The Implant-Buccal Plate Distance: A Diagnostic Parameter. A Prospective Cohort Study on Implant Placement in Fresh Extraction Sockets

Capelli Matteo DDS§ Testori Tiziano MD DDS * Galli Fabio MD ‡ Zuffetti Francesco MD DDS.§
Motroni Alessandro MS ** Weinstein Roberto MD DDS ‡‡ Del Fabbro Massimo BSc, PhD ‡

§ Assistant, Section of Implantology and Oral Rehabilitation, Department of Biomedical, Surgical and Dental Sciences, Dental Clinic, IRCCS (Istituto di Ricerca e Cura a Carattere Scientifico: Institute for Scientific Clinical Research and Treatment), Galeazzi Institute, University of Milan, and private practice, Milan, Italy.

* Head of the Section of Implantology and Oral Rehabilitation, Department of Biomedical, Surgical and Dental Sciences, Dental Clinic, IRCCS Galeazzi Institute, University of Milan, and private practice, Como, Italy.

‡‡ Full Professor, Head of the Dental Clinic, Department of Biomedical, Surgical and Dental Sciences, IRCCS Galeazzi Institute, University of Milan.

** Director, Applied Medical Imaging Research Group, Milan, Italy.

‡ Researcher, University of Milan, Department of Biomedical, Surgical and Dental Sciences, Head of Section of Oral Physiology, IRCCS Galeazzi Institute, Milan, Italy.

Aim: The aim of this study was to investigate contour changes around immediate implants in fresh extraction sockets when different grafting procedures are performed based on the distance between the external implant collar and the bony surface on the Buccal Plate (I-BP). A secondary aim was to assess the aesthetic outcome utilizing the Implant Aesthetic Score (IAS).

Materials and methods: A prospective cohort study was performed in three centers. Suitable patients to undergo implant placement in fresh extraction sockets were selected. Periodontal biotype, horizontal and vertical peri-implant bone defects and dehiscences were assessed. Depending on the I-BP distance, two types of grafting procedures were performed. In group A (I-BP distance ≥4mm) only the peri-implant gap was grafted during the surgical phase (internal grafting-IG) while group B (I-BP distance <4mm) received both internal and external grafting (IEG). Pre-op (before implant placement) and post-op (after 1-year of loading) master casts of the sites were made and optically scanned. A computerized analysis of the contour changes at the involved sites was performed by superimposing the scanned models.

Results: A total of 20 patients (12 females and 8 males) were recruited and 20 non-submerged implants placed in fresh extraction sockets. No implant failed during the observation period. The mean follow-up was 25 months (range 12-37 months). After one year of loading, group A showed a slight decrease in the mean buccal volume, while group B had an increase in volume. Such a difference was statistically significant (P=0.02). Implant Aesthetic Score (IAS) was higher for group B as compared to group A. Conclusion: When implants are placed immediately after tooth extraction, the implant-buccal plate distance (I-BP) may represent a useful diagnostic parameter in choosing the most appropriate grafting procedure (IG vs IEG). In clinical cases in which the distance between implant surface and
the buccal plate is < 4 mm the combination of an internal and external grafting (IEG) is recommended to maintain the volume and the contour of the ridge, and to achieve a successful aesthetic outcome.

KEY WORDS
immediate dental implants; cohort studies; aesthetic outcome, dental; bone regeneration

One of the most challenging objectives of implant treatment is the preservation of hard and soft tissues following the loss of one or more teeth. From a surgical perspective, the current concept is that a proper soft tissue morphology and symmetry can be achieved with correct three-dimensional implant placement that optimizes the emergence profile of the restoration.

Immediate implants have been advocated to preserve soft tissue contour and bone dimension, to minimize the period of edentulism and to reduce the overall treatment time. The concept of immediate placement of dental implants is a well accepted protocol even after removal of a tooth with periapical pathology. However, other studies have questioned that immediate implant placement can prevent bone resorption.

Flapless surgery was proposed to preserve bone vascularization and minimize bone resorption. If a full-thickness flap is elevated, disruption of the blood supply will occur with subsequent bone loss. Due to the close relationship between osseous structure and the overlying gingival architecture, the bone resorption resulting from full thickness flap elevation may result in soft tissue recession.

