A Retrospective Study of Bone Level Stability Around 441 Mandibular and 350 Maxillary Molar Implants Placed with an Immediate Implant Protocol

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The purpose of this retrospective study was to evaluate bone level stability around 441 mandibular and 350 maxillary molar implants, placed using an immediate implant protocol, that had been in function from 2 to 17 years postrestoration (mean: 9.9 years). Independent radiographic measurements using the known distance between threads on the specific implant that was used indicated a mean bone loss of 0.27 ± 0.68 mm around maxillary implants and 0.27 ± 0.67 mm around mandibular implants. Maxillary implants showed a statistically significant (SS) difference in bone loss on the mesial (0.20 mm) compared to the distal side (0.34 mm). In the mandibular group, there was an SS difference in bone loss around implants with wide (≥ 5 mm) and regular (< 5 mm) diameters. There was also an SS difference in bone loss in patients 50 years and older (0.28 mm) compared to patients younger than 50 (0.18 mm). In both groups, there were no SS differences in bone loss between machined- and rough-surface implants, men and women, single and splinted implants, nonsmokers and light/heavy smokers, or in patients with a penicillin allergy who were prescribed azithromycin as an alternate prophylactic antibiotic. All SS differences found in variables evaluated in the study were < 1.0 mm and therefore were considered clinically insignificant. Int J Periodontics Restorative Dent 2020;40:635–643. doi: 10.11607/prd.4678

Immediate implant placement (IIP) in fresh extraction sites was first described in 1989 and has been shown to be an effective method of replacing hopeless teeth with implant-supported restorations.1,2 The authors of the present study reported a 96% implant survival rate using an IIP protocol over a period of 16 years with a sample size of 1,925 implants.3 In another study, long-term bone stability was reported around 1,187 immediately placed implants with a 1- to 22-year follow up. That study reported a mean bone loss of 0.52 ± 0.79 mm with an overall bone loss less than 1.5 mm in 90% of the implants evaluated.4 Utilization of IIP in molar sites has now become an acceptable option for implant placement.5–9 In fact, cumulative survival rates have demonstrated to be similar for implants placed in healed sites and in molar sites with an IIP protocol.10

An 11-year retrospective study reported an overall survival rate of 97.3% for 300 implants that were placed with an IIP protocol in molar extraction sockets.11 The IIP protocol has the advantages of a “reduced number of surgical procedures and patient visits, lower cost of treatment, and shorter time required from beginning to completion of treatment.”11 A recent publication described a sequenced technique for predictable IIP in maxillary and...
mandibular molar sockets using ultra-wide-diameter dental implants and reported a 95.17% survival rate based on 580 clinical cases over a 10-year period. The purpose of the present retrospective investigation was to evaluate marginal bone levels around implants placed with an IIP protocol replacing maxillary and mandibular molar teeth with a 2- to 17-year follow-up after loading.

Materials and Methods

All patients who received molar implants placed with an IIP protocol by one of the authors (B.W.) in a private practice setting that were restored for a minimum of 2 years were placed on a reference list used for contact. All patients on this list who were not returning for regular recall maintenance were contacted by telephone with a request they return for radiographic follow-up of the previously placed implants. If patients did not respond to telephone or email contact, the referring dentist was contacted to determine if current radiographs were available. If patients changed residency, an attempt was made to contact their current dentist to obtain radiographs. Reasons for not participating in the radiographic follow-up were recorded and were identical to those documented in a previous paper. Patients from a previous study of long-term bone stability around 1,187 immediately placed implants provided 64 of the 350 maxillary implants and 139 of the 441 mandibular implants for evaluation in the current study. The remaining implants were obtained from the list of immediately placed molar implants mentioned earlier. Two databases were utilized to track the details of the implants in this study. Implant Tracker and Sesame Database Manager (Lantica Software) were utilized to obtain the details of each patient’s treatment. Each patient who qualified for inclusion in this follow-up study was assigned a patient number, which blinded the identifiers to all examiners.

The surgical protocol used on the molar implants included in the current study was described in a previous paper. To briefly review: All teeth were extracted atraumatically by severing the clinical crowns and separating the roots. A long, thin diamond bur was used to separate the root attachments until, with minimal pressure, each root moved easily. The roots were then removed and the sockets and adjacent areas thoroughly debrided. Osteotomies were then made with drills in the mandible and osteotomes (or a combination of drills and osteotomes) in the maxilla. Following root removal in the maxilla, internal sinus elevations were performed using osteotomes and mineralized freeze-dried cortical bone (300 to 500 microns, University of Miami Tissue Bank), which was packed into the site and used to elevate the sinus membrane.

