Customized vs Conventional Implant-Supported Immediate Provisional Crowns for Fresh-Socket Implant: A Medium-Term Cone Beam Computed Tomography Study

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Purpose: To measure the volume effect on maintaining a sealing around immediately rehabilitated dental implants in a comparison between customized and conventional provisional crowns at a 3-year follow-up. Materials and Methods: A single crown supported by a dental implant was used as a rehabilitation strategy for a failing tooth. The primary predictor was the type of immediate restoration with custom or conventional provisional crowns; a secondary predictor was tooth position: incisor, canine, or premolar. In order to accurately measure the width between buccal and palatal plates at the alveolar margin in a comparison between preoperative (before tooth extraction) and postoperative (at the 3-year follow-up) radiographs, two cone beam computed tomography (CBCT) scans were three-dimensionally analyzed and superimposed. Results: Seventy-six patients, rehabilitated with single implants, were selected (31 implants belonging to the custom group and 45 to the conventional group). In patients treated with conventional restorations, a significant shrinkage (−0.6 ± 1.2 mm with P = .002) was registered. On the other hand, the bone change registered for the custom restoration group appeared negligible, with a nonsignificant and slight increase in width (+0.2 ± 0.7 mm). When the subgroups regarding the implant sites were investigated, the decrease in width was very limited for the canine tooth in the custom group (−0.3 ± 0.2 mm), whereas the shrinkage at the canine in the standard group appeared to be significantly higher (−1.5 ± 0.7 mm with P = .0001). Conclusion: An anatomically contoured provisional restoration may provide a strategy to stimulate peri-implant soft tissue healing, minimize loss of buccal bone plate at the marginal level, and maintain pristine volume in the alveolar bone better than noncustomized restorations. Int J Oral Maxillofac Implants 2019;34:1505–1511. doi: 10.11607/jomi.7199

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To preserve a good esthetic profile of the tissue volume contour around implants supporting fixed prostheses, several authors placed a dental implant in a fresh extraction socket with immediate loading protocols (mainly an immediate loading of provisional restorations), and reported excellent survival rates. However, it was attested that immediate placement of implants cannot completely prevent the shrinkage of the buccal tissue contour, due to a complex and not completely understood relationship existing among peri-implant tissues. The peri-implant buccal area could undergo a reduction in hard tissue volume after tooth extraction, and this may lead to a clearly evident shrinkage of the gingival contour. Because the morphology of the tissues around a dental implant is dependent mainly on features of the alveolar bone as well as on the prosthetic-implant restoration, proper prosthetic devices may provide a quick and correct anatomical shell structure that gives natural support.
to the soft tissues after tooth extraction by conforming to and generally maintaining the pre-extraction soft tissue appearance at the cervical aspect.¹⁹ Clinicians have attempted to prevent the alveolar collapse by different surgical and prosthetic strategies such as filling in the gap between the implant and the peripheral bone with substitute materials,¹⁰–¹² increasing soft tissue volume with a graft,¹³ or delivering an immediate provisional restoration.¹⁴,¹⁵ Even though provisional crowns can potentially lead to significant complications, such as manufacture loosening or surface damage, the implant immediately placed and loaded with a provisional prosthesis could provide physical support for soft tissue around the dental implant, although the relevant studies reported conflicting results.¹⁶,¹⁷ Trimpou and coworkers suggested that a patient’s individual setting was needed to exactly replicate the dimensions of the remaining teeth, mainly at the cervical level of the provisional prostheses, in order to maintain biologic features, to maximize the esthetic aspect, and to create a natural-looking emergence profile out of the soft tissue.¹⁸

Moreover, an emergent property of the provisional prosthesis in the first phase of healing could be to give adhesion for the marginal soft tissue. Adherent mucosa might also act as a biologic barrier during the healing stage.¹⁹ In addition, the aforementioned data were obtained from two-dimensional and clinical results. The present study was carried out by cone beam computed tomography (CBCT),²⁰ since it improved views of the anatomical features that could not be observed with orthopantomographic images or intraoral radiographs.²¹

The aim of this clinical and radiologic study was to measure the volume effect at a 3-year follow-up on maintaining a very small gap between the pristine dentogingival soft tissue collar and the prosthesis, that is, just like with perfect sealing around immediately rehabilitated dental implants by means of a custom provisional crown that could favor soft tissue preservation during the healing process. Measurement of the bone remodeling at the 3-year survey was performed via three-dimensional (3D) investigation.