However, a recent clinical study showed that the adoption of either full-thickness flap elevation or a flapless approach to immediate implant placement led to a similar successful outcome.

When immediate implants are placed, peri-implant voids are frequently present due to a gap between the alveolar socket and the implant. Healing of the peri-implant bone defect is a process involving both bone apposition and bone resorption, the latter occurring to a larger extent than the former. Resorption prevails during healing when the gap is large and the biotype is thin. However, the presence of a thick buccal bone wall does not consistently prevent crestal resorption.

It has been suggested that the gap between an implant and the socket can be filled with a bone graft in order to preserve the volume.

The preservation of bone volume and soft tissue morphology is considered of utmost importance for achieving a highly aesthetic result.

The aim of this study was to investigate contour changes around immediate implants in fresh extraction sockets when different grafting procedures are performed based on the distance between the external implant collar and the bony surface on the Buccal Plate (I-BP). A secondary aim was to assess the aesthetic outcome utilizing the Implant Aesthetic Score (IAS).

MATERIAL AND METHODS

A cohort, controlled, multicenter clinical trial was performed in three centers. Treatments were carried out between 2008 and 2009; all surgical procedures were performed by three operators. Patients were recruited according to the following inclusion criteria: need for an immediate post-extraction implant of Type I according to the 2004 ITI consensus, the socket walls had to be intact and patients older than 18 years of age.

The exclusion criteria were: the presence of any systemic disease that could interfere with implant therapy, infection at the extraction site, probing depth >4 mm at the adjacent teeth, inadequate oral hygiene and presence of adjacent implants.
The patients were enrolled after they had been informed about the study protocol and they signed an informed consent to the treatment. This study was approved by the Review Board of IRCCS Galeazzi Institute in the registration number 78/2012 and was conducted in accordance with the Helsinki Declaration of 1975.

All patients received prophylactic antibiotic therapy of 2 g of amoxicillin (or clindamycin 600mg if allergic to penicillin) 1 hour before the extraction and implant placement procedures. The patients rinsed for 1 minute with chlorhexidine mouthwash 0.2% prior to surgery. Local anesthesia was induced using articaine 4% with adrenaline 1:100,000. The surgical procedure started with a marginal incisions extended to one tooth mesial and one tooth distal to the implant site without vertical releasing incisions. This type of flap design allows the surgeon to expose and visualize the buccal bony plate. Care was taken in all these steps to avoid any damage to the buccal bone wall.

After tooth extraction the socket was debrided and the implant placed ** in the correct prosthetically driven position, with the implant platform placed one millimeter below the marginal level of the buccal wall. The final insertion torque was measured utilizing a calibrated wrench ** and taken as an indicator of implant stability right after implant position. A healing abutment was connected and implants were left to heal according to a one-stage protocol.

After implant placement the distance between the implant collar and the external Buccal Plate (I-BP) was measured. No palatal measurements were taken since the palatal resorption is less important from the aesthetic point of view. (Fig.1)

When the I-BP distance was ≤ 4 mm (Group B) both an internal (between implant and alveolar bone) and an external grafting (on the outer surface of the buccal plate) were performed (IEG) using deproteinized bovine bone³. This was done in order to achieve a width > 4 mm from the implant surface to the outer surface of the buccal plate (Fig. 2)

When the distance between the implant surface and the outer surface of the alveolar bone wall was > 4 mm (Group A), deproteinized bovine bone was placed in the peri-implant gap only (Internal Grafting: IG). In both cases a resorbable membrane ** was placed to stabilize the graft material (Fig.3).

The surgical flaps were then sutured around the healing abutment achieving soft tissue primary closure. In cases in which an external graft was placed, due to the small amount of graft material added and the length of the horizontal incision (one tooth mesial and one tooth distal to the implant site), no releasing incisions were made to adapt the flap to the healing abutment.

Sutures were removed after one week and the patients were seen monthly thereafter.

