Current concepts in implant dentistry include a spectrum of loading schedules that includes immediate, early, conventional, and delayed loading of dental implants.¹ Success with immediate loading has been reported for a wide range of dental implant applications, including procedures involving multiple splinted implants in the parasympyseal mandible²–⁶ and the maxilla.²⁹ The immediate provisionalization of a single unsplinted maxillary anterior implant results in reproducible osseointegration and high implant survival rates of 96% to 100%.¹⁰–¹⁵

**Comparison of Radiographic and Clinical Outcomes Following Immediate Provisionalization of Single-Tooth Dental Implants Placed in Healed Alveolar Ridges and Extraction Sockets**

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**Purpose:** The primary goal of this study was to compare implant survival 12 months after immediate loading of single implants placed in healed ridges versus extraction sockets. Secondary outcomes were to compare marginal bone adaptation and soft tissue changes over time. **Materials and Methods:** A prospective multicenter clinical investigation was initiated to assess clinical performance of immediately loaded implants in the maxilla. Implant survival was ascertained at the time of impression making (8 to 10 weeks) and after 1 year by clinical stability. Radiographic marginal bone levels, soft tissue levels, and plaque and bleeding scores were compared with baseline values (implant placement and provisionalization). **Results:** One hundred thirty-nine patients received 157 implants in the maxilla. Single implants with provisional crowns were placed in extraction sockets of 55 patients (58 implants) and in healed ridges of 60 patients (65 implants). In addition, 19 patients (23 implants) required bone grafting prior to implant placement, and 11 implants in 10 patients among all groups were not immediately loaded because of insufficient initial stability after surgery. Three implants (5.2%) failed in extraction sites and one implant (1.5%) failed in a healed ridge. The mean change in marginal bone level 1 year after implant placement was 1.30 mm (SD 2.52) (gain) in extraction sockets and –0.40 mm (SD 1.43) (loss) in healed ridges. The mucosal zenith was stable or moved incisally following definitive crown placement in 83.7% of immediate implants and 87.0% of implants placed in healed ridges. Plaque and inflammation scores were low and did not differ between groups. **Conclusions:** The responses of local bone and soft tissues at immediately loaded implants placed in extraction sockets or healed ridges were similar. Furthermore, these 1-year results suggest that clinical management of esthetically critical soft tissue may be predictably achieved in both indications. INT J ORAL MAXILLOFAC IMPLANTS 2010;25:1222–1232

**Key words:** dental implants, immediate loading, immediate placement, single-tooth replacement

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Success following immediate provisionalization of single unsplinted implants requires good primary stability and the avoidance of occlusal or eccentric contact during the healing period.\textsuperscript{11,16,17} Other measures often employed to ensure success include adherence to strict inclusion and exclusion criteria and ensuring good bone formation by both local and systemic control. Under such circumstances, immediate provisionalization of single, unsplinted implants has been reported to be highly successful.

A recent meta-analysis of treatment outcomes of single-tooth implants treated with immediate, early, and conventional loading protocols demonstrated that overall survival was 95.5%, with no discernible difference between the different loading protocols.\textsuperscript{16} However, the analysis failed to identify sufficient information concerning theesthetic parameters dependent on hard and soft tissue changes around these implants. In a systematic review of immediate loading of implants, De Rouck et al\textsuperscript{14} reported that survival of implants and management of interproximal tissue levels were possible by means of immediate loading or provisionalization procedures. However, the data also indicated that “maintaining the midfacial gingival margin may be more problematic.”

Esthetic success with anterior maxillary tooth replacement involves many clinical parameters but is largely dependent on the peri-implant mucosal architecture.\textsuperscript{18} When excellent treatment planning protocols are deployed, esthetic satisfaction can be reproducibly achieved. A more comprehensive assessment of anterior dental implant success is reflected by both the implant crown esthetic index\textsuperscript{19} and the pink esthetic score,\textsuperscript{20} which implicate the position of the mucosal zenith and the interproximal tissue volume (papillae) as important clinical measures of therapeutic esthetic success.

