval and 80% power of the test for this study. After obtaining ethical approval from the ethical review committee of the Institute of Dentistry, CMH Lahore Medical College, the sample was collected for 6 months. Patients desiring interim immediate dentures in the maxillary anterior segment, with implant restoration planned as a definitive restoration, were included in the study via consecutive sampling technique. The age group was 25-64 years. Patients outside this age group and with any systemic diseases such as diabetes, osteoporosis, trauma to the anterior maxillary segment, congenital cleft lip, and palate were excluded.

On the day of the patient reporting to the department, a CBCT was taken (day Zero) via the Planmeca Romexis 3d unit. Each tooth to be replaced, as per the inclusion criteria, in that patient was evaluated on the CBCT individually.

The height and width of the alveolar bone in the region of each tooth to be replaced were measured via landmarks. The landmarks for measuring the height of at mesial and distal aspects of each tooth were as follows:

Point A crest of the alveolar bone of the tooth to be extracted.

Point B marginal ridge of the adjacent tooth.

Bone height at the mesial and distal aspect of the tooth to be replaced was assessed by measuring the distance of the crest of the alveolar bone of the tooth to be extracted from the marginal ridge of the adjacent tooth.

The landmarks for measuring the width of alveolar bone at mesial and distal aspects of each tooth were as follows:

Point A = Buccal aspect of the alveolar crest at the narrowest point of bone of the tooth being assessed.

Point B = Lingual aspect of the alveolar crest at the narrowest point of bone of tooth being assessed.

The width of the bone around each tooth was assessed by measuring the distance across the bucco-lingually narrowest points of the crest of the alveolar bone of the tooth being assessed.

Three readings were taken for each tooth by two examiners at one-week intervals. An average of those three readings was taken as final measurements to eliminate inter-examiner bias.

After obtaining the day zero readings on CBCT, immediate denture fabrication was done to replace these teeth via the Spatial Modelling cast modification technique. The considered anatomic values were as follows:

Facial sulcus: 1.5mm, Biological width: 2mm, Thickness of free gingiva=1.56 mm, Thickness of attached gingiva=1.25mm

The following steps were performed in the Spatial Modelling cast modification technique:

The teeth to be extracted were removed from the cast, and facial and lingual margins were connected linearly. Two lines were drawn to guide facial reduction. The first line originated at the mesio-facial line angle, arcing to a point 2 mm lingual to the mid-facial surface and continuing to the dentofacial line angle. The second line was drawn 4mm from and parallel to the facial gingival margin. These two lines were connected with a bur. Similarly, two lines were drawn for lingual reduction. The first line started from a mesio-lingual line angle, arcing to a point 2mm facial to the mid-lingual surface and continuing to a disto-lingual line angle.

The second line was drawn 2mm from and parallel to the lingual gingival margin and connected to the first line. Sharp contours were rounded off.

After the fabrication of immediate dentures, the teeth were extracted, and immediate dentures were inserted. Another CBCT was taken 3 months after the provision of immediate dentures fabricated via Spatial Modelling Technique, using the same CBCT unit as used at day zero.

The bone's height and width at the extracted tooth's region were assessed using the same landmarks as mentioned previously. The difference between the baseline readings and those taken at 3 months was calculated which gave the net alveolar bone loss. Inter-examiner bias was again eliminated by taking an average of three readings on the CBCT images by the same two examiners who performed the day zero CBCT evaluation. The interval between each reading was one week.

For quantitative analysis, mean ± standard deviation was calculated for numerical variables like net decrease in height and width of alveolar bone. Qualitative variables like gender, systemic health status, and age groups were presented as frequency and percentage. Data was stratified for age and gender. Two age groups were defined, from 25 to 40 years and from 41 to 64 years. The net loss of alveolar bone height and width was calculated w.r.t the two age groups to analyze any significant difference in bone loss between the two groups. Net loss of alveolar bone was also calculated w.r.t to the male and female groups to analyze any significant difference between the two genders. a p-value of < 0.05 was considered significant.