All patients continued to take the antibiotic postoperatively - 1g amoxicillin (or 300 mg clindamycin) twice a day for 5 days. They also took non-steroidal anti-inflammatory drugs if needed (naproxen sodium 550 mg). Chlorhexidine mouthwash twice a day was prescribed for 3 weeks post-surgery.

Soft tissues were allowed to mature for three months prior to the placement of the definitive restoration ²¹.

**Evaluation of Tissue Contour Changes**

A pre-op (before implant placement) and post-op (after 1-year of loading) master casts of the surgery site were made and optically scanned. A computerized analysis of the contour changes was performed by superimposing the scanned models. Master casts of 20 patients were made out of dental stone⁴ utilizing the impressions taken pre-extraction and after 1- year of loading.
For the evaluation of the dimensional changes at the extraction sites, the casts were optically scanned §§, after performing the standard calibration procedure written by the manufacturer before the acquisition of each group of models. The scans of models were superimposed by means of a “best-fit” algorithm # that progressively reduces the relative distance between the meshes, adapting to the common regions taken in the reference areas, namely the natural teeth not involved in the surgical procedure. It is possible that, due to the impression technique and materials, the two models present small variations also in the areas not affected by the regeneration process. These variations, less than 0.1 mm, do not compromise the results since, working in relative terms (variations between models), it is possible to precisely calculate these variations on the external surface of teeth and subtract the mean value to the superposition results from the analyzed area of interest. In this way the final results is corrected from the variations not dependent on the tissue regeneration. The statistical significance of the difference between IEG and IG groups in terms of mean variation of buccal and lingual/palatal surface distance was analyzed by using the unpaired Student's t-test.

The aesthetic outcome was evaluated utilizing the Implant Aesthetic Score (IAS)(17), that index takes into consideration the following items: a) presence and stability of the mesio-distal papilla (score between 0 and 2); b) ridge stability bucco-palatally (0 to 1); c) texture of the peri-implant soft tissue (0 to 2); d) color of the peri-implant soft tissue (0 to 2); e) gingival contour (0 to 2). According to this score, a "perfect" outcome is achieved when the score is 9, between 4 and 8 the outcome is considered "acceptable" and between 0 and 3 it is "compromised". IAS was assessed by an independent evaluator (an operator that was not involved in the surgical and the proesthetic procedures) at each center. The group code (IG or IEG) was only revealed to the evaluator at the end of the IAS evaluation.

RESULTS
A total of 37 patients were screened but only 20 patients fulfilled the inclusion criteria. In this patient data set 12 were females and 8 males and 20 implants were placed according to a one-stage protocol in the maxilla and in the mandible in the area comprised from second premolar to second premolar. Patients' mean age was 53.9 years (range 18-78 years). Five patients were smokers. The mean follow-up duration was 25 months (range 12-37 months). The results of the displacement between the optical scans of the 20 cases are summarized in Table 1. One year following prosthesis placement, the treatment group B (IEG) showed a slight increase in the mean buccal tissue thickness (by 0.16±0.48 mm), while in the control group A (IG) the buccal dimension was reduced by 0.37±0.38 mm. The difference was statistically significant (P=0.02) in favor of the group B. At the lingual/palatal aspect no significant difference in mean variation was found (P=0.19) between the IEG group (0.06±0.28 mm) and the IG group (-0.22±0.59 mm). The results of the analysis have been expressed as a linear displacement between the points belonging to the pre-op and post-op scans of the models. In this way it is possible to evaluate the positive or negative tissue displacement with respect to the whole area, and is useful to study specific regions as a whole (buccal area) and not only along single profiles which could give partial results (considering that a simple monodimensional profile analysis is right just on the profile that is observer and is anatomy dependent). The results of the displacement can be also represented with a color map that visually shows the decrease versus increase of the volumes (Fig.4,5).

The Implant Aesthetic Score (IAS) was consistently higher for group B as compared to group A, mainly due to the preservation of the bucco-palatal dimension in the former group (Table 2). During the soft tissue healing any interproximal papillae loss was observed. During the whole observation period no implant failure was reported.
DISCUSSION

Implant placement in fresh extraction sockets has been thoroughly documented and discussed in literature. Several Consensus statements and clinical recommendations have been drawn up in recent years in order to guide clinicians towards the choice of the best treatment options for such procedures. A recent prospective study completed over 10 years on 159 implants placed in fresh extraction sockets confirmed the long-term predictability of this treatment.