### MATERIALS AND METHODS

#### Patient Selection

Patients were treated from February 2014 to June 2015 at the Tuscan Dental Institute and followed up until 3 years after surgery for the period 2014 to 2018 at the Complex Operating Unit of Maxillo-Facial Surgery of the University of Pisa. Case sheets were retrospectively gathered and reviewed, and the patient’s information was acquired.

The inclusion criteria were as follows:

- Maxillary single-tooth extraction (from incisor to first premolar)
- Immediate dental implant placement and single crown rehabilitation
- CBCT scans before tooth extraction and after surgery (from 2 to 3 years)
- Presence of at least 4 mm of bone beyond the root apex
- No chronic and systemic disease

Patients were excluded if the following items of information were included in the case-sheet document:

- Report of dehiscence or fenestration in the residual bony walls
- Report of acute infection at the surgical site
- Heavy smoking habit (> 10 cigarettes per day)
- Alcohol or drug abuse, and oral parafunctional habits (bruxism)

All patients were treated by a single surgeon (U.C.) and a single prosthodontist (R.C.). The study was conducted according to the principles embodied in the Helsinki Declaration of 1975, revised in 2000, for biomedical research involving human subjects. Since the authors analyzed preexisting and no identifiable data of patients, who were all informed about the nature of data treatment, and their written consent was obtained prior to participation, present retrospective data analysis did not require approval by a review board.

Clinicians adhered to standard treatment guidelines, according to which it was possible to routinely prescribe pretreatment CBCT for diagnosed and surgical planning (preoperative or before tooth extractions). An additional CBCT scan was required to determine the appropriate surgical approach in the event that additional dental implants had to be placed (postoperative).

#### Surgical Procedure

The implants were immediately inserted and restored. Before surgery (60 minutes), patients received 1 g of antibiotic (Zimox, Pfizer Italia), then 1 g twice a day for 7 days. Patients underwent surgery with local anesthesia (optocaine, Molteni Dental, 20 mg/mL + adrenaline 12.5 μg/mL). Teeth were extracted with Magnetic Mallet (Magnetic Mallet, Meta-Ergonomica) in order to preserve the integrity of the sockets, and to avoid flap raising.

After tooth extraction, a manual probe (Hu-Friedy PGF-GFS, Hu-Friedy) served to check integrity of the fresh extraction socket. Neither postextraction
were placed at the crestal level. The bone quality was assessed according to Lekholm and Zarb classification. The implant site was prepared using the standard drills following the palatal bony wall as a guide. Dental implants were titanium plasma-sprayed, external hexagon, with a rough surface, progressive thread design, and short smooth collar of 0.5 mm (Outlink, Sweden & Martina). Implants were placed at the crestal level.

**Prosthetic Procedure**

Postoperative impressions were taken with vinyl polysiloxane (one-step/two-viscosity technique) individual impression tray, and multifunctional cap shifted onto the implant head. Provisional crowns were all fabricated using acrylic resin. For both groups, the provisional crowns were screw-retained. In the custom group, customized provisional crowns were fabricated coping the shape of the emergence profile and contours of extracted teeth via a wax-up and computer-aided design/computer-aided manufacturing (CAD/CAM) technology. In this case, the emergence profile of the provisional crown should mimic the natural tooth profile, for which the technician reported exactly the volume features of the natural tooth in the alveolus. In the conventional group, conventional provisional crowns were fabricated for the fresh socket implants without exactly mimicking the extracted tooth. Three months after implant placement, the prosthetic restoration was finalized. A new impression coping was positioned, so that a direct registration of the emergence profile was performed. An ideally constructed definitive abutment or screw-retained prosthetic crowns were fabricated so that the most apical point of the labial gingival contour (zenith) was moved slightly more apical. If needed, an indirect cementing technique was employed to provisionally cement the definitive metal-ceramic restorations.

**Radiographic Examination**

The CBCT scans were performed with a scanner (Gendex GXCB-500, Gendex Dental Systems) whose setting is the following: 120 kV, 30.89 mAs, isotropic voxel size of 0.2 mm, bit depth 12-bit grayscale, and FOV 87.2 mm. Freeware i-CAT Vision software was used to analyze the cross-sectional view at the longitudinal coronal portion. Measurement of the alveolar width was performed perpendicular to the direction of the implant as the distance between the most prominent points from the palatal to the buccal side, at 1 mm apical to the most coronal point (Fig 1). The loss in bone width was the difference between preoperative and postoperative measurements.

