Dental Implants Immediate Loading Versus the Standard 2-Staged Protocol: An Experimental Study in Dogs

Mansour Rismanchian, DDS, MS
Bijan Movahedian Attar, DDS, MS
Sayed Mohammad Razavi, DDS, MS
Ali Nasir Shamsabad, DDS, MS
Majid Rezaei, DDS

The endeavors to shorten implant treatment time have led to the concept of immediate loading. This research was designed to compare the immediate loading and the 2-staged methods on implant placement from a clinical, histological, and histomorphometric standpoint. Three months postextraction of 12 premolars of 3 dogs, 12 implants were inserted. Bone-implant contact (BIC), implant stability quotient (ISQ), the bone type in a 2-mm periphery around the implant, and the marginal bone loss (MBL) were recorded for unloaded implants (n = 6) and immediately loaded ones (n = 6). BIC, ISQ, MBL in the mesial, and the bone types around the implants were not significantly different in the 2 groups. The distal MBL was higher in the immediately loaded group. Immediate loading does not appear to be perilous for osseointegration, BIC, or new bone type around implants.

Key Words: dental implant, immediate loading, dog, histomorphometric study

INTRODUCTION

Since introduced by Branemark, dental implants have traditionally required 3 to 6 months in an unloaded state to be osseointegrated. During this course, patients need to wear a provisional removable prosthesis, which is to be relined occasionally. This long healing phase is unpleasant to the patients, and they usually look for a definitive treatment that can be finished sooner. To address this demand, the concept of immediate loading has been developed. In brief, an immediate restoration of missing teeth will have the following advantages: reduction of number of surgeries, shortening of total treatment course, enhancement of soft tissue forming, diminished need for removable prosthesis, and an overall satisfaction of patients.

The term immediate loading does not have a single meaning in that different stratification of implant loading has led to different definitions. During the Sociedad Espanola de Implants World Congress held in
Barcelona, Spain, in May 2002, a consensus meeting was organized to present and discuss the different protocols of immediate/early loading methods. Immediate loading, as presented in the consensus report, indicates that the prosthesis is attached to the implant the same day the implant is placed. On the other hand, nonocclusal loads have been considered important for a successful outcome for immediate/early-loaded short-span bridges and single-tooth replacements. This is similar to what Micsh et al called nonfunctional immediate restoration. Thus, there is no occlusal contact on the prosthesis. Instead, they introduced the term immediate occlusal loading when the prosthesis is involved in the occlusion and function. Degidi and Piatelli used the terms immediate functional and immediate nonfunctional loading for relevant conditions. Therefore, when comparing the results of different loading systems, contemplating these stratifications is of paramount importance. We have used the Spain congress declaration in our study.

Different criteria have been proposed for immediate loading to be indicated. Primary stability; surgical technique; bone quality; systemic diseases; number of implants being inserted; the design, shape, and topography of the implant; occlusal forces; and the design of the prosthesis should all be factors to be considered.

The ideal state for immediately loaded implants would include bone types II and III, greater number of implants, screw-shaped implants, rough implant surface, a minimum length of 10 mm, and avoidance of lateral forces. Ganeles et al compared 161 immediately loaded implants with diverse prosthetic designs and found no differences between the groups with the various designs.

Primary stability seems to be the most important factor in immediate loading. Insertion torque and resonance frequency analysis are ubiquitous methods for appraisal of primary stability. Insertion torques between 30 and 60 N-cm have been considered to be necessary for the immediate loading technique. Values of resonance frequency presented by Osstell mentor (mentor instrument, Goteborg, Sweden) are usually expressed as a percentage of the named implant stability quotient (ISQ). A minimal ISQ of 60 to 65 has been suggested for the immediate loading technique.

Our intention was to determine the effect of loading time on implant integration by means of clinical, radiographic, and histomorphometric parameters.

**Materials and Methods**

Three dogs were selected for this animal study, which was approved by the ethics committee of Isfahan University of Medical Sciences. The dogs were anesthetized with intravenous ketamine hydrochloride (5 mg/kg), followed by inhalated halothane and nitrous oxide. First, their mouths were rinsed with antiseptic chlorhexidine gluconate 0.2% for 30 seconds. Next, infiltrating local anesthesia (lidocaine 2%, epinephrine 1:100 000) was used. Four premolars of the mandibular arch were extracted (N = 12). To ensure atraumatic extraction of the teeth, we bisected the teeth buccolingually using a high-speed handpiece to separate the roots. The roots were removed with molar forceps. Periapical radiography confirmed that no root remnants were left in place.