Implant placement at the time of tooth extraction can facilitate implant positioning into the socket thanks to availability of space. Socket morphology, on the other hand, may present a disadvantage to the immediate implant procedure as it could lead to a compromised implant positioning and initial implant stability.

Vertical and horizontal alveolar bone resorption occurring during the healing phase after tooth extraction may adversely affect the aesthetic results. In fact, many studies have reported the occurrence of a buccal recession after immediate implant placement.

Furthermore, when considering the frequency of marginal tissue recession, it was noted to be independent of the gingival biotype, since it occurred at both thin and thick biotype Sites. This would suggest that a thick gingival biotype alone does not prevent marginal tissue recession. However, recession at thin biotype sites tends to be of a greater magnitude. The initial thickness of the buccal crestal bone may be a factor in determining the extent of the buccal bone resorption during the healing phase. Such thin buccal bone, mainly located in the most coronal part is susceptible to interruption of the vascular supply as a consequence of flap elevation.

When the buccal plate is damaged, significant resorption could occur leading to aesthetic issues. In our study, the pre-operative thickness of the buccal plate was not considered per se, but is included in the I-BP distance. No post-operative CT scan were performed so the post-operative buccal bone thickness was not calculated.

As opposed to autogenous bone grafts, xenograft volume is rather stable over time since it is slowly resorbed. This feature may justify the use of xenografts for filling the gap between an implant and the alveolar walls in order to reduce bone collapse. In this context, bone substitutes with slow resorption rate and the use of a barrier membrane may be a preferred alternative to autogenous bone for the reconstruction of buccal plate dehiscence defects.

Grafting the peri-implant gap may limit the horizontal resorption of the original bone dimension.

Other studies investigating preservation of socket dimensions after tooth extraction have reported a gain in vertical bone height of about 1 mm by “overbuilding” the marginal defects or by overlaying the buccal bone externally with the graft. This concept was recently speculated about in a study where immediate implants in anterior maxilla were frequently associated (87%) with thin buccal walls (<1mm). This means that augmentation procedures are needed to achieve adequate bony contours around the implant and optimal aesthetic outcomes. However no clinical indication about the regenerative procedures and actual graft thickness was reported in the study.

In order to achieve adequate bone contour around the implant and optimal soft tissue contour a final distance of 4 mm from the implant surface to the external buccal graft side should be obtained at the end of the surgical procedure. A horizontal buccal bone width of at least 2 mm should remain at
the end of the resorption phase allowing for the conical peri- implant bone resorption to be still inside the width of the bone wall 40 41.

The tissue volume changes measured in the present investigation demonstrate that the IG group underwent a loss of buccal tissue contours 1-year after prosthesis delivery, while the IEG group displayed a slight gain or stability of the buccal tissues. The proposed volume change measurement, with respect to a standard contour distance measurement, takes into account the whole area, and is not limited to a single profile. The present results reveal that overbuilding the buccal aspect in combination with immediate implant placement may be a suitable technique to compensate for the physiological alveolar bone changes occurring after tooth extraction and immediate implant insertion.

CONCLUSIONS

When implants are placed immediately after tooth extraction, the implant-buccal plate distance (I-BP) is a critical parameter and could be a useful diagnostic tool that guides the clinician in performing the most appropriate grafting procedure (IG vs IEG). In clinical cases in which the distance between the external implant collar and the bony surface on the Buccal Plate (I-BP) is < 4 mm an internal and an external grafting should be placed to maintain the ridge contour and to achieve a successful aesthetic outcome, as validated by the IAS that showed consistently higher scores for the IEG group.

Studies with a larger sample size are needed to confirm the promising outcome of this study.

ACKNOWLEDGEMENTS

The authors do not have any financial interest in the companies whose materials are included in this article.

