Clinical and Radiographic Evaluation of Early Loaded Maxillary Anterior Implants: Three-Year Follow-up

Erkut Kahramanoglu, DDS, PhD1
Yılmaz Umut Aslan, DDS, PhD1
Yasar Özkan, DDS, PhD2
Yasemin Özkan, DDS, PhD1

The aim of this study was to evaluate clinical and radiologic results up to 3 years in patients treated with early loading of anterior implants supporting single-tooth all-ceramic restorations. Twenty-four patients were treated with 29 screw-type implants in the anterior maxilla. The implants were evaluated by clinical and radiographic parameters. Clinical parameters Plaque Index (PI), Sulcus Bleeding Index (BI), peri-implant probing depth (PD), and marginal bone loss (MBL) were recorded. At the recall examinations, all implants were successfully integrated, demonstrating healthy peri-implant soft tissues as documented by standard clinical parameters. No biologic complications were observed. There was no statistically significant increase in MBL between the baseline and recall stages (P > .05). Early loaded maxillary anterior implants supporting single-tooth restorations reveal successful clinical and radiographic outcomes when treatment steps were performed.


Implant placement and restorations in the esthetic zone are considerably challenging. Successful implant treatment relies on the osseointegration of the implant and on the functional and esthetic outcomes of the final prosthesis.1–3

The esthetic zone represents a sensitive restorative region where multiple risk factors have to be considered. The esthetic outcome and level of peri-implant mucosa could be affected by the loss of peri-implant marginal bone. Peri-implant soft tissue health is critical for the long-term survival and esthetic stability of dental implant restorations. Achieving a predictable outcome in the esthetic zone requires an appropriate treatment plan and selection of the loading protocol.4–10

Marginal bone loss (MBL) around dental implants has been attributed to several factors, including surgical trauma, poor osteotomy preparation, occlusal forces and micromotion, and microgap or establishment of biologic width. MBL may be the result of the establishment of a pathogenic microflora, promoting the occurrence of peri-implant diseases with mucosal inflammation, increased pocket depth, and progressive bone resorption.1–10

Stability of the implant-abutment connection is of high importance for the long-term success of implant-based prosthetic reconstructions.
Different geometric designs of positional indices are used in various implant systems. Recent studies were conducted regarding the design and surface treatment of implants to minimize instability. An important factor for providing good stability is a strong and reliable connection between implants and abutments. The abutment components are manufactured for precise fit and ideal load distribution, which enhances stability and ensures long-lasting esthetics and maintenance of crestal bone.\textsuperscript{11–14}

Many studies have demonstrated that the design of implant-abutment connections appears to limit crestal resorption, mediate the implant-abutment microgap and inflammatory cell infiltration, and preserve peri-implant bone levels.\textsuperscript{15–23}

The Camlog Implant System has a “tube-in-tube” implant-to-abutment connection, and the implants with a Promote Plus surface present a machined neck of 0.4 mm. The high-precision positive press-fit and antirotational stability allow a secure and lasting screw connection to fabricate simple and durable prostheses. As a result of the positive press-fit and “tube-in-tube” connection, the force distribution of the implant abutment connection is ideally established.\textsuperscript{11–13}

The success criteria and patient-centered outcomes may be affected by loading protocols. There are few studies in the literature about short- and long-term follow-up results for single-tooth implant replacement with early loading in the esthetic zone.\textsuperscript{7,8,10,23}

The purpose of this study was to prospectively assess the implant success rate and marginal bone response of early loading implants using Camlog Implant Systems in maxillary anterior areas.

**Materials and Methods**

Twenty-four patients were treated with 29 screw-type implants in the anterior maxilla. The patients consisted of 7 women and 17 men with a mean age of 40 years. The implant sites included 10 central incisors, 9 lateral incisors, 2 canines, and 8 first premolar positions.

All the surgical procedures were performed at the Department of Oral Maxillofacial Surgery, School of Dentistry, University of Marmara, Turkey, and all restorative procedures were performed at the Department of Prosthodontics, School of Dentistry, University of Marmara, Turkey. Ethical approval was obtained from Medipol University Ethics Committee (66291034-28), and participants received oral and written information about the study and provided informed consent. The exclusion criteria were: general contraindications to implant surgery, poor oral hygiene, poor motivation, pregnancy, treated or untreated periodontitis or periapical pathology, smoking more than 10 cigarettes per day, needling grafting procedures, healed extraction sites, and Angle Class III malocclusion. Opposing occlusion (natural teeth or dentures) and natural teeth that were mesial or distal to the edentulous space were included in the study.