Three months postextraction, radiography was repeated to be sure of properly healed edentulous areas. In a sterile fashion, crestal incisions were made, and twelve 4- × 10.5-mm Biohorizons dental implants (Biohorizons Implant Systems Inc, Birmingham, Ala) were inserted (Figure 1). The required torque to bury the implants completely in the bone (except the highly polished part)
was recorded with a calibrated torque wrench. Following abutment removal and insertion of proper smart pegs, Osstell mentor recorded the ISQ values for each implant. Cover screws then were fastened over the unloaded implants group (n = 6) and submerged beneath the mucoperiosteal flap. In the immediately loaded group (n = 6), abutments were installed with a torque of 30 N-cm. Prefabricated polycarbonate veneers were relined with acrylic resin (Bosworth Trim II, Skokie, Ill) and cemented over the abutments with zinc phosphate (Figure 2). Occlusion was adjusted so that no contact would occur during centric occlusion and lateral excursions. Periapical radiographs were taken to check the level of crestal bone with regard to the implant. During 4 weeks postsurgery, the dogs were kept on a soft diet so as not to overload the implants. Pursuant to this plan, dogs were then allowed to have a usual diet for the remaining of the healing course.

After 3 months, the dogs were anesthetized as previously described and reexposed for a second postsurgical radiograph. To record a second ISQ, crowns were removed; abutments and cover screws were screwed out. At last, all implants encompassed in bone were retrieved by a 10-mm trephine. However, none of the animals were killed. The samples were embedded at once in formalin 10% followed by glutaraldehyde solution for 6 hours. Ascending series of alcohol dehydrated the specimens. Cold-cured acrylic resin (Bosworth Trim II) was used to encircle the samples and to provide the acrylic blocks surrounding the implant-bone complex. Ground section slices with a diameter of 150 μm were prepared along the longitudinal axis of implants (Figure 3). Specimens were dipped in distilled water for 5 minutes and then in 65°C hematoxylin for an additional 10 minutes. After the preparation of specimens with picric acid, pancierivd 5%, phosphomolibic acid 5%, and aniline blue 5% was complete, they were assessed under microscopic magnification of ×40 to calculate the percentage of bone-implant contact (BIC) and different bone types (Figure 4). As a second survey, the captured images of slices were analyzed for
BIC using Adobe Photoshop 10. Eventually, mean values of these 2 measured BICs were considered as the ultimate BIC.

Statistical analysis was carried out using an independent t test. All values were presented as mean ± SD. All differences set at \( P < .05 \) were considered statistically significant.

One of the acrylic blocks pertaining to the unloaded implants group was devastated during the laboratory process for microscopic examination.

**RESULTS**

We evaluated different parameters of 2 different loading systems: immediate loading vs unloading. These parameters included BIC, ISQ, histological study of bone type 2 mm around implants, and marginal bone loss (MBL).

Table 1 shows the values of BIC in the 2 groups. Contemplating the devastated sample in the unloaded group, the mean values of BIC in immediately loaded implants were more than their counterparts in the unloaded group; however, this difference was not significant (\( P = .230 \)).

Two groups showed no significant differences (\( P = .111 \)) in second (before implant retrieval) ISQs, even though the ISQ was higher in the unloaded group (Table 2).

In the 2-mm periphery of all implants, both types of lamellar and woven bone, some areas of connective tissue, and inflammatory agents were present, and the t test failed to demonstrate significant differences between the 2 groups (Table 3).

The MBL was calculated using radiographs taken on the day of insertion and at the time of implant removal. The difference in mesial was not significant (\( P = 1 \)), but MBL
in distal of immediately loaded implants was significantly more apparent ($P = .002$; Table 4).

**DISCUSSION**

Immediate loading is a prosthodontic concept that provides the patient with many benefits such as shortened treatment phase, early rehabilitation, and superior esthetics. Comparable durability of such a loading system to the standard 2-stage system should further be confirmed.