Changes in peri-implant mucosal architecture occur following the placement of the implant, the associated abutment, and the affiliated crown. Many studies suggest that interproximal tissue volume will increase following crown placement. In an important early report of soft tissue volume changes after abutment connection surgery, Henriksson and Jemt\textsuperscript{21} reported that the increased buccal volume observed immediately after abutment connection was diminished 1 year later. A longer-term evaluation showed increased interproximal (papillae) volume and confirmed a reduction in the buccal tissue volume.\textsuperscript{22} This recession of buccal soft tissue has been reiterated.\textsuperscript{23} However, varied and positive buccal tissue responses have been recorded after immediate implant placement.\textsuperscript{24,25} These changes in soft tissue dimensions following implant placement under many different clinical scenarios require careful definition.

When clinicians elect to place an implant into an extraction socket, the potential for remarkable alveolar architectural change exists. The basis for this has been suggested, through histologic examination of wound healing in beagle dogs, to reflect the preferential resorption of the collagen-rich bundle bone.\textsuperscript{26} Clinical measurement of buccal tissue resorption confirms that the alveolar dimension is dynamic and resorption occurs following placement of a dental implant into an extraction socket.\textsuperscript{27} This suggests that esthetic success following immediate placement and provisionalization of an endosseous dental implant may not be achieved easily. Given the acknowledged loss of buccal bone following tooth extraction,\textsuperscript{28} the response of the buccal tissues following immediate loading of implants in extraction sockets versus healed ridges requires thoughtful consideration and investigation.

The aim of the present investigation was to compare the clinical and radiographic outcomes of implant crowns 1 year following immediate placement and provisionalization in healed ridges and extraction sockets. The primary outcome measure was implant survival. Secondary outcome measures included the changes in interproximal marginal bone levels, papillae, and buccal mucosal zenith positions. The null hypothesis was that there is no difference in implant survival between implants placed in healed ridges and those placed in extraction sockets at 1 year following treatment.

**MATERIALS AND METHODS**

The present investigation was designed as a multicenter, prospective, noninferiority clinical trial. The study was conducted in four centers under a single protocol and received local institutional review board approval and the informed consent of all subjects. Patients were recruited from local dental clinics by requesting individuals in need of replacement of single missing or failing teeth in the maxilla involving the area between the second premolars. Interested patients were screened according to particular inclusion and exclusion criteria (Table 1). Because of the nature of the comparisons, blinding of the investigators and the patients was not possible.

**Treatment Groups**

Patients were placed into either the healed ridge group or the fresh extraction socket group according to the observed clinical condition. Standardized panoramic or periapical radiographs were taken prior to inclusion of subjects in the study, and all participants were screened and treated accordingly for
Table 1  Study Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>In need of single implants replacing missing, extracted, or avulsed</td>
<td>Untreated rampant caries and/or periodontal disease</td>
</tr>
<tr>
<td>teeth in the maxilla between the second premolar positions</td>
<td>Current smoking or tobacco use</td>
</tr>
<tr>
<td>A minimum of 20 teeth with stable interocclusal contacts</td>
<td>Bone augmentation in the planned implant area within 4 mo</td>
</tr>
<tr>
<td>Age at least 18 years</td>
<td>History of extraction in the planned implant area within 3 mo</td>
</tr>
<tr>
<td>Provision of written informed consent</td>
<td>Absence of opposing dentition</td>
</tr>
<tr>
<td></td>
<td>Absence of adjacent natural tooth root</td>
</tr>
<tr>
<td></td>
<td>Uncontrolled diabetes</td>
</tr>
<tr>
<td></td>
<td>Pregnancy at time of inclusion</td>
</tr>
<tr>
<td></td>
<td>Alcohol or drug abuse</td>
</tr>
<tr>
<td></td>
<td>Any systemic or local disease or condition that would</td>
</tr>
<tr>
<td></td>
<td>compromise postoperative healing and/or osseointegration</td>
</tr>
<tr>
<td></td>
<td>Need for systemic corticosteroids or any other medication</td>
</tr>
<tr>
<td></td>
<td>that would compromise postoperative healing and/or</td>
</tr>
<tr>
<td></td>
<td>osseointegration</td>
</tr>
<tr>
<td></td>
<td>Unable or unwilling to return for follow-up visits for 5 y</td>
</tr>
<tr>
<td></td>
<td>Unrealistic esthetic demands</td>
</tr>
<tr>
<td></td>
<td>Unlikely to comply with study procedures according to</td>
</tr>
<tr>
<td></td>
<td>investigators’ judgment</td>
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</tbody>
</table>