RESULTS

The mean age of the participants was 35.00 ± 6.82 years, of which 92 (38.49%) were males and 147 (61.51%) were females. The mean height of bone at day zero was 17.88 ± 1.14 mm, whereas the mean height at 3 months post extraction was 17.54 ± 1.41 mm. The mean change in height was 0.13 ± 0.14. (Table 1)

The mean width of bone at day zero was 8.08 ± 1.30, whereas the mean width at 3 months post extraction was 5.13 ± 1.01 mm. The mean change in width was 2.95 ±1.24. (Table 2)

In the age group of 25-40 years, the mean change in height was 0.12 ± 0.14, and the mean change in width was 2.95 ± 1.21 mm. In the age group of 41-64 years, the mean change in height was 0.16 ± 0.13mm, and the mean change in width was 2.96 ± 1.35 mm. The mean change in height was statistically insignificant between the two age groups. The mean change in width was also statistically insignificant between the two age groups.

In male cases, the mean change in height was 0.14 ± 0.20, whereas the mean change in width was 3.72 ± 1.31 mm. In female cases, the mean change in height was 0.12 ± 0.10 mm, whereas the mean change in width was 2.48 ± 0.91 mm. There was no statistically significant change in height and width between the two gender groups.

Table: 1 Descriptive Statistics of mean height at baseline and at 3rd month (mm)

Mean height (mm)	Study group	Mean	S.D	Minimum	Maximum
At baseline (day zero)	**n=240**	17.88	1.14	13.90	20.80
At 3 months post extraction	**n=240**	17.54	1.41	13.50	20.60

Table: 2 Descriptive Statistics of mean width at baseline and at 3rd month (mm)

Mean width (mm)	Study groups	Mean	S.D	Minimum	Maximum
At baseline (day zero)	**n=240**	8.08	1.30	4.87	11.97
At 3 months post extraction	**n=240**	5.13	1.01	3.30	8.50

DISCUSSION

Post-tooth extraction, satisfactory alveolar bone volumes and architecture are essential for optimal functional and esthetic prosthetic reconstructions, particularly in the anterior region.[1,2,3,16] One of the challenges faced by reconstructive dental surgeons is to provide prosthetic restorations that harmonize with the adjacent soft and hard tissues.[1-4,16] Therefore, assessment of the alveolar bone remodeling process is vital for comprehensive treatment planning. This assessment should evaluate the vertical and horizontal dimensions of the bone since the healing of the extraction socket results in a decrease in the height and width of the alveolar bone.[1,5,6,16] This loss of alveolar bone can be quantitatively assessed by using advanced imaging technologies like Cone Beam Computed Tomography, which is the gold standard for such assessments.[12-15]

Post-extraction residual ridge resorption may be due to loss of functional stimulus.[1,2,3,16] Provision of immediate dentures to patients has been shown to result in less alveolar bone reduction as compared to patients who are provided with prostheses after initial healing of the extraction socket has taken place.[7,8,10,16,18] Immediate dentures may preserve bone volume, architecture, esthetics, phonetics, and masticatory function throughout the period of healing of the extraction sockets.[7,8,10,17,18] These dentures can be fabricated through casting modification techniques, i.e., the Jerbi, Standard, and Spatial Modeling techniques.[7-11] An initial conservative cast modification technique may lead to reduced levels of alveolar bone resorption as compared to more aggressive cast modification techniques.[17-21]

The present study evaluated dimensions of alveolar bone, 3 months post extraction, in both height and width. 3 months post extraction, the mean change in height was

0.13 ± 0.14, whereas the mean change in width was 2.95 ±1.24. There was a statistically significant greater loss in the width of the alveolar bone as compared to height. This may be due to various factors. A cortical bone bridge fills the socket's coronal portion approximately 60 days after tooth extraction, forming a continuous alveolar ridge. The periodontium of the adjacent teeth preserves the mesial and distal height of the bone to a certain extent. However, the width, i.e., buccolingual dimensions of bone, are not preserved by this mechanism and undergo significant reduction, particularly in the first few months, post-extraction, as observed in this study as well. This loss is highest in volume in the coronal portion of the bone.[1-5,17,18]