**BIC**

In a clinical trial, Degidi et al$^{14}$ reported more bone formation at the interface of the bone-implant in the loading group. They also concluded that immediate loading was able to stimulate bone remodeling, which was similar to that of the unloaded state.$^{14}$ In another study, immediate loading has been shown not to have any impact on bone deposition over the implant surface.$^{15}$ Furthermore, Berglundh et al$^{16}$ and Godfredsen et al$^{17}$ demonstrated greater amounts of BIC in implants exposed to functional loading. In our study, mean values of BIC in immediately loaded implants (51.33%) and in the unloaded group (44.4%) were not statistically different. Nkende et al$^{15}$ in a study of 35 implants were not able to detect a significant difference. Based on an animal study, Ghanavati et al$^{18}$ showed no differences between 2 groups of implants with different loading conditions. Results of these 2 studies were congruent with ours. Results of a series devised by Piattelli et al$^{19}$ implied a higher range of BIC for loaded implants. Zubery et al$^{20}$ appraised osseointegration of 18 implants in the mandible of 3 dogs and concluded that more BIC could be obtained by unloaded implants. On the other hand, diverse values have been reported for BIC in immediately loaded implants. In a recent study by Romanos et al$^{21}$ after 2 to 10 months of being loaded, 29 implants of different designs brought about a BIC of 66.83% ± 8.96%. Studies by Iezzi et al (68% ± 5%),$^{22}$ Proussaefs (81.3%),$^{23}$ Degidi et al

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Min</th>
<th>Max</th>
<th>Significance Between Groups</th>
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<tr>
<td>Immediately loaded</td>
<td>6</td>
<td>51.33</td>
<td>7.42</td>
<td>3.02</td>
<td>43.59</td>
<td>59.12</td>
<td>42</td>
<td>62</td>
<td>.235</td>
</tr>
<tr>
<td>Unloaded</td>
<td>5</td>
<td>44.4</td>
<td>10.45</td>
<td>4.67</td>
<td>31.41</td>
<td>57.38</td>
<td>35</td>
<td>62</td>
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<table>
<thead>
<tr>
<th>Time</th>
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<th>SD</th>
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<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Max</th>
<th>Min</th>
<th>Significance Between Groups</th>
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<tbody>
<tr>
<td>Insertion day</td>
<td>Immediately loaded</td>
<td>6</td>
<td>64.33</td>
<td>5.98</td>
<td>2.44</td>
<td>58.04</td>
<td>70.61</td>
<td>59</td>
<td>72</td>
<td>.671</td>
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<tr>
<td></td>
<td>Unloaded</td>
<td>6</td>
<td>62.16</td>
<td>10.59</td>
<td>4.32</td>
<td>51.05</td>
<td>73.28</td>
<td>51</td>
<td>78</td>
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<tr>
<td>3 months later</td>
<td>Immediately loaded</td>
<td>6</td>
<td>75.5</td>
<td>3.13</td>
<td>1.27</td>
<td>72.21</td>
<td>78.78</td>
<td>70.5</td>
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<tr>
<td></td>
<td>Unloaded</td>
<td>6</td>
<td>66.75</td>
<td>11.85</td>
<td>4.84</td>
<td>54.30</td>
<td>79.19</td>
<td>51</td>
<td>80</td>
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(71% ± 3.2%), Trisi et al (47.81%), and Froum et al (52.9% ± 13.81%) are exemplary examples.

**ISQ**

Lindeboom et al in their study of 50 immediately loaded implants divided the samples into functionally loaded (IL) and nonfunctionally loaded (IP). Immediate loading in our study was similar to the latter. ISQ at the insertion time was 41.2% ± 12.2% for IL and 43.4% ± 14.2% for IP, less than their counterpart in our study (64.33% ± 5.98%). After 6 months, the values were 63.7% ± 5.8% for IL and 63.2% ± 4.3% for IP, both of which were less than our results after 3 months (75.5% ± 3.13%). These differences are probably due to the specific density of human vs canine bone and different design, surface, length, and diameter of applied implants.

Many have supported the idea that the more the insertion torque, the better the primary stability and ultimate success. Insertion torques of 45 N-cm, 35 N-cm, and 42 N-cm have been presented as optimal, and we set up the implants with a torque of 50 N-cm. Norton showed that with a minimal torque of 25 N-cm, an ISQ of at least 60% is achievable. Our results are in agreement with Norton’s.

