Evaluation of Bone Healing Following Immediate and Delayed Dental Implant Placement

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Abstract

Aim: The purpose of this study was to compare bone healing and coronal bone remodeling following both immediate and delayed placement of titanium dental implants in extraction sockets.

Methods and Materials: The study included 49 patients (28 women, 21 men) in need of implant treatment in the anterior teeth region of either the maxilla or mandible. Twenty-three subjects received 37 immediate (Im) implants and 26 subjects received 37 delayed (De) implants. The implants were placed immediately in the alveoli following the extraction in the Im group and the implants in the De group were placed approximately six months following the extractions. The width and depth of the marginal bone defects mesial and distal to the implants were evaluated radiographically using computer software designed to measure distances in digitized radiographs.

The mean reduction of bone defect over time was 48% (from 3.4 to 1.3 mm) in the Im group which was statistically significant (P <0.05) when tested using a sample t-test, while the mean reduction was 17% (from 2.1 to 1.9 mm) in the De group.

Conclusion: The potential exists for bone healing and remodeling in fresh extraction socket defects associated with immediately placed implants.
Introduction

Implant surgery, perhaps more than other aspects of dentistry, demands predictability and longevity. Fortunately, there are new advances in implant therapy designed to decrease the length of treatment time and functional stresses, enhance implant survival rates, and improve the psychological impact on the patient.

History has recorded tooth extractions and prosthetic rehabilitation being performed in the time of the pharaohs. However, it seems most dental treatment has been improved except dental extractions. The result of any extraction remains the same with alveolar bone loss; 40% to 60% of which occurs in the first two to three years following surgery and then a resorption rate of 0.5% to 1% every year for the rest of the patient’s life.\(^1\)

The degree of alveolar-ridge resorption generally depends on the region in which tooth loss is experienced as well as the amount of time that has passed since extraction. In the anterior maxilla atrophy is most severe during the first month post-extraction with the degree of horizontal bone resorption being nearly twice as high as that of vertical bone resorption.\(^2\) In the posterior maxilla horizontal bone resorption nearly corresponds to vertical bone resorption, amounting to 3 to 7 mm after six months.

Placement of an implant immediately after tooth extraction (fresh alveolus) will usually result in a gap between the occlusal portion of the implant and the surrounding alveolar bone crest. Synthetic bone substitutes, membranes, bone grafting, osteoinductive substances, or a combination of these have been used to achieve bone formation in such defects.\(^3\)

Barzilay et al. found the osseointegration of implants immediately placed in extraction sockets can be achieved without bone augmentation procedures and with a success rate comparable to that of delayed (De) implant placement.\(^4,5\) The present study was carried out to evaluate bone healing after immediate (Im) and De implantation.

Methods and Materials

Forty-nine patients (28 women, 21 men) were referred to the Department of Oral and Maxillofacial Surgery of the Faculty of Dentistry at the University of Malaya for tooth extraction. Only patients who required implant treatment in the anterior region of either the maxilla or the mandible were included in this study. The mean age of the subjects was 49 years (range, 20 to 74 years). Twenty three of these patients received 37 Im implants and 26 patients received 37 (De) implants. The reasons for the extractions included the following:

- Traumatic root fracture
- Periodontally compromised teeth
- Endodontic failures
- Advanced carious lesions
- External root resorption
- Periapical infections

Clinical Significance: Im implantation offers the advantages of reduced operating time and the preservation of alveolar bone volume.

Keywords: Immediate implant, delayed implants, bone healing, standardized periapical radiographs

All patients willing to participate in the study signed an informed consent form. The study was approved by the Medical Ethical Committee, Faculty of Dentistry, University of Malaya [Ethic approval No. DF OSO4O6/0043/ (P)].

Prospective radiographical evaluation for the 49 subjects was carried out to compare the bone healing and crestal bone changes following Im versus De placement of titanium dental implants.

Inclusive criteria included patients with a minimum of 4 mm of sound bone (clinically and radiographically) beyond the socket apices for implant stabilization. The implants in the Im group were placed immediately post-extraction. In the De group implants were placed approximately six months following tooth extraction. All subjects had no local or systemic factors that would affect osseointegration.