The preoperative planning was based on clinical and radiographic examination. The implant site was evaluated with cone beam computed tomography (CBCT) and orthopantomography (OPTG).\textsuperscript{3–5} All surgical procedures were performed by one surgeon (Y.O.) and carried out under local anesthesia. Thereafter, vertical and mid-crest incisions were performed, and a full-thickness flap was elevated. Twenty-nine implants (K series Camlog Screw-Line Promote plus, Camlog) were placed in 24 patients according to standard surgical protocol. After 3 weeks of the healing, a screw-retained provisional restoration from polymethyl methacrylate (IMIDENT, Imicryl) was fabricated using the temporary abutment made of polyether ether ketone (PEEK; Camlog Temporary Abutment, PEEK, Camlog) for soft tissue remodeling. Throughout the osseointegration period, temporary crowns had minimal occlusal contact during lateral and protrusive movements. Following completion of osseointegration (8 weeks), all-ceramic crowns (IPS e.max, Ivoclar Vivadent) were fabricated using ceramic abutments, which is a two-part abutment consisting of a titanium base and a zirconium oxide sleeve. Then the all-ceramic restorations were adhered to ceramic abutments with resin cement (Multilink Automix, Ivoclar Vivadent). The occlusal relationships were checked for canine-guided occlusion. The patients were recalled 1 week after cementing the restorations (baseline), at 6 months, and
annually thereafter (12, 24, and 36 months) for clinical data collection. All data were retrieved by two blind-examined examiners (E.K. and Y.U.A.). Figures 1 and 2 show the early loading procedure as carried out in two patients treated in the present study.

**Clinical Evaluation Parameters**

Modified Plaque Index (mPI) was used to determine plaque levels on the mesial, distal, buccal, and palatal surfaces of the implants. For each implant, the mPI value was calculated based on the average of the four obtained values: 0 = no detection of plaque; 1 = plaque only recognized by running a probe across the smooth marginal surface of the implant; 2 = plaque can be seen by the naked eye; and 3 = abundance of soft matter. Bleeding on probing was measured using the Modified Bleeding Index (mBI) at four aspects around the implants: 0 = no bleeding when a periodontal probe is passed along the gingival margin adjacent to the implant; 1 = isolated bleeding spot visible; 2 = blood forms a confluent red line along the margin; and 3 = heavy or profuse bleeding.

Probing depth (PD) was measured in mm using a periodontal probe (PGF-GFSR, Hu-Friedy) on the mesial, distal, buccal, and palatal surfaces of the implants. For each implant, the PD value was calculated based on the average of the four measured values.12–14

**Radiologic Evaluation Parameters**

Assessments of bone quantity at the implant sites were done after implant placement (baseline for marginal bone level) and at the 6-,

---

**Fig 1** Case 1. (a) Cone beam computed tomography before treatment. (b) Intraoral view before treatment. (c) Intraoral view after treatment (at 3 years). (d) Periapical radiograph at baseline. (e) Periapical radiograph at 3 years.
12-, 24-, and 36-month follow-ups with the help of intraoral periapical radiographs (VistaScan Mini, Dürr Dental), obtained by the long-cone paralleling technique to minimize the distortion caused by using standard film holders (Super-Bite, Kerr). To correct dimensional distortion, the apparent dimension of each implant was measured on the radiograph and then compared with the real implant length. Both the implant and the adjacent teeth were analyzed on the facial aspect. The implant-abutment junction was set as a reference point. Measurements were obtained from successive radiographs, which were then digitized and analyzed at ×20 magnification using a software program (CorelDraw 9.0, Corel). The actual bone level measurement was performed independently by two examiners (E.K. and Y.U.A.), the average of the two calculations was used as the marginal bone level value (MBLV). Differences between MBLV at every recall appointment were recorded as MBL or marginal bone gain (MBG).