**MBL**

Marginal bone loss after 1 year of follow-up in most clinical trials is less than 1 mm. However, in our study, it was greater than 1 mm, both in immediate loading and submerged groups, either in mesial or distal.

### Table 3
Composition of the bone in 2-mm periphery of the implants

<table>
<thead>
<tr>
<th>Type of Tissue</th>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Max</th>
<th>Min</th>
<th>Significance Between Groups</th>
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<tbody>
<tr>
<td>Woven bone, %</td>
<td>Immediately loaded</td>
<td>6</td>
<td>36.55</td>
<td>2.92</td>
<td>1.19</td>
<td>33.48</td>
<td>39.61</td>
<td>32.5</td>
<td>40.1</td>
<td>.684</td>
</tr>
<tr>
<td></td>
<td>Unloaded</td>
<td>5</td>
<td>35.80</td>
<td>2.97</td>
<td>1.33</td>
<td>32.10</td>
<td>39.49</td>
<td>32.3</td>
<td>40.2</td>
<td></td>
</tr>
<tr>
<td>Lamellar bone, %</td>
<td>Immediately loaded</td>
<td>6</td>
<td>54.13</td>
<td>2.14</td>
<td>0.87</td>
<td>51.88</td>
<td>56.38</td>
<td>52.4</td>
<td>58</td>
<td>.135</td>
</tr>
<tr>
<td></td>
<td>Unloaded</td>
<td>5</td>
<td>57.80</td>
<td>3.11</td>
<td>1.39</td>
<td>53.93</td>
<td>61.66</td>
<td>53</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Inflammatory and connective tissue, %</td>
<td>Immediately loaded</td>
<td>6</td>
<td>6.40</td>
<td>2.55</td>
<td>1.52</td>
<td>2.56</td>
<td>11.03</td>
<td>4.5</td>
<td>12.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unloaded</td>
<td>5</td>
<td>9.31</td>
<td>3.05</td>
<td>1.24</td>
<td>6.11</td>
<td>12.51</td>
<td>5.7</td>
<td>14.5</td>
<td>.124</td>
</tr>
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</table>

### Table 4
Marginal bone loss in mesial and distal of the implants presented in millimeters

<table>
<thead>
<tr>
<th>Time</th>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Max</th>
<th>Min</th>
<th>Significance Between Groups</th>
</tr>
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<tbody>
<tr>
<td>Mesial</td>
<td>Immediately loaded</td>
<td>6</td>
<td>1.33</td>
<td>0.51</td>
<td>0.21</td>
<td>0.79</td>
<td>1.87</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Unloaded</td>
<td>6</td>
<td>1.33</td>
<td>0.51</td>
<td>0.24</td>
<td>0.719</td>
<td>2.08</td>
<td>1</td>
<td>2</td>
<td></td>
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<tr>
<td>Distal</td>
<td>Immediately loaded</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>Unloaded</td>
<td>6</td>
<td>1.16</td>
<td>0.40</td>
<td>0.2</td>
<td>0.64</td>
<td>1.75</td>
<td>1</td>
<td>2</td>
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</table>
Differences in radiographic techniques, implant design, topography, length, and diameter or, even more importantly, differences in human diet, pattern of occlusion, and biting force with those of the dogs may explain this discrepancy. We found 54.3% ± 2.14% of lamellar bone in 2 mm around the immediately loaded implants and 57.8% ± 3.11% around unloaded ones. These measures around cancellous bone were 36.55% ± 2.92% and 35.8% ± 2.97% for the immediately loaded and unloaded groups, respectively. Similar to Ghanavati et al. we were not able to detect significant differences between the 2 groups with regard to lamellar bone formation.

CONCLUSION

According to results of our study, immediate loading seems to have no disadvantages in comparison with the standard 2-staged protocol. Like many other studies, we found no differences in BIC, ISQ, or peripheral bone types between the 2 groups. Our records for MBL were not congruent with most clinical trials, which may be due to different conditions between humans and dogs. Having no significant drawbacks compared with the standard 2-staged protocol, along with the aforementioned advantages of immediately loaded implants, convinced us to conclude that it could be considered an acceptable alternative plan when the minimal requirements exist.

ABBREVIATIONS

BIC: bone-implant contact ISQ: implant stability quotient MBL: marginal bone loss

REFERENCES