caries and endodontic or periodontal infections. Upon surgical evaluation of either the healed alveolar ridge or the fresh extraction socket, clinical decisions were made regarding whether or not an implant could be placed and immediately provisionalized. The first criterion included the dimension of available alveolar bone and, for sockets, the presence of an intact buccal plate of bone or only clinically insignificant deficiencies or fenestrations that would not preclude implant stability or mandate apical displacement of the implant. If implant placement was not possible at this time, a guided bone regeneration procedure was performed using anorganic bovine bone (Bio-Oss, Geistlich Pharma) and a resorbable collagen membrane (Bio-Gide/Bio-Mend; Geistlich Pharma). The latter were allocated to a third treatment group and received an implant 4 to 5 months following grafting. If implant placement could not be achieved with good primary stability, as assessed clinically, patients in these groups were further allocated to a subgroup of exit patients irrespective of the final treatment protocol. Patients in the extraction socket, healed ridge, and grafted site groups were treated according to the approved protocol. The outcome of treatment in the grafted group will be the focus of a separate report.

**Implant Placement**

Treatment was provided for implants required in the second premolar-second premolar areas. Implants with diameters of 3.5, 4.0, 4.5, and 5.0 mm (Osseot Speed, AstraTech) and lengths of 11 to 19 mm were allowed. Implant placement was performed using local anesthesia. Preoperative analgesics and antibiotics were administered. For extraction sockets, the osteotomies were directed through the palatal aspect of the socket such that the implant was well stabilized in the remaining alveolar bone without contacting the intact buccal plate. Osteotomies were initiated with a small round bur, followed by a 2.0-mm drill to the correct depth. Progression to a 3.2-mm-diameter drill (for 3.5- and 4.5-mm implants) or a 3.7-mm-diameter drill (for 4.0- and 5.0-mm implants) was performed using the manufacturer’s protocol. For 4.5- and 5.0-mm implants, conical tapered drills were finally used to the depth of placement. The integrity of the buccal bone was evaluated by probing after each bur sequence. Implants were placed level with the facial osseous crest using up to 50 Ncm of torque. For healed ridges, an apical osteotomy of 3.2 mm or 3.7 mm in diameter was prepared for 3.5- to 4.5-mm or 4.0- and 5.0-mm implants, respectively. Conical bur preparation for 4.5- and 5.0-mm implants was performed and implants were placed using up to 50 Ncm of torque. The horizontal distances from the implant to the buccal and lingual bone crest were measured using a UNC 15 periodontal probe (accurate to ± 0.5 mm). The stability of the implant was measured clinically at the time of placement as the absolute absence of axial or rotational movement by the removal of the implant mount without use of the stabilizing wrench.

**Provisionalization**

Immediate provisionalization procedures were enabled by use of the Direct abutment, the Profile BiAbutment, or the TiDesign abutment (all AstraTech); abutments were inserted immediately after implant placement. Abutments were hand tightened with finger pressure (approximately 15 to 20 Ncm).
abutment dimensions ranged from 4.0 to 6.5 mm in diameter and from 1.55 to 3.5 mm in height (distance from crown margin to implant-abutment interface). Following abutment placement, acrylic resin provisional crowns were fabricated directly in the mouth and adapted in the laboratory onto an abutment analog or the TiDesign abutment. They were highly polished and evaluated for the absence of centric or eccentric contacts using articulating paper and adjusted to ensure this result. The well-fitted and polished provisional crowns were cemented onto the abutment using a glass-ionomer cement to prevent premature debonding during the healing period. The occlusion was evaluated following provisional crown cementation and a periapical radiograph was made to evaluate implant placement, ensure proper abutment placement, and find any residual cement. The mucosal zenith score (linear distance from the mucosal zenith to the incisal edge) and the papilla score (linear distance from the papilla tip to the incisal edge) were recorded to the nearest 0.5 mm. The time of provisional crown cementation was designated as baseline (Fig 1).

