Conservative Implant Removal for the Analysis of the Cause, Removal Torque, and Surface Treatment of Failed Nonmobile Dental Implants

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This study was performed to study the effect of implant surface treatment on the cause and removal torque of failed nonmobile implants. Implant explantation was achieved by the application of countertorque at the implant–bone interface. The explantation socket was examined carefully and curetted to remove any granulation tissue. Immediate implant placement was accomplished when primary stability could be achieved. Eighty-one patients were treated according to the described treatment protocol for the explantation of 158 nonmobile implants in the maxilla and the mandible. The patient’s mean age was 62 ± 11 years. The main cause of implant explantation was peri-implantitis (131 implants; 82.9%) followed by malpositioning of the implants (22 implants; 13.9%). The explantation of 139 implants at 146 ± 5 Ncm was performed without the need for trephine bur. However, the use of trephine burs to cut into the first 3 to 4 mm was necessary in 19 explantations, and the removal torque was 161 ± 13 Ncm. All titanium plasma-sprayed implants were removed due to peri-implantitis at a significantly lower torque when compared to acid-etched, particle-blasted, and oxidized implants. The postoperative recovery of the patients was uneventful and the conservation of the available hard and soft tissues was successfully achieved. The protocol followed in this study could constitute a real alternative to other traumatic technique for the removal of failed implants and advanced stages of peri-implantitis. The type of implant surface treatment could influence the value of removal torque and the occurrence of peri-implantitis.

Key Words: peri-implantitis, explantation, implant removal, countertorque, surface treatment

INTRODUCTION

The wide acceptance of dental implants as the choice to replace lost dentition has significantly increased the number of patients being treated with implant-supported prosthesis. It is estimated that more than half a million implants in United States, about 120 000 implants in France, 185 000 in Spain, 410 000 in Italy, and 420 000 in Germany are placed every year.1,2 This is partly motivated by the reliability and high success rate of implant-based oral rehabilitation, making this option predictable and safe.3 The implant survival rate of implant-supported fixed partial denture is reported to be 92% to 97%.4

However, an implant failure rate of at least 3% is occurring and there will be a need to efficiently resolve failure cases. Implant failure could arise as a result of infection (peri-implantitis), biomechanical stresses, as well as improper positioning that may require the removal of the implant.5

Peri-implantitis is an inflammatory process around an implant, which includes both soft tissue inflammation and progressive loss of supporting bone beyond biological bone remodeling.6 Advanced stages of peri-implantitis would result in severe bone loss around the dental implants and indicate the need for implant removal.

Inadequate communication between the surgeon and restorative dentist would result in improper implant positioning and or angulations.7 Solutions for improper implant positions include second surgeries or prosthetic compensation, solutions that will increase time and cost to achieve functioning prosthesis.8,9 Implant-osseous osteotomy and distraction osteogenesis have been reported for the repositioning of malpositioned implants.10

A failed implant site would present reduced bone volume (horizontally and vertically) that would increase the difficulty for resolving such clinical problem. Traumatic implant removal would further complicate the accomplishment of prosthetic rehabilitation with satisfactory function and esthetics. It would also increase the risk for vascular injury with important consequences if it occurs in the floor of the mouth. For that, it is important to perform minimally invasive implant removal not only for conserving the available bone and gingival tissues but also to permit the identification and diagnosis of pathological lesions.11

Different techniques have been reported to explant a failed dental implant that include block resection, buccal bone

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osteotomy, and trephine osteotomy. However, these techniques require the protection of neighboring tissues and may need the application of regenerative techniques to restore the surgical area. Consequently, immediate placement of dental implants would be jeopardized, and the cost and time necessary to complete the treatment will increase. In a recent study, a minimally invasive implant removal is achieved by a circumferential osteotomy performed with piezosurgery.

The majority of techniques available to remove failed implants do not allow for quantitative measurement of the force necessary to remove the implant. For that, in this study, a conservative implant explantation is performed by the application of countertorque to break the implant–bone union. The failed nonmobile implants are analyzed to retrieve data about implant type, surface treatment, cause for implant removal, and the removal torque. The effect of surface treatments on the cause for implant removal and removal torque is analyzed.

**MATERIALS AND METHODS**

Patients were treated between March 2010 and March 2014 for dental implant removal. The inclusion criteria were:

- Patients aged over 18 years
- Explantation of at least 1 nonmobile implant
- Identification of the indication for explantation
- Recording of the removal torque

Patients and or implants that did not meet any of these criteria were excluded from the study.

Prior to surgery and in order to make a proper treatment plan, all patients underwent standard diagnostic protocol consisting of reviewing the medical and dental history, diagnostic casts, and radiographic evaluation.

**Surgical procedure**

Patients received 2 g of amoxicillin (600 mg of clindamycin for allergic patients) and 1 g of acetyaminophen 60 minutes before surgery. Local anesthesia was achieved by inferior alveolar nerve block anesthesia and buccal and or lingual infiltration anesthesia using articaine hydrochloride with epinephrine (1:100 000). A crestal incision was practiced to elevate a full-thickness flap and expose the surgical site, and peri-implantitis was classified according to the status of surrounding bone into:

Class I: Slight horizontal bone loss with minimal peri-implant bone defect.
Class II: Moderate horizontal bone loss with isolated vertical defect.
Class III: Moderate to advanced horizontal bone loss with broad circular bony defect.
Class IV: Advanced horizontal bone loss with broad circumferential vertical defect as well as loss of oral and or vestibular bony wall.