**Statistical Analysis**

Statistical analyses were performed with statistical software (Statistics Toolbox, MatLab 7.11, The Math-Works). Normal distributions of the groups and subgroups were not confirmed. The two groups, custom and conventional, were independent (one treated site per patient): each pairwise comparison was performed by Wilcoxon rank-sum test. Tooth position and time (preoperative vs postoperative) showed matched data: groups were compared by Wilcoxon signed-rank test. Variables are described as mean ± SD (rounded to the nearest decimal). The significance was set at $P < .05$.

**RESULTS**

A total of 76 patients, 46 women and 30 men (age 54.6 ± 5.9 years, range: 40 to 69.5 years) were selected for the present study. All dental implants were placed at the same time as the removal of maxillary failing teeth; overall, 31 and 45 teeth were immediately replaced for the custom group and for the conventional group, respectively. The precise distribution of the sample is shown in Table 1.

**Surgical and Prosthetic Procedures**

After 3 years of follow-up, patients did not experience any failure of the included implants, so the overall survival rate of immediately loaded dental implants with or without restoration was 100%. Events of minor swelling were registered in the first days, whereas other surgical complications (such as mucositis or suppurative gingival contour) occurred in no patients. No prosthetic failures (that is, fracture or detachment of the crowns) were registered at 36 months of follow-up.

**Radiographic Evaluations**

The value of the bone width at baseline (preoperative 7.5 ± 1.4 mm) and at 3 years from implant loading (6.9 ± 1.3 mm) attested that for the group of patients treated with conventional restorations, a significant shrinkage (−0.6 ± 1.2 mm) was registered with a $P$ value of .002. On the other hand, the bone change registered for the custom abutment group appeared negligible, with a slight increase in width (+0.2 ± 0.7 mm). Furthermore, there were significant differences in width change found in the intergroup analysis: for the sake of clarity, changes in the bone width of +0.2 ± 0.7 mm and of −0.6 ± 1.2 mm, for crowns with or without customization, respectively, appeared to be different at a statistically significant level ($P = .0007$).

When subgroups related to the tooth site were analyzed separately, larger and more significant differences were revealed for the canines ($P ≥ .0554$) and premolars ($P ≥ .1057$) in...
Fig 1 Example of measurements of the buccal-lingual bone width in fused CBCT scans of the site from tooth extraction to 3 years after surgery.

Table 1  Demographic Data Description for the Two Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Customized abutment</th>
<th>Conventional abutment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age at implant placement (n = 76) (y)</td>
<td>53.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Variable describing sample</td>
<td>No.</td>
<td>Percent</td>
</tr>
<tr>
<td>Sex (n = 76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>12</td>
<td>38.7</td>
</tr>
<tr>
<td>Women</td>
<td>19</td>
<td>61.3</td>
</tr>
<tr>
<td>Location (n = 76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incisor</td>
<td>21</td>
<td>67.7</td>
</tr>
<tr>
<td>Canine</td>
<td>7</td>
<td>22.6</td>
</tr>
<tr>
<td>Premolar</td>
<td>3</td>
<td>9.7</td>
</tr>
<tr>
<td>Implant diameter (n = 76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.75 mm</td>
<td>14</td>
<td>45.2</td>
</tr>
<tr>
<td>4.10 mm</td>
<td>17</td>
<td>54.8</td>
</tr>
</tbody>
</table>
The intragroup and intergroup analysis (Table 2). For the canine subgroup, significant loss in width was registered for both groups; the values of the bone width at baseline (8.8 ± 1.3 mm and 8.3 ± 1.3 mm for custom and standard crowns, respectively) were significantly higher ($P \leq .0075$) than those measured at 3 years from implant loading (8.5 ± 1.3 mm and 6.8 ± 1.3 mm, for custom and standard crowns, respectively). It is worth noting that, even if the decrease in width was very limited for the canine custom group (–0.3 ± 0.2 mm), the shrinkage in the canine standard group appeared to be significantly higher (–1.5 ± 0.7 with $P = .0001$).

### DISCUSSION

In the present study, customized provisional crowns that mimicked the pristine tooth emergence profile and standard provisional crowns were compared in order to test at a 3-year follow-up the effectiveness in maintaining alveolar bone width in the buccolingual dimension evaluated at the dental implant site.