Postoperative prescriptions for mouth rinse (0.12% chlorhexidine gluconate) were given to all patients, and analgesics and antibiotics were prescribed if needed. Instructions for oral hygiene included the maintenance of conventional brushing and flossing, with local restrictions around the provisional crown for the first 7 to 10 days after placement. All patients were examined 7 to 10 days after implant placement for suture removal, recording of treatment-related complications, and oral hygiene reinforcement. The peri-implant socket was examined for residual cement and the occlusion was adjusted, if needed, to eliminate centric and excursive contacts during the remainder of the healing period. The peri-implant soft tissue status was evaluated by monitoring the presence or absence of plaque and by light probing of the peri-implant sulcus to register possible bleeding at four points on each crown (mesiobuccal, distobuccal, mesiolingual, distolingual). Three to 4 weeks after implant placement, the patients returned for another follow-up visit. Periapical radiographs were made. The soft tissue status was evaluated, oral hygiene instruction was reinforced, and treatment-related complications were recorded.

**Definitive Crown Procedures**

Eight weeks after the immediate provisionalization procedure, the provisional crown was removed and the abutment was tightened to 20 to 25 Ncm with a torque wrench. Tightening of the abutment without implant movement or pain was considered a sign of clinical osseointegration. The abutment (or implant for TiDesign) was impressed and a definitive ceramic crown (Procera, Nobel Biocare) was fabricated using conventional prosthodontic procedures. Three to 4 weeks later, the definitive crown was cemented and a periapical radiograph was made. Soft tissue status, plaque and bleeding scores, mucosal zenith scores, and papilla scores were recorded.

**Follow-up Evaluation**

Individuals were evaluated in an unblinded manner at 6 and 12 months after implant/provisional crown placement. Any implants that presented with pain, peri-implant radiolucency, and/or mobility were considered failures. Implant mobility was assessed clinically. Abutment or crown complications as well as other treatment-related complications were recorded. Plaque, bleeding on probing, and mucosal zenith and papilla scores were measured. The mucosal zenith and papilla scores were represented as the average distance measured clinically from the mucosal zenith to the incisal edge of the crown (Fig 1d). Periapical radiographs were made to assess bone levels and detect any possible peri-implant radiolucencies.

**Radiographic Analysis**

Periapical radiographs were taken using the long-cone paralleling technique. An independent radiologist not affiliated with the four study centers interpreted all radiographs. The distance from the mesial and distal interproximal bone to the reference point (outer aspect of the implant bevel) was measured to the nearest 0.1 mm and the mean of these two measurements was calculated for each implant. The changes from baseline (day of implant/crown placement) were calculated for all follow-up periods.

**Statistical Analysis**

The enrollment was calculated using standard methods for statistical power with the assumption that there would be a 10% difference in implant survival between groups. It was determined that 48 evaluable patients would be needed in each group to accept or reject the null hypothesis (80% power and 5% significance level). Nonparametric statistics were used for the nonnormally distributed data. The Fisher exact test was used to test for differences regarding implant survival and other frequencies between the groups. Descriptive statistics were used to analyze patient group characteristics. Data were evaluated according to the per-protocol assessment. If a patient had received more than one single implant, a randomization was performed at the time of inclusion unknown to the surgeon. This allowed the patient to be taken as the statistical unit.
Fig 1a  Implant placement. Note the intentional palatal displacement of the implant.

Fig 1b  Provisional implant crown prior to cementation. Note that the gingival tissues are not displaced by the abutment-crown complex.

Fig 1c  Provisional implant crown 8 weeks after placement. Note the stability of the peri-implant mucosal tissues.

Fig 1d  Definitive crown at the 1-year follow-up evaluation. Note the resolution of inflammation at the contralateral central incisor; this was attributed to scaling and root planing. The location of the peri-implant buccal mucosa has remained stable. Line x = the measurement for the papilla score; line z = the measurement of the mucosal zenith.

Fig 1e (Left) Preoperative periapical radiograph of the tooth prior to fracture and replacement.

Fig 1f (Right) One-year follow-up radiograph of implant, abutment, and crown indicating the relative position of the implant to the teeth and the interproximal crestal bone relative to the defined reference point.
RESULTS

This study provided insight into at least four aspects of implant success using an immediate provisionalization protocol for implants placed in healed ridges versus extraction sockets. They included 1-year outcomes and information concerning (1) planning versus actual treatment outcomes, (2) implant survival, (3) interproximal bone level changes, and (4) peri-implant mucosal changes.