Exclusive criteria included patients with a history of the following:
- Smoking more than ten cigarettes per day
- Heart disease
- Connective tissue disorders
- Metabolic bone diseases
- Uncontrolled diabetes
- Severe periapical infection
- Severe bone resorption
- Fenestrations or dehiscence’s of residual bony walls

**Radiological Examination**
Panoramic and standardized periapical radiographs were taken of the subjects. The periapical radiographs were obtained using the parallel technique. A customized occlusal bite index was fabricated by attaching a silicone bite block made of polyvinyl silicone putty impression material (Heraeus Kulzer, Germany) to a film holder as shown in Figure 1.

Standardized periapical radiographs were taken preoperatively, immediately after placement of the implants and three to four months later during the second stage operation in both groups. The index was saved for use at all visits to standardize film placement and cone angulation. A single examiner performed the radiographic interpretation and measurements.

A dental X-ray machine equipped with a 20 cm long cone was used to expose the periapical film (Agfa Dentus, Size 0; Agfa Gevaert). Exposure parameters were 70 kV(peak), 7 mA and 0.12 seconds at the focus-to-sensor distance of 25 cm. 

**Radiographic Data Collection and Analysis**
All radiographs were scanned at a resolution of 300 dpi using a Canon 2000AC flatbed scanner (Canon Japan, Inc., Tokyo, Japan) with a transparency module and saved in the Tagged Image File Format (TIFF) to avoid image deterioration associated with file compression.

The Leica QWin® (Leica Microsystems Imaging Solutions Ltd, Cambridge, England) image analysis software program designed to measure distances in digital images was utilized in the present study (Figure 2).

Linear radiographic measurements at implant placement and at abutment placement were performed as follows:
- The horizontal linear dimension (HD) of the defect from the bone crest to the implant surface in a direction perpendicular to the long axis of the implant.
- The vertical linear distance (VD) from the shoulder of the implant (implant-abutment joint level) to the first visible bone-to-implant contact.
Reproducibility of linear measurements of the bone levels in the radiographs was determined by comparing the repeated measurements using the Wilcoxon matched pairs signed-ranks test.

### Results

#### Horizontal Linear Radiographic Measurement Over Time
The horizontal linear radiographic measurements were taken in a direction perpendicular to the long axis of the implant mesially and distally from the bone crest to the implant surface. In the Im group the measurements were taken one week after placement of the implants and the mean distance was 3.4 mm. This measurement diminished to a mean of 1.3 mm during the second measurement at abutment placement. This reduction of the gap was 48% and was statistically significant at $P < 0.05$.

The same linear measurements were taken in the De group one week after implant placement and the mean was 2.1 mm. This declined to a mean of 1.9 mm at the second reading during abutment placement. This was a 17% reduction which was not statistically significant as is shown in Table 1.

#### Vertical Linear Radiographic Measurement Over Time
The changes in bone levels evaluated radiographically (as well as the agreement between the repeated measurements) were analyzed using the Wilcoxon matched-pairs signed ranks test.

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**Figure 2.** Leica QWin Image processing and analyzing system for measuring mesial, distal, horizontal, and vertical gaps.

c. The radiographic length of the implant was measured to determine the image magnification (M). The measurement of bone levels were then adjusted according to the magnification.

Note: Magnification factor $M = \frac{\text{actual implant length}}{\text{radiographic implant length}}$

Actual horizontal bone gap = $M \times $ radiographic HD
Actual vertical bone defect = $M \times $ radiographic VD

Measurements were done separately for the mesial and distal surfaces. A mean of the mesial and distal measurements was used for analysis and comparison.

**Statistical Analysis**
Paired sample t-tests were used to determine if there were any changes in the vertical gaps within the groups at implant placement and at a three month follow-up visit. A General Linear Model Repeated Measures procedure was used to assess the difference between group interaction effects and to obtain the profile plots.