Implants were placed to a depth of 1.0 to 1.5 mm below the bone crest on the labial or lingual/palatal side (whichever was more...

Fig 1 (a) Placement of the implant 1 to 1.5 mm apical to the buccal plate of bone. (b) The flap sutured over the implant. Bone graft and Vicryl membrane were placed with no attempt to cover the membrane with the flap procedure.
Bone was then firmly packed into the sockets, over the cover screws, and over the buccal or lingual walls of the socket if these were ≤ 2 mm in thickness and augmentation was required. A Vicryl membrane (Ethicon, Johnson & Johnson) was custom-contoured and extended 5 to 7 mm beyond the margins of the defects and tucked under the flaps both labially and palatally without suturing. The flaps were closed using 4-0 chromic gut sutures. No attempt was made to advance the flaps and cover the membrane (Fig 1b). In over 80% of cases, cover screws were partially showing through the tissue prior to abutment placement (Fig 2). Patients were premedicated with amoxicillin (500 mg; Teva Pharmaceuticals USA), four times daily the day prior to the procedure, the day of the procedure, and for 10 days postsurgery. Penicillin-sensitive patients were premedicated with one Azithromax (250 mg, Pfizer Pharmaceuticals) a day starting 2 days prior to the day of the surgery, the day of surgery, and continued for an additional 6 days, for a total of nine single doses. Patients were instructed to utilize 0.12% chlorhexidine glu-

Fig 2 (a) The mandibular right first molar had a 10-mm pocket and suppurative from the furcation area. (b) The molar was extracted, and an implant was placed just below the height of the most apical crest of bone. Note the bone fill into existing sockets, at the buccal and lingual aspects, and over the height of the cover screw. (c) After 3 months of healing, the top of the cover screw is exposed, making abutment connection easier. Note the increased amount of keratinized tissue between the buccal and lingual flaps. (d) Radiographic view of the abutment connection. Bone is visible at the top thread on the distal side and over the top thread on the mesial side. (e) At 11 years postrestoration, bone levels are seen at the coronal-most aspect of the first thread on both the mesial and distal sides.
conate (Peridex, Vila Pharmaceuticals) as a mouthrinse twice daily for 2 days prior to the surgery and to use a cotton tip to lightly clean any exposed membrane three times daily for 2 weeks postsurgery and twice daily (after breakfast and prior to sleep) until the membrane was absorbed. Patients whose implant(s) were at least 2 years postrestoration were recalled, and periapical or bitewing radiographs were taken to ascertain bone levels on the mesial and distal aspects of the implants. At time of implant placement, patient gender, patient age, whether the implant was an individual unit or splinted, exact implant type, and implant length and width were recorded.

An independent clinician measured, to the nearest half thread, the bone between the peaks of the threads on both the mesial and distal aspects of each implant (Fig 3). Each implant company supplied the exact distances between the peaks of adjacent threads, and the statistician converted the radiographic measurements to calculate actual bone loss in millimeters. Measurements were evaluated in millimeters and by calculating thread bone fill on both the mesial and distal aspects of each implant, using the top of the first thread as a reference point. The threads were utilized as a reference point instead of the top of the collar because collar lengths differ between implants within a company and between different companies. Thread peak dimensions are known quantities by the specific manufacturer and are not affected by potential radiographic distortions. Thus, they are more accurate. In addition, it is very common after the healing period for the bone to resorb to the top of the first thread.

All implants that had mesial or distal bone coronal to the reference point on follow-up x-rays were considered as having + bone (the bone was placed over the top of the thread and remained there). When bone levels were even with the top of the first thread, bone loss was considered 0. If < 50% of the thread had bone fill, the entire thread was assumed devoid of bone. Data on thread level was converted to millimeters of bone loss based on the known millimeter distances of the threads of the specific implant. Patient and implant data—including gender, age, implant location (maxilla or mandible), location of bone level (mesial or distal), implant diameter (≥ 5 mm, ≥ 4 mm, or < 4 mm), single or splinted implants, smoker or non-smoker, and penicillin allergy—were recorded and sent to a statistician to determine if any statistically significant (SS) correlations were present between bone loss and any of these variables.

**Statistical Analysis**

The statistical analysis was performed using a commercially available software program (SPSS for Windows, version 22.0; IBM). Means and standard deviations were calculated for all quantitative data. In terms of analyzing bone loss, mesial- and distal-side measurements were considered separate measurements. For the maxilla, there was one missing measurement, and therefore 350 implants and 700 sites were analyzed. For the mandible, 441 implants and 882 sites were analyzed. For the statistical evaluation of difference in bone loss over all clinical parameters, Student t test was used. Levene’s Test for equality of variances was used for each comparison to verify equal variance in t tests.