Planning Versus Treatment

In this prospective trial, 139 patients with 157 implants were recruited. Of the 73 patients selected for immediate implant placement and provisionalization (n = 79 sites), 15 patients (21%; 17 implant sites [22%]) revealed insufficient bone for implant placement. Among the 70 patients selected for implant placement in a healed ridge (n = 78 sites), 7 patients (10%; eight sites [10%]) possessed insufficient bone for implant placement. Because of the suggested twofold greater risk of placing an implant in a fresh extraction socket versus a healed alveolar ridge, these patients were allocated into the grafted group according to protocol. Forty of 55 implants were placed with a flapless approach or with minimal mucoperiosteal flap reflection. In 15 sites, full-thickness flaps and reflection were required. During implant placement in the respective extraction, healed, and grafted groups, 4, 5, and 2 implants did not achieve primary stability. Eleven implants in 10 patients comprised the exit group and represent patients treated off protocol. In total, of the 157 sites enrolled for immediate provisionalization, 34 sites (22%) did not receive a dental implant and provisional crown at the planned treatment visit.

A randomization procedure was performed so that only one implant per patient was analyzed. Finally, 55 implants in the extraction group and 58 in the healed ridge group were evaluated. The demographic profiles are provided in Table 2. Among these patients, a wide range of clinical conditions was accommodated by the study design. No sites involved type 4 bone and no differences were observed in the range of bone quality and quantity for the two groups. The distribution of implants according to position and site condition is represented in Table 3. The dimensions of implants selected for treatment ranged from 3.5 to 5.0 mm in diameter and 11 to 17 mm in length (Table 4). However, longer and larger implants were used more frequently in the extraction socket group compared to the healed ridge group. For example, 69% of implants in extraction sockets were 15 to 17 mm in length, whereas only 38% of implants in healed ridges were 15 to 17 mm long.

Implant Survival

Of the 113 patients included in the analysis, 108 experienced implant survival (96%) after 1 year. In the extraction socket group, three implants failed, resulting in a survival rate of 94.5%. One implant was unaccounted for (the patient was lost to follow-up), and consequently the “worst case” survival rate is 51 of 55 after 1 year (92.7%). For the healed ridge group, 1 of 58 implants failed, giving a survival rate of 98.3%. There was no statistically significant difference between the treatment groups.

Peri-implant Bone Response

Average changes in interproximal marginal bone levels for healed ridges and extraction sites are shown in Fig 2. In the extraction socket group, a bone gain of

<table>
<thead>
<tr>
<th>Table 2  Demographic Features of Randomized Patients</th>
</tr>
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<tbody>
<tr>
<td>n</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>Extraction socket</td>
</tr>
<tr>
<td>Healed ridge</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3  Planned Implant Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Extraction socket</td>
</tr>
<tr>
<td>Healed ridge</td>
</tr>
<tr>
<td>Total*</td>
</tr>
</tbody>
</table>

*Representing the 113 implants randomized for per-patient evaluation.
Cooper et al

1.30 ± 2.52 mm (range, –1.9 to 8.1 mm) was measured, while the healed sites lost an average of 0.40 ± 1.43 mm of bone (range, –4.7 to 4.0 mm); this difference was statistically significant ($P < .05$). At 1 year, the bone levels (relative to the reference point) were 0.81 ± 0.86 mm and 1.18 ± 1.19 mm for implants in healed ridges and extraction sockets, respectively (difference not significant).

**Peri-implant Mucosal Responses**

The health of the peri-implant mucosa in all patients was good, as indicated by low values for bleeding on probing among the entire study population and irrespective of treatment group. This was also reflected by the low Plaque Index. The evaluation of interproximal tissue revealed an increase in papilla height over the 1-year period. An important observation is that the initial distance from the distal papilla tip to the incisal reference point differed among the groups, with mean distances of 5.9 ± 2.1 mm and 5.3 ± 2.2 mm for the healed ridge and extraction socket groups, respectively. The average changes in interproximal tissue dimensions for the mesial and distal sites are shown in Figs 3a and 3b. It should be noted that the calculated median changes in the mesial papillae from implant placement/provisionalization to definitive crown delivery were 0.0 mm for both groups. After 1 year, median changes for the mesial papillae were 0.0 mm for the extraction socket group and –0.2 mm (gain) for the healed ridge group. Similar changes were recorded for the distal papillae.