According to a study in which the width of the buccal bone in the anterior region was measured via Cone Beam Computed Tomography, the width was < 1mm and 50% of sites had a width of <0.5 mm.[23] This is also one of the reasons why loss in bone width in anterior region after tooth loss is more rapid and drastic as compared to height.[23-26] According to a meta-analysis evaluating post-extraction alveolar bone changes, 16 the mean change in height 3 months post-extraction was observed to be 0.7 mm, which is more than the loss in height observed in the present study, i.e. 0.13 mm. This difference in loss of alveolar height post-extraction may be attributed to functional stimulation provided by immediate dentures in the present study.[3,4,7-11,17,18,21]

The mean change in width in the same study was 2.03 mm 24, which is less than the loss in width observed in the current study, i.e., 2.95 mm. This increase in loss of alveolar width may be due to the bone reduction that is performed by the doctor at the time of extraction, as per the cast modification technique.[10,11,12] The Spatial modeling technique requires labial modification of almost 1 mm, extending 4 mm and 2 mm beyond the labial and lingual gingival margins, respectively.[11] This reduction, albeit more conservative than other techniques, may lead to further loss of alveolar bone width.[20-22] Therefore, it may be recommended that labial reduction in the Spatial Modeling technique be performed more conservatively to prevent increased alveolar bone loss, particularly in width.

Another factor that may cause increased alveolar bone loss in width is the presence of a labial flange in the denture.[11,20-22] In some instances, labial bone needs to be reduced to allow a labial flange to be inserted without hindrance caused by a labial undercut. This may lead to increased bone resorption with increased loss of alveolar bone width.[11,12,20,21] Also, the pressure exerted by a labial flange may cause increased bone resorption during the healing period, again leading to an increased loss in bone width.[11,12,22] Therefore, for maximum bone preservation, flangeless immediate dentures may be preferred.

In the present study, the mean age of the sample was 35.00 ± 6.82 years. Data was stratified according to age, and two age groups were formed, i.e., 25-40 years and 41-64 years. There was no statistically significant difference in the alveolar bone loss in both height and width between the two groups. It has been demonstrated that with increasing age, there may be a decrease in the rate of bone remodeling throughout the body.[6,27,29] This phenomenon is also observed to a certain degree in alveolar bone. [6,29] The degree of functional stimulus is still a major determinant affecting the rate of alveolar bone remodeling even in ages 65 and above, and adequate levels of bone mass are found in individuals in whom alveolar bone is provided with continuous mechanical stimulation.[6,27-29] In the present study, both age groups had the same alveolar resorption, which may indicate normal rates of bone remodeling being maintained even in older age groups because of the functional stimulation provided to the underlying bone by immediate dentures.

In the present study, data was also stratified according to gender. Before menopause, the patterns and rate of bone modeling and remodeling are similar in both males and females.[6,29,30] After menopause, estrogen deficiency in females results in increased bone remodeling and bone loss.[6,29,30-32] According to some authors, the effect of estrogen deficiency on bone turnover rate subsides after 10 years and any subsequent increase in bone loss is possibly due to multiple other factors such as reduced vitamin D absorption and thyroid disorders.[30-32] Although there is a lack of data on differences in bone remodeling patterns according to gender in alveolar bone, some studies postulate that the same principles can also be applied to the jaw region.[29-32] According to Carlsson *et al*.,[22] bone resorption that takes place under immediate dentures does not display any correlation to age or gender.[6,27-32] This observation has been reinforced by the present study in which the net decrease in alveolar bone volume is statistically the same for both genders and age groups. The uniformity of the results across both age groups and genders can be an indicator of the validity of the results of this experimental study.