For the comparison of bone loss over different surfaces (machined vs smooth) and smoking status, two-way analysis of variance was used. The error was set at 0.05, and $P < .05$ was used as the level of statistical significance.

**Results**

Statistical evaluations were done separately for the maxillary and mandibular molar implants. Figure 4 shows the age distributions for patients included in the study.
Maxillary Implants

Two hundred and eighty-eight (82%) of the 350 maxillary implants were evaluated at 5 to 16 years postrestoration (mean: 9.5 years).

Bone loss was measured on both the mesial and distal aspects of the implants. A total of 379 (54%) of the mesial and distal implant aspects had bone coronal to the first thread, while 185 (26%) of the mesial and distal implant aspects had bone levels even with the top of the first thread. This indicated that 80% of the mesial and distal bone level measurements had no bone loss relative to the first thread. When the bone levels were converted to millimeters, 564 (80%) of the mesial and distal measurements had bone levels coronal to or over the first thread. An additional 85 (12%) of the mesial and distal measurements showed bone loss of 0.5 to 1.5 mm. Further, 36 (5%) surfaces demonstrated bone loss of 1.5 to 2.5 mm; 10 (1%) had bone loss between 2.5 and 3.5 mm; 4 (1%) showed bone loss between 3.5 and 4.5 mm; and 1 (0%) surface had lost > 4.5 mm of bone.

Of the total 700 sites examined, the range of bone loss was 0.0 to 4.8 mm, and the mean bone loss was 0.27 ± 0.68 mm.

An SS difference in bone loss occurred on the mesial side of the implants (0.20 ± 0.59 mm) compared to the distal side (0.34 ± 0.76 mm) (P = .011, t test).

In the maxilla, there were no SS differences in bone loss:

- between implants with ≥ 5 mm and < 5 mm diameters (P = .06, t test)
- between machined- and rough-surfaced implants (P = .16, t test)
- between single and splinted implants (P = .09, t test)
- between nonsmokers and smokers (light and heavy smokers) (P = .9, t test)
- between men and women (P = .05, t test)
- between patients ≥ 50 years and < 50 years of age (P = .85, t test)
- between patients taking penicillin vs patients taking Azithromax (P = .53, t test)

Mandibular Implants

Of the 441 mandibular implants, 89% were evaluated 5 to 16 years postrestoration (mean: 10.2 years).

Of the 882 sites evaluated, 484 (51%) of the mesial and distal implant aspects had bone coronal to the first thread, while 255 (29%) of the mesial and distal aspects showed no bone loss relative to the first thread. This indicates that 80% of the mesial and distal bone-level measurements had no bone loss relative to the first thread, which was also seen when the bone loss was converted into millimeters (709 sites, 80%). Conversely, 111 (13%) of the mesial and distal measurements...
showed a bone loss between 0.5 and 1.5 mm; 46 (5%) surfaces had bone loss between 1.5 to 2.5 mm; 6 (1%) had bone loss between 2.5 and 3.5 mm; 8 (1%) surfaces demonstrated bone loss between 3.5 and 4.5 mm; and 2 (0%) had bone loss > 4.5 mm. Of the total of 882 sites measured, the range of bone loss was 0.0 to 5.6 mm and the mean bone loss was 0.27 ± 0.69 mm. This represents bone loss from the coronal portion of the most coronal thread.

Of the total maxillary and mandibular sites measured (1,582), the mean bone loss was 0.27 ± 0.68 mm (range: 0.0 to 5.6 mm). There was an SS difference in bone loss around implants with diameters ≥ 5 mm (0.30 ± 0.73 mm) and implants with diameters < 5 mm (0.20 ± 5.5 mm) (P = .031, t test). In the mandibular group, there was also an SS difference in bone loss (mm) in patients 50 years and older (0.18 ± 0.48 mm) and patients younger than 50 years (0.28 ± 0.73 mm) (P = .026, t test). However, as with implants in the maxilla, there was no SS difference in bone loss (mm) between patients without a penicillin allergy and patients with a penicillin allergy who were placed on Azithromax (P = .80, t test).

In the mandible, there were no SS differences in bone loss:
- on the mesial and the distal sides (P = .6, t test)
- between machined- and rough-surfaced implants (P = .51, t test)
- between men and women (P = .72, t test)
- between single and splinted implants (P = .95, t test)

Fig 5 (a) Maxillary left second molar with a significant abscess apical to the root apices. (b) An osteotomy was created using osteotomes. Bone was placed, followed by the implant, with additional bone placed over the cover screw. (c) Radiographic view of the implant at the second stage connection. (d) At 6 years postrestoration, the bone level covers the first thread.