The relationship between the buccal gingival tissue and an incisal reference point was monitored throughout the study period following implant placement/provisional crown cementation. For implants placed immediately in extraction sockets, the average

---

**Table 4 Implant Lengths and Diameters**

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
<th>Extraction socket</th>
<th>Healed ridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 mm</td>
<td>11 mm</td>
<td>2 (4%)</td>
<td>3 (5%)</td>
</tr>
<tr>
<td>4.0 mm</td>
<td>13 mm</td>
<td>4 (7%)</td>
<td>3 (5%)</td>
</tr>
<tr>
<td>4.5 mm</td>
<td>15 mm</td>
<td>2 (4%)</td>
<td>6 (11%)</td>
</tr>
<tr>
<td>5.0 mm</td>
<td>17 mm</td>
<td>1 (2%)</td>
<td>4 (7%)</td>
</tr>
</tbody>
</table>

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**Fig 2** Mean changes in marginal bone levels from placement to the 1-year follow-up.

**Fig 3a** Distance of the mesial papillae from the incisal reference point over time. The vertical line indicates the time of definitive crown delivery.

**Fig 3b** Distance of the distal papillae from the incisal reference point over time. The vertical line indicates the time of definitive crown delivery.
mucosal zenith score was reduced over time and reflects a more coronally positioned mucosal margin (Fig 4). Similar positive changes were noted in the healed ridge group. Both groups demonstrated an increased tissue dimension at the time of definitive crown cementation and an overall increased mucosal zenith score between definitive crown placement and 1 year (Table 5): 0.35 ± 0.89 mm for the extraction group and 0.3 ± 0.76 mm for the healed ridge group. The mucosal zenith was stable or moved coronally at 83.6% of implants placed in extraction sockets versus 87.0% of implants placed in healed ridges. This difference was not statistically significant.

**DISCUSSION**

The current investigation sought to extend existing information concerning immediate provisionalization of dental implants placed in healed ridges versus fresh extraction sockets in terms of implant survival and success, marginal bone adaptation, peri-implant mucosal responses, and prosthetic complications. Based on acceptable survival rates for immediate loading of implants in healed ridges, it was of interest to define the outcome of immediate provisionalization for implants placed in extraction sockets versus healed ridges. Chaushu et al compared immediate loading of implants in sockets and showed 82% survival, versus 100% survival of implants placed in healed ridges. More recently, Ribeiro et al compared the survival of immediate nonocclusal loading of 46 implants placed in extraction sockets versus 36 placed in healed ridges. Three implants failed in the extraction socket group (93.5% survival) and no implants failed (100%) in the healed ridge group (difference not significant). The results of this prospective investigation also reveal a statistically insignificant reduction in the recorded survival of immediately loaded implants placed in extraction sockets (94.5% [“worst case” 92.7%] versus 98.3%). Whereas the majority of implants were placed using a similar flapless approach, many implants were placed following full-thickness flap incision and modest reflection to reveal the condition of the crestal bone or to permit inspection of the socket. No relationship between failure and flapless versus flap surgery could be ascertained in this investigation.

Of the features that may influence osseointegration, primary stability is regarded as the principal clinical determinant. Without the use of a particular definition or measurement of primary stability, clinical judgment (absence of axial or rotational movement at abutment placement) was used to define stability for loading. The provision of a grafted bone group permitted clinicians the latitude to delay implant placement following extraction of a tooth or initial drilling of a healed alveolar ridge. Additionally, the presence of infection and/or the absence of a buccal plate of bone were considered contraindications for implant placement into a socket. Twenty-two percent of the sockets were not suitable

Table 5 Change in Mucosal Zenith (Mucosal Zenith Scores*) Between Placement of the Definitive Crown and 1 Year Later

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction socket</td>
<td>49</td>
<td>-0.35</td>
<td>0.89</td>
<td>0</td>
</tr>
<tr>
<td>Healed ridge</td>
<td>54</td>
<td>-0.30</td>
<td>0.76</td>
<td>0</td>
</tr>
</tbody>
</table>

*Scores shown in millimeters; negative values denote increased tissue dimension.