The present study used the Spatial Modelling Technique to fabricate immediate dentures for the subjects. In a study comparing ridge resorption with various bone removal techniques for immediate dentures, the rate of mean decrease in alveolar ridge height was 37.19 ± 8.504 % at 3 months with the conservative bone removal corresponding to the Spatial Modeling method.[33] The rate of mean decrease in alveolar ridge height in the same subject with the more aggressive bone removal corresponding to the Standard technique was 38.66 ± 9.395 % at 3 months. At 6 months, in the same subject, the mean decrease in alveolar ridge height with the Spatial Modeling method was 44.51 ±11.767 %, whereas with the

Standard technique, it was 54.55 ±10.746 %. Jerbi's technique is based on the principle that for the best residual ridge, as much of the bone structure should be conserved and retained as possible.[11]

Some studies advocate the use of aggressive cast modification followed by bone re-contouring to reduce further alveolar bone resorption and to promote aesthetic adaptation of the denture.[20,21] According to other studies, the more conservative the cast modification technique, the lesser the need for bone re-contouring at the time of tooth extraction and the decreased net resorption of the residual ridge.[3,4,7,8,11] Carlsson *et al*[22] stated that minimal contouring of cast and bone should be undertaken to preserve as much of the alveolar process as possible. Lisowski *et al*.[21] reported the same result, i.e., extensive modifications of the casts lead to radical surgical alterations of the alveolar bone, which result in extensive resorption of bone under immediate dentures.

According to a study by Kelly *et al*.,[34] which evaluated two halves of the same residual ridge, the half loaded with immediate dentures had a better-rounded and well-preserved alveolar ridge than the other half not loaded with immediate dentures. An experimental study done on rats stated that early functional stimulation of bone under immediate dentures within the physiologic limits of tolerance helps the formation of new bone faster than if it were left alone.[35]

Changes in alveolar bone levels may be assessed via clinical modalities, e.g., direct assessment, study cast measurements, or radiographic modalities such as cephalograms or panoramic or peri-apical radiographs.[12-15] The limitations in using these 2D diagnostic images are primarily the evaluation of a three-dimensional structure on a two-dimensional image, in which only bone height can be assessed, whereas the bucco-lingual width cannot be assessed.[12,13] In peri-apical and panoramic images, there is under-estimation of the amount of bone present or lost due to multiple errors such as distortion, magnification, superimposition of anatomic structures, projection errors, etc.[12,13]

In this study, the means of bone level assessment at both baseline and after 3 months post extraction was done by Cone Beam Computed Tomography, which is a three-dimensional scan of the oral structures. The primary advantage of using this imaging modality is the ability to perform accurate 3d measurements of bone, less magnification errors, and radiation exposure as compared to panoramic and peri-apical radiographs.[12-15,36]

For further research in this area of prosthodontics, an evaluation of bone resorption patterns in posterior regions of the oral cavity as well as the anterior region may be undertaken with a comparison amongst multiple cast modification techniques, which can lead to more widely applicable results, clinically. An introduction of randomization during the sample collection may provide us with more valid results.

CONCLUSION

The functional stimulation and protection provided by an immediate denture may result in improved preservation of alveolar bone as compared to bone healing without immediate dentures. A conservative cast modification technique for the fabrication of immediate dentures may lead to decreased post-extraction alveolar bone loss in height and width. The labial and lingual reduction in the Spatial Modelling technique performed in a more conservative manner may further reduce the alveolar bone loss post-extraction. The selection of a flangeless design of the immediate denture may further preserve the width of the alveolar bone.

DECLARATIONS

Compliance with Ethical Standards:

Ethical Review Committee Approval: Approval was obtained from the Ethical Review Committee of the Institute of Dentistry, CMH Lahore Medical College, Lahore, Pakistan, Case #.37/ERC/CMH/LMC. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent to participate: Informed consent was obtained from all individual participants included in the study.

Consent to publish: The authors affirm that participants provided informed consent for the publication of this study.

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LIMITATIONS & RECOMMENDATIONS

An increased sample size may improve the applicability of the results to the general population. The inclusion of posterior regions for alveolar bone evaluation may provide increased information about alveolar bone preservation in posterior regions exposed to higher forces. Comparison of spatial modeling cast modification technique with other cast modification techniques may provide further insight in the selection of best technique for the fabrication of immediate dentures.

CONFLICT OF INTEREST / DISCLOSURE

The authors declare that they have no conflict of interest.

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