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**Table 1. Linear radiographic (horizontal) measurements and percentage reduction over time.**

<table>
<thead>
<tr>
<th>Implant Group</th>
<th>First Reading (Implant Placement) Mean ± SD</th>
<th>Second Reading (Abutment Placement) Mean ± SD</th>
<th>% Reduction Over Time</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Im n = 35</td>
<td>3.4 ± 1.5</td>
<td>1.3 ± 1.1</td>
<td>59</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>De n = 36</td>
<td>2.1 ± 1.4</td>
<td>1.9 ± 0.9</td>
<td>17</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>
The vertical linear radiographic measurements in the Im group taken one week after placement of the implants resulted in a mean of 5.4 mm then to a mean of 1.2 mm at abutment placement. This gap reduction was 91.2% which was statistically significant at P < 0.001.

The same measurements were taken in the De group one week after implant placement which resulted in a mean of 4.9 mm then to 1.3 mm during subsequent measurements performed during the abutment connection appointment. The gap reduction was 90.3% which was statistically significant at P < 0.001 as shown in Table 2.

**Discussion**

The most important goals of dental implant surgeons is to achieve full osseointegration and gingival healing without complications, long-term stability of the implant, and a favorable esthetic outcome.

The rationale for Im implant placement is to utilize the process of new bone formation in the extraction socket to achieve osseointegration. This surgical strategy can offer advantages over the De implant placement by eliminating the need for a second surgical episode and using the natural healing process of an extraction site to facilitate osseointegration as well as offering the potential of improving patient acceptance of the procedure.

The highest percentage of gap reduction vertically and horizontally was found in the Im placement group followed by the De placement group.

Most of the gaps in the Im group were related to the extraction of the teeth; whereas in the De group most of the defect resulted from preparation of the implant site or because the alveolar ridge was narrow.⁸

A possible explanation for the difference in bone healing between defects related to Im implants versus De implants could be the Im implants were placed into sites where the inflammatory response of the tissues, as well as wound healing, was in its active stage.

In the present study the survival rates in the Im group and De groups were 94.6% and 97.3%, respectively, without any significant difference. The survival rates in both groups were high due to the primary stability of the implants (obtained during the first stage operation) and primary wound closure over extraction site in both groups.⁹

The use of wide implants could offer several advantages in Im implant placement cases. These advantages include the following:¹⁰

- An improved emergence profile for prosthetic rehabilitation.
- Gap reduction between the implant and the surrounding alveolar walls.

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**Table 2. Linear radiographic (vertical) measurements and percentage reduction over time.**

<table>
<thead>
<tr>
<th>Implant Group</th>
<th>First Reading (Implant Placement) Mean ± SD</th>
<th>Second Reading (Abutment Placement) Mean ± SD</th>
<th>% Reduction Over Time</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Im n=35</td>
<td>5.4 ± 0.18</td>
<td>1.5 ± 0.13</td>
<td>91.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>De n=36</td>
<td>4.9 ± 0.16</td>
<td>1.3 ± 0.14</td>
<td>90.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Leica QWin® computer software was used to analyze the digitized radiographic images and determine the micro-gap. The software was very useful to detect and measure the micro-gap in the De group which was difficult to measure or probe clinically due to the relatively intimate contact of the implant surface to the surrounding bone. The diameter of the surgically formed “socket” is almost identical to the implant making it difficult to accommodate a probe between the implant and the bony wall to determine the gap.14

In the case of extraction of a tooth in the anterior region, De implantation could destroy the future recipient site through collapse of the osseous crest and creation of an unesthetic gingival defect.15 To obtain an optimal esthetic result, it is essential to preserve the osseous and gingival structure of the damaged tooth. The immediate placement of the implant is recommended to minimize the loss of the osseous architecture and the marginal variations resulting from the extraction especially in anterior region of the mouth which is frequently affected by a significant degree of atrophy immediately following an extraction.

Conclusion
There is the potential for improved bone healing and remodeling to take place in fresh extraction socket defects associated with immediately placed implants. Results of the present study revealed implant osseointegration can be successful in Im implantation as compared to De implantation during the same healing period.

Clinical Significance
The principle advantages of Im implantation are the savings of clinical time, elimination of the need for a second surgical procedure for the patient, and preservation of bone volume. However, the drawback of this technique is a more complicated management of the soft tissue in order to obtain an esthetically satisfactory result.
References
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