Table 6 Evaluation of Midfacial Peri-implant Mucosal Changes at Single-Tooth Implants

<table>
<thead>
<tr>
<th>Study</th>
<th>Measured midfacial recession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small and Tarnow</td>
<td>≈ 1 mm</td>
</tr>
<tr>
<td>Oates et al</td>
<td>0.6 mm</td>
</tr>
<tr>
<td>Kan et al</td>
<td>0.55 mm</td>
</tr>
<tr>
<td>Cornelini et al</td>
<td>0.75 mm</td>
</tr>
<tr>
<td>Lindeboom et al</td>
<td>No change at 43 of 45 implants</td>
</tr>
<tr>
<td>Reyser et al</td>
<td>Not reported</td>
</tr>
<tr>
<td>Kan et al</td>
<td>Up to 1.5 mm</td>
</tr>
<tr>
<td>Evans and Chen</td>
<td>0.9 mm</td>
</tr>
<tr>
<td>Palattella et al</td>
<td>0.8 mm</td>
</tr>
<tr>
<td>Chen et al</td>
<td>4.6% (of the incisor length)</td>
</tr>
<tr>
<td>Ziglon and Machtler</td>
<td>0.62 mm</td>
</tr>
</tbody>
</table>

Fig 4 Distance from the mucosal zenith to the incisal reference point versus time. Mucosal zenith scores were measured at baseline, after 8 to 10 weeks on the provisional crown, after definitive crown delivery, and after 1 year.
for implant placement and were grafted. Obtaining primary stability may depend on careful site selection and preparation. Sockets may be classified to aid in the selection of appropriate clinical therapy; however, the current protocol did not use a defined socket classification system. Kan et al demonstrated that buccal socket wall defects of increasing severity (V-shaped, U-shaped, and ultra-U-shaped) were associated with an increased incidence of midfacial recession greater than 1.5 mm. It is likely that the current protocol’s triage of patients to a grafting group eliminated many high-risk scenarios that have been reported to show progressive midfacial recession.

An incremental reduction in survival for immediately loaded implants in extraction sockets may be observed even when rigorous inclusion and exclusion criteria are employed and procedures are performed by experienced clinicians. In this study, longer implants were placed in extraction sockets to achieve primary stability. Additionally, a modified drilling protocol employing undersized-diameter drills (3.2 mm for 3.5- and 4.5-mm implants and 3.7 mm for 4.0- and 5.0-mm implants) was used, but neither minimal torque values nor implant stability quotients (resonance frequency values) were deployed as indicators of stability. Previous recommended torque values typically reflect the torque needed to tighten the associated abutment screws (eg, 32 Ncm). In the present study, the use of conical-interface abutments permitted mechanical interlocking without high torque (> 20 Ncm) or the use of a torque control device. This approach is associated with little or no abutment loosening during the provisional healing period. The ability to place an abutment on an immobile implant served as a pragmatic clinical indicator of primary stability.

The process of immediate provisionalization also involves the process of mucosal integration with a dental implant abutment and related crown. The 8-week healing period corresponds closely to the period necessary for soft tissue integration with a titanium abutment. This time period further permits osseointegration (bone-to-implant contact) at the hydrofluoric acid–modified/TiO₂ grit–blasted implant surface (OsseoSpeed). Rapid bone accrual is in part a result of surface-mediated osteogenesis related to the nanoscale topographic modification of the surface. Importantly, bone formation and peri-implant mucosal integration proceeded without clinical intervention.

The interproximal loss of marginal bone levels of 0.4 mm (SD 1.43) after 12 months is in agreement with other reports on the use of the Astra Tech Implant System in healed ridges. It is consistent with those obtained in an early loading study. Most recently, Donati et al demonstrated mean changes in marginal bone levels of 0.17 mm (SD 0.66) for 4.0-mm implants and 0.48 mm (SD 1.0) for 4.5-mm implants at 1 year following immediate functional loading. Whereas other investigations compared bone level changes at immediately loaded versus conventionally loaded implants or immediate loading versus immediate provisionalization and did not identify differences in interproximal marginal bone levels, this study recorded similar resultant interproximal bone-to-implant contact levels after the immediate provisional loading of implants placed in extraction sockets versus healed ridges.