The data were statistically analyzed with respect to mPI, mBI, PD, MBL/MBG, and success rates or frequency of adverse events. For statistical analysis in this study, each patient was considered as one unit. For the statistical analysis of mPI and mBI, Wilcoxon signed rank test and Mann-Whitney U test were used. Soft tissue recession, PD, MBL, and MBG measurements were evaluated using time-dependent repeated-measures analysis of variance (ANOVA). All tests were performed using statistical software (SPSS version 11.5, IBM) at a level of significance of $P = .05$.

**Results**

At the recall examinations, all implants were successfully integrated, demonstrating healthy peri-implant soft tissues as documented by standard clinical parameters. During the 36-month observation period, there was no incidence of implant failure, excessive bone loss around implants, or peri-implant inflammation. There were no patient dropouts during the observation period. The implant cumulative survival rate was 100%.

The results of baseline and recall evaluations are shown in Table 1. Soft tissues were clinically healthy. No mPI scores of 2 and 3 were noted during the entire study. The average mBI was 0.07 ± 0.26 mm at baseline and was 0.31 ± 0.47 mm at the end of 3 years of follow-up. Throughout the study, comparing mPI and mBI values revealed no
statistically significant differences ($P > .05$). The mean PD at baseline was $2.82 \pm 0.60$ mm and increased to $3.06 \pm 0.88$ mm at 3 years, but the difference was statistically insignificant ($P > .05$). When evaluating MBLV, two of the implants showed an increase in the level of bone contact. The mean MBL at 6 months and 1 year was $0.12 \pm 0.13$ mm and $0.21 \pm 0.19$ mm, respectively. The MBL reached to $0.47 \pm 0.75$ mm at 3 years (Table 1). No statistically significant differences in MBLV changes were observed between any recall appointments ($P > .05$).

No prosthetic complications, such as porcelain fracture or recementation, were observed during the 3-year evaluation period. The results suggest that the soft tissue status around implants was found to be satisfactory.

**Discussion**

Prosthetic management with implants in the anterior maxillary region can be functionally and esthetically challenging. In this clinical study, maxillary anterior single-tooth gaps were restored with early loading implants with 3.8 or 4.3 mm diameter (9 to 16 mm in length) and 0.4-mm machined-neck implants with matching abutments, placed at bone level.

Evaluations of mPI, mBI, and PD showed gingival stability around implants. There was no bleeding on probing in gingiva and peri-implant mucosa. Plaque levels were fairly low, and the levels measured at baseline and the 3-year assessment were comparable. Similar observations have been described in a long-term study,\(^1\) which may be explained by stabilization of the gingiva and peri-implant mucosa at 3 weeks after installation of the temporary prosthesis. The aid of an accurate emergence profile of the temporary prosthesis should help gingiva heal without recession. Moreover, gingiva’s resistance to external stimuli is increased by using zirconia abutments with gingival collar height as final abutments.

Interdental papillae loss and decreased facial gingival height, particularly when provoked by peri-implant marginal bone resorption, may cause patient dissatisfaction or, even worse, functional failure of implants. Six weeks following implant placement, all cases showed adequate marginal bone levels except for one, in which the implant was misplaced above the alveolar crest. Initial bone loss is generally expected due to surgical trauma and bone remodeling after implant placement.\(^2\) According to the radiographic evaluation, all implant proximal crests were completely surrounded by bone at the time of provisional crown connection; the inherent design and surface texture of the Camlog implants appear to have contributed to the stability of marginal bone level in the present study.

In this study, early loaded implants showed an average MBL of $0.47 \pm 0.75$ mm at 3 years after implant placement. Most of the patients showed less than 0.5 mm of bone resorption. Two cases even showed positive bone gain during the study. These values are smaller than similar clinical studies of two-piece dental implants with similar designs.\(^10,14\) It is obvious that the implant surface has an effect on peri-implant bone resorption. It was indicated that chemically modified implant surfaces seem to enhance bone regeneration in acute-type buccal dehiscence defects of submerged implants.\(^12,14\)

In this study, Camlog Screw-Line Promote plus Implant Systems were used. Schwarz et al\(^13\) investigated the effect of two different Camlog Screw-Line implant designs (2-mm [Promote] vs 4-mm [Promote plus] neck length) on crestal bone resorption in a canine study. Both implant types were inserted in the