Some studies have demonstrated the clinical relevance of dental implants immediately placed and restored into fresh extraction sockets, providing reproducible osseointegration and survival outcomes quite similar to those achieved with abutments using conventional prosthetic protocols.1,27

The use of customized healing abutments, appearing natural in shape and size, should be one among several affective methods to enhance the esthetic and clinical success for implant therapy in the case of loss of fewer teeth in the esthetic zone.28 As said, achieving excellent esthetic results of immediate maxillary anterior single implants could be challenging.29 In fact, the placement of immediately loaded fresh socket implants might lead to a discrepancy between the implant surface and alveolar socket, which could be overcome with the use of bone substitute materials and of demanding flaps covering the filled discrepancy.11 The aforementioned demanding procedures could lead to loss in the alveolar volume and to negative remodeling of the gingival tissue contour, with suboptimal esthetic results due to improper fitting of the prosthetic abutment system in the surrounding supporting tissues.
A recent study\textsuperscript{30} described the use of a vacuum-fit shell-like abutment to fabricate a custom healing abutment. In the present protocol, the subgingival contours were designed by duplicating the anatomical contours of the existing tooth via a virtual wax-up, rather than approximating the subgingival contour by postextractive conventional laboratory techniques.

Another study reported a technique combining the use of the 3D printed surgical template for immediate implant placement and the CAD/CAM technology employed to realize the virtual shape optimization of a socket sealing abutment after bone grafting.\textsuperscript{31} When biomaterials were used to fill the void between the implant surface and alveolar bone, customized prosthetic restorations were able to seal the grafted area and to separate the substitute material from the growing soft tissue without the use of a membrane.\textsuperscript{31}

Tarnow and Chu,\textsuperscript{32} in their clinical and histologic study, showed that healing can be achieved with immediate dental implants placed into intact extraction sockets, despite the presence of a wide cervical gap between the bone and implant or of primary wound closure, and irrespective of the use of bone grafting materials or barrier membrane. Results of the histologic specimens demonstrated that the immediate implant sites showed a similar healing process by secondary intention to that observed in extracted teeth.

Notwithstanding that the epithelium from the margins of the soft tissue migrated just after maturation of granulation tissue in the socket, evidence shows that the soft tissue could interfere with bone-to-implant contact when the implant was placed in an extraction site without soft tissue closure.\textsuperscript{32}

As reported in the present radiologic and clinical study, cross-sectional images showed that custom provisional prosthetic restorations might serve to support gingiva and to protect the bone tissue during the healing of the sockets after implant placement, in order to reach more predictable results in terms of prosthetic treatment and socket volume maintenance. A prosthetic crown with a custom emergence profile acted as a mechanical barrier and, thus, sealed the socket and stabilized the blood clot, although clinicians should strive to minimize the risk of premature loading of the implant during the healing process.

Data collected during the survey attested that the hard and soft tissues of the rehabilitated site appeared to mimic the emergence profile of the natural dentition, a perfect anatomical pattern, giving the technician the possibility of fabricating a definitive restorative crown for optimal fit, function, and esthetic effect. Moreover, preoperative width of sites undergoing surgical treatment appeared to be maintained after 3 years of follow-up. In the present prosthetic procedure, a precise custom abutment acting as a perfect socket seal, as well as an optimal support for the soft tissue, allowed the preservation of the gingival contour during osseointegration. Statistically significant differences found between the two groups at the maxillary canine region suggested that for a tooth with the widest buccolingual cervical dimension, a customized provisional crown mimicking the pristine tooth emergence profile might be more conservative and make results improve in the medium term. In the literature, significant differences in the buccolingual dimension between the incisor and canine have been encountered irrespective of loading procedures, attesting that the canine is a high-sensitivity site for dimensional loss.\textsuperscript{33}

Saito and coworkers advocated that placement of the provisional prosthesis, carefully mimicking the lost tooth, could anatomically support the marginal gingiva and protect the healing extraction socket.\textsuperscript{34} Furthermore, Waerhaug\textsuperscript{19,35} attested that soft tissue could adhere to the clean surface of both ceramic and acrylic resin.

Further clinical trials are advocated to support these encouraging results in obtaining anatomical support of implant-prosthetic restorations with simple procedures.

CONCLUSIONS
From the results obtained in this clinical study, an anatomically contoured provisional restoration may provide a strategy to stimulate better conservation of the buccolingual ridge dimension at the cervical site than that registered for a standard immediate provisional crown, in which a loss in width has been found. Maintaining pristine volume of the alveolar bone probably enhances better peri-implant soft tissue conservation.

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REFERENCES