In this report, soft tissue responses were quantified using objective measures of papilla and mucosal zenith architecture. This prospective and objective evaluation of papilla maintenance/regeneration demonstrated the maintenance of or increases in both the extraction socket and healed ridge groups. Comparison of immediate loading versus immediate provisionalization revealed only minor differences in papilla status after 1 year. A comparison of immediate loading versus delayed loading failed to reveal differences in papilla status. As anticipated, the extraction socket group presented intact papillae without subsequent tissue increases. Greater interproximal tissue (papillae) formation was recorded around implants placed in healed ridges. It is suggested that the responses reflect the condition of the tissues prior to implant placement and that interproximal tissue formation should be part of the response to careful implant placement and restoration.

Numerous reports have demonstrated midfacial recession following implant placement in healed ridges or sockets (Table 6). The present 1-year observation revealed mucosal zenith index stability. Evans and Chen reported buccal tissue stability in the superior/inferior direction when the thickness of tissue facial to the dental implant/abutment complex was greater than 1.8 mm; when the tissue was less than 1.8-mm thick facial to the implant, buccal tissue recession occurred. In the present investigation, the distance between the implant and the facial crest was measured at the time of implant placement. The average 1.52-mm palatal displacement of the implant from the buccal bone crest in the extraction sockets is consistent with a goal of achieving approximately 2 mm of tissue facial to the implant-abutment interface and is consistent with the observations made by Evans and Chen. In this study, the vertical displacement of the margin was also controlled. The protocol designated the use of a titanium abutment with the implant-abutment interface at least 1.55 mm apical to the crown margin. It is possible that these spatial relationships permitted peri-implant mucosal integration.
with the abutment in a supracrestal position. The peri-
implant mucosal stability observed here may reflect
the designated buccolingual and palatal placement of
the implants relative to the tissues and the integrity of
the interface, as suggested previously.48

Tissue biotype was not considered as a variable in
the present investigation, and the study was not
designed to discern differences. It is difficult to con-
sider the tissue biotype of teeth prior to extraction
versus the tissue quality of the healed alveolar ridge.
In fact, the biotype may not be relevant after tooth
extraction. Potentially, the effect of what is consid-
ered as a thick or thin biotype on implant esthetic
outcomes may reflect the buccolingual (horizontal)
orientation of the implant to existing buccal bone.

Other investigations have not focused fully on
buccal architecture.15,20 In a previous investigation,
Cooper et al34 measured the stability of buccal peri-
implant mucosa and recorded an improvement in the
mucosal zenith score over 3 years. The reasons for this
are not fully elucidated, but may include (1) preser-
vation of buccal osseous architecture related to implant
placement location or biomechanical responses of
tissues to the component system; (2) contribution of
new surface technologies to sulcular bone forma-
tion or preservation; (3) peri-implant mucosal integration
with the abutment (or the implant); (4) the frequent
use of flapless surgery; (5) the use of abutments that
displaced the crown margin approximately 2 mm
from the implant-abutment and implant-bone inter-
face; (6) prosthetic management of loading and
restoration, often using a single-piece titanium abut-
ment that served as both the provisional and defini-
tive abutment, thus avoiding repeated abutment
removal and replacement; and (7) careful peri-
implant tissue management that prevented the inclu-
sion of cement or restorative materials in the sulcus
or at the implant/bone interface. Block et al49 dem-
onstrated that immediate nonocclusal loading pre-
served a gingival margin position that was 1 mm
more facial compared with delayed restoration of an
implant. It is important to recognize that these tissue
responses reported represent 1-year postoperative
changes, and the intent of the present study is to
consider fully the 5-year outcomes of this therapy in
the different groups.

CONCLUSION

Immediate provisionalization of dental implants in
both extraction sockets and healed ridges resulted in
acceptable implant survival rates, minimal bone
resorption, and modest peri-implant tissue changes
after 1 year. This outcome is similar to that seen with
conventional loading protocols using the same
implant and component system. One potential
advantage observed using this protocol and compo-
nent system is the controlled management of buccal
peri-implant mucosal architecture. Longer-term eva-
ulation and assessment of the potential facets of ther-
apy that contribute to this positive tissue response is
the focus of ongoing investigation.

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