REFERENCES


Corresponding author: Prof. Tiziano Testori, University of Milano, Department of Biomedical, Surgical and Dental Sciences Istituto Ortopedico Galeazzi I.R.C.C.S. Via R. Galeazzi 4,20161 Milano, Italy; Fax: 0039-02-50319960., e-mail: Tiziano.Testori@unimi.it

Submitted July 30, 2012; accepted for publication February 7, 2013.

1. Distance between the external implant collar and the bony surface on the Buccal Plate (I-BP)

2. Implant -buccal plate distance less than 4 mm. The graft should be placed inside the residual implant gap and outside the buccal bone plate. The graft should be protected with a resorbable membrane.

3. Implant -buccal plate distance more than 4 mm. The graft should be placed inside the peri-implant gap and should be protected by a resorbable membrane.

4: Overlapping of the scanned impression model taken one year after surgery with IG graft. Blue-azure areas indicate a decrease in volume, yellow-red areas indicate a volume increase after the intervention. Gray regions are not involved into the analysis because they were present in only one of the two scanned and overlapped models. L=lingual; B= buccal; A=anterior; P=posterior; N= tooth element number.

5: Overlapping of the scanned impression model taken one year after surgery with IEG graft Blue-azure areas indicate a decrease in volume, yellow-red areas increase in volume after the intervention. Gray regions are not involved into the analysis because they were present in only one of the two scanned and overlapped models. L=lingual; B= buccal; A=anterior; P=posterior; N= tooth element number.
Table 1.

Results of the alveolar bone tissue displacement evaluation.

<table>
<thead>
<tr>
<th>Type of</th>
<th>Tooth</th>
<th>Buccal side</th>
<th>Lingual/palatal side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Buc</td>
<td>±SD, mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>-0.35 ± 0.54</td>
<td>0.13 ± 0.57</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>-0.09 ± 0.07</td>
<td>-0.14 ± 0.02</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-1.05 ± 0.77</td>
<td>-0.43 ± 0.46</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>-0.28 ± 0.38</td>
<td>0.19 ± 0.15</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0.04 ± 0.23</td>
<td>0.60 ± 0.84</td>
<td></td>
</tr>
<tr>
<td>IG</td>
<td>7</td>
<td>-0.41 ± 1.33</td>
<td>0.31 ± 2.48</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>-0.26 ± 0.83</td>
<td>-0.09 ± 0.23</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>-1.01 ± 0.64</td>
<td>-1.31 ± 0.88</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-0.14 ± 0.95</td>
<td>-0.50 ± 0.40</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>-0.10 ± 0.35</td>
<td>-0.98 ± 0.44</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>0.15 ± 0.52</td>
<td>0.07 ± 0.56</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>0.35 ± 0.17</td>
<td>0.18 ± 0.18</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.06 ± 0.27</td>
<td>0.11 ± 0.38</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.45 ± 0.44</td>
<td>0.10 ± 0.21</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.34 ± 0.21</td>
<td>0.04 ± 0.14</td>
</tr>
<tr>
<td>IEG</td>
<td>7</td>
<td>0.12 ± 0.27</td>
<td>-0.12 ± 0.23</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>-0.90 ± 0.5</td>
<td>0.09 ± 0.25</td>
</tr>
</tbody>
</table>

SD=standard deviation
Table 2. Clinical outcome evaluated with the IAS score

<table>
<thead>
<tr>
<th>IAS evaluation</th>
<th>Group A (IG)</th>
<th>Group B (IEG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent outcome</td>
<td>0</td>
<td>2 (score 9)</td>
</tr>
<tr>
<td>Good outcome</td>
<td>9 (Score 4-6, Avg. 5)</td>
<td>8 (Score 6-8, Avg. 7)</td>
</tr>
<tr>
<td>Poor outcome</td>
<td>1 (score 3)</td>
<td>0</td>
</tr>
</tbody>
</table>

** 3i Biomet, West Palm Beach, USA
§ Bio-Oss, Geistlich, Wolhusen, Switzerland
**BioGide, Geistlich, Wolhusen, Switzerland
¶ GC Fujirock type 4, GC Corp., Tokyo, Japan
§§ Dental wings 5 axis scanner, Canada
## Geomagic Studio 12, Research Triangle Park, NC, USA