Discussion

Many clinicians avoid IIP in molar sites. One reason is the proximity of the root sockets to vital anatomical structures (ie, the inferior alveolar canal in the mandible and sinus membrane in the maxilla). For many clinicians, limited apical bone from the root-tip sockets to these vital structures, as well as problems achieving primary stability, preclude the use of the IIP protocol in molar areas. However, there are two factors favoring success of IIP: (1) the fact that following atraumatic extraction of a molar, the socket is at its greatest width, and (2) when the socket walls are preserved, they provide an improved healing capacity and aid in primary implant stability. The high survival rates and advantages using an IIP protocol that were cited earlier attest to the fact that
IIP in molar areas is advantageous.\textsuperscript{11} Molar teeth with infections or with a relatively low sinus can be treated with the IIP protocol if the roots are removed, leaving behind as much bone as is possible (Figs 5 and 6). Use of the Vicryl membrane has many potential advantages, including not needing to be tacked down or covered by advanced flaps, as well as the increase in keratinized tissues between the flaps.\textsuperscript{3} Bone level stability in the current report compares favorably with a previous study by the authors in which bone stability around 1,187 immediately placed implants was evaluated with a 1- to 22-year follow-up.\textsuperscript{4} That study, which looked at implants in all tooth positions, reported statistically significantly more bone loss in maxillary teeth (0.68 ± 0.83 mm) than mandibular teeth (0.43 ± 0.80 mm). Mean bone loss

**Fig 6** (a) A hopeless maxillary left second molar requiring removal. (b) The remainder of the crown was severed, and the roots were separated and removed individually. The sockets were thoroughly degranulated. (c) An osteotomy was prepared using osteotomes, the sinus was elevated, and mineralized freeze-dried bone was placed, followed by the implant. (d) Bone was placed, and the area was covered with a Vicryl membrane and sutured. (e) Implant placement. Bone fill is seen around all root sockets and in the sinus. (f) After 6 months of healing, an abutment was placed. (g) Final restoration 6 years after loading. Bone loss is seen at the first thread on the mesial side, but there is no bone loss on the distal side.
on the 1,187 implants was 0.52 ± 0.79 mm.

The current study evaluated only molars and showed a mean bone loss of 0.27 ± 0.68 mm in the maxilla and 0.27 ± 0.69 mm in the mandible. The current paper, which used the same method of measuring bone loss as the previous study, reported no bone loss past the first thread in 80% of the maxillary molar implants, with a mean bone loss of 0.20 ± 0.59 mm on the mesial side of all implants compared to a mean loss of 0.34 ± 0.79 mm on the distal side. Implants replacing mandibular molars reported no bone loss in 80% of the molar implants at the time of the follow-up examination. When bone loss was converted to millimeters, 80% of the mesial and distal measurement showed bone levels coronal to or covering the first thread reference point. Moreover, there was no SS difference in mean bone loss on the mesial side (0.24 ± 0.66 mm) compared to the distal side (0.30 ± 0.71 mm).

It should be noted that with all of the variables that showed an SS difference in bone loss, in both maxillary and mandibular molar implants, these differences were of a magnitude < 1 mm and would not be considered clinically significant. Another noteworthy finding is that the present authors’ previous study showed that patients unable to utilize postsurgical amoxicillin were 3.34 times more likely to experience implant failures as patients who received amoxicillin. In that study, patients allergic to penicillin were prescribed azithromycin. This is in agreement with a 2007 statement released by the American Heart Association and the American Academy of Orthopedic Implants for patients undergoing dental procedures, which recommended the removal of clindamycin and cefazolin as alternative antibiotic options.

The effect of various antibiotics on dental implant success and bone maintenance should be verified in more controlled research studies. In the present study, the use of azithromycin in patients allergic appeared to act as effectively as penicillin in implants placed with an IIP protocol.

Conclusions

Based upon the outcomes of this retrospective study of bone stability around 441 mandibular and 350 maxillary molar implants that had been in function from 2 to 17 years (mean: 9.9 years postrestoration), the following conclusions can be established:

Mean bone loss was 0.27 ± 0.68 mm around the maxillary implants and 0.27 ± 0.69 mm around the mandibular implants. Maxillary implants demonstrated an SS difference in bone loss on the mesial side of the implant compared to the distal side. This was not the case with mandibular implants. Only mandibular implants demonstrated an SS difference in bone loss with implant diameters ≥ 5 mm compared to implants with diameters < 5 mm, and in patients 50 years and older compared to patients younger than 50 years. These differences were < 1 mm and not considered clinically significant.

No significant differences in bone loss were seen using the IIP protocol for molars for smoking, implant surface (machined vs rough), singly restored vs splinted implants, men vs women, and peri-surgical use of azithromycin as an alternate to amoxicillin.

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References