<p>| Table 1 Baseline and Recall Evaluation Results |
|-------------------------------|------|------|------|------|</p>
<table>
<thead>
<tr>
<th>Time</th>
<th>MBL (mm)(^a)</th>
<th>SPD (mm)(^b)</th>
<th>mPI(^b)</th>
<th>mBI(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>2.82 ± 0.60</td>
<td>0.02 ± 0.01</td>
<td>0.07 ± 0.26</td>
<td></td>
</tr>
<tr>
<td>6 mo</td>
<td>0.12 ± 0.13</td>
<td>2.96 ± 0.73</td>
<td>0.04 ± 0.19</td>
<td>0.17 ± 0.38</td>
</tr>
<tr>
<td>1 y</td>
<td>0.21 ± 0.19</td>
<td>2.93 ± 0.75</td>
<td>0.07 ± 0.26</td>
<td>0.21 ± 0.41</td>
</tr>
<tr>
<td>2 y</td>
<td>0.34 ± 0.41</td>
<td>3.00 ± 0.65</td>
<td>0.14 ± 0.36</td>
<td>0.21 ± 0.41</td>
</tr>
<tr>
<td>3 y</td>
<td>0.47 ± 0.75</td>
<td>3.06 ± 0.88</td>
<td>0.29 ± 0.60</td>
<td>0.31 ± 0.47</td>
</tr>
</tbody>
</table>

MBL = marginal bone loss; SPD = sulcus probing depth; mPI = modified Plaque Index; mBI = modified Bleeding Index.

\(^a\)Baseline is implant placement.

\(^b\)Baseline is cementation of the final prosthesis.
mandibles of dogs following standard protocol (0.4 mm above the bone crest). Histologic evaluation took place after 2 and 12 weeks. Bone changes were found in both implant types after 12 weeks. However, the neck area in the Promote plus implants appeared to have a positive effect on marginal bone growth. Data demonstrated that the new surface design efficiently reduced crestal bone changes. Therefore, the less peri-implant bone loss seemed to be an effect of the design of surface treatment. The reason for the low MBL found in this study may be due to the surface properties of Camlog Screw-Line Promote plus implant systems. 13

Stability of the implant-abutment connection is strongly influenced by the precision of fit, connection design, and manufacturing precision. It has been postulated that early MBL is related to the establishment and stabilization of a biologic seal in implant design. 6,18,19 The Camlog implant system, which has “tube-in-tube” implant-to-abutment connection, was used in the present study. The positive, high-precision press-fit and antirotational stability allow a secure and lasting screw connection to fabricate simple and durable prostheses. 6,20 As a result of the positive press-fit and “tube-in-tube” connection, the force distribution of the implant abutment connection is ideally established. Screw loosening and fractures are practically excluded because the abutment screws are hardly loaded and only have a holding function. The results of the present study confirm these outstanding properties.

There are similarities between the present results and those of studies using platform-switched implants. 1,10,14 Platform switching is the concept in which the implant-abutment interface is placed away from the implant shoulder and closer to the long axis of the implant, increasing the microgap distance from the surrounding bone. In the present study, using non-platform-switched abutments for early loading of single-tooth implants in the anterior maxilla showed successful treatment outcomes with high predictability and a low risk of complications. All 29 implants achieved and maintained successful osseointegration and healthy peri-implant soft tissues, according to the standard clinical and radiographic guidelines, at 3 years of follow-up. Although platform-switched designs were not used in the present study, the results are comparable and may be related to precision fit and a tight connection between the abutment and implant system.

Conclusions

The internal “tube-in-tube” implant system showed promising long-term results, even with early functional loading after implant placement. All implants were osseointegrated with no complications and showed clinically acceptable bone loss after 3 years. The peri-implant soft tissue was esthetically favorable and had long-term stability. Within the limitations of the present study, Camlog Screw-Line Promote plus Implant Systems in the anterior zone revealed successful clinical and radiographic outcomes when ideal treatment steps were performed. However, these preliminary results need to be confirmed with minimum 5-year follow-ups.

Acknowledgments

The authors report no conflicts of interest related to this study.

References