However, the extraction of malpositioned implants could be performed without the reflection of a mucoperiosteal flap if no implants would be inserted. Implant explantation was carried out using an extraction kit (BTI Biotechnology Institute, Vitoria, Spain). For that, a ratchet was first engaged into the implant connection (Figure 1). The choice of the insert was based on the recommendations of the manufacturer although in some cases the insert was shortened using a cutting disk for better retention. The removal torque was exerted by a wrench in counterclockwise direction maintaining a perpendicular position of the assembly in relation to the implant platform (Figure 1). Only in cases where the torque wrench opened (the maximum of wrench torque was set at 200 Ncm), the extraction assembly was removed and specialized trephine burs were employed to cut into the first 3 to 4 mm of implant-bone contact (Figure 2). The implant explantation was then continued with the torque wrench. For all cases, the removal torque was registered in the patient’s record.

The explantation socket was carefully examined to identify abnormalities and the status of the bony walls. The socket was carefully curetted to remove any granulation tissue. The decision for immediate implant placement was based on the design of the prosthesis and the possibility to achieve primary stability of the implant. The insertion of the dental implant was done with a surgical motor at an insertion torque of 25 Ncm and then continued manually to finish the implant placement.

The low-speed drilling and the design of the bone drills permitted the collection of bone particles during the preparation of implant site. The harvested autologous bone was stored in fraction 2 of the PRGF-Endoret (BTI Biotechnology Institute) until use. This resulted in the formation of a fibrin clot that glued together the autologous graft particles. Fibrin-glued bone graft was applied to fill the gap between implant and bone. Fibrin membrane, prepared from F1 of PRGF, was compressed to provide thin and consistent membrane that was then applied to cover the surgical site before flap reposition and suturing (interrupted suture) with monofilament 5/0 nylon suture. Postoperatively, patients were instructed to perform light and gentle brushing of the tooth/structures close to the surgical area after 24 hours and to avoid chewing on the operated site.

To obtain plasma rich in growth factors (PRGF), peripheral blood was extracted by venipuncture into four 9 mL extraction tubes containing 3.8% sodium citrate (BTI Biotechnology Institute) and processed according to the manufacturer instructions. Fifty μl of calcium chloride solution (PRGF activator; BTI Biotechnology Institute) per each milliliter of plasma were employed to activate platelets and fibrin formation.

**Postoperative phase**

Follow-up visits were scheduled to remove sutures and to detect any surgical complications. Clinical evaluation and implants status were also monitored. After at least 4 months, a second surgery was then performed to connect transepithelial abutments (Multi-Im; BTI Biotechnology Institute). Success or failure of osseointegration was annotated in the patients’ records.

**Data collection and statistical analysis**

The patient was the statistical unit for the description of demographic data. Mean and standard deviations were
calculated for the age variable while relative frequency was calculated for the gender. The implant was the statistical unit for the statistical description of indication for implant removal, location, removal torque, and manufacturer (surface treatment). Mean and standard deviation were calculated for torque values. Relative frequency was calculated for indication for implant removal, implant location, and surface treatment.

Shapiro-Wilk test was performed to evaluate if the data of insertion torque. Kruskal-Wallis test was performed to detect the statistical significance of the effect of surface treatments on the removal torque. Mann-Whitney U test was applied for pairwise comparison between the surface treatments. The statistical significance was set at \( P < 0.05 \). All the statistical analyses were performed using SPSS v.15.0 for Windows statistical software package (SPSS Inc, Chicago, Ill).

**RESULTS**

This study reports the data of 81 patients with 158 nonmobile implant explantations, which fulfilled the inclusion criteria. All patients received periodontal cleaning sessions and oral hygiene instructions before surgery (Figure 3).

Fifty-six patients were females and the patient mean age was 62 ± 11 years (range: 34–81 years). Seventy-nine (50%) implant explantations were performed in the maxilla and 35.3% were in the anterior sectors. The main cause for implant explantation was peri-implantitis (Figure 4; 131 implants; 82.9%) followed by malpositioning of the implants (22 implants; 13.9%). One implant was extracted due to fracture of prosthetic components and 2 were transitional implants. Another 2 implants were affected by bisphosphonate-related osteonecrosis of the jaws (BRONJ).

The peri-implantitis was classified according to the classification proposed by Jovanovic and Spiekermann.\(^{14,15}\) Peri-implantitis Class III affected 28 implants and class IV affected 103 implants.

**Implant type**

The removed implants were classified according to the surface treatments into acid-etched, particle-blasted, particle-blasted + acid-etched, oxidized, titanium plasma-sprayed, and turned implants. One implant was hydroxyapatite coated. Most of the implants removed were acid etched (47.5%) and oxidized (19.6%) as shown in Table 1.
Removal torque

The implant removal technique followed in this study allowed the registration of the torque necessary to remove the implant. The explantation of 139 implants was performed without the need for trephine burs. The removal torque of these explantations was 146 ± 5 Ncm. However, use of trephine burs was necessary in 19 explantations and the removal torque was 161 ± 13 Ncm. The indications of using trephine bur were an initial removal torque higher than 200 Ncm (15 implants), fractured implants (3 implants), and fractured prosthetic component (1 implant).

Figures 3 and 4. Figure 3. (a) Malpositioned implants and poor oral hygiene as indicated by the accumulation of dental plaque on the implants surface. (b) The clinical picture after receiving cleaning and polishing to improve the peri-implant soft tissue. (c) and (d) Implants with bone defects were removed and new implants were placed. The 4 implants in the anterior sector and the old prosthesis were maintained as provisional prosthesis. Figure 4. (a) Fracture of the implants at the level of the implant's neck that justifies limiting the maximum torque to a value of 200 Ncm. (b) Higher magnification.
The torque necessary to break the implant–bone union showed variations between the different surface treatments. The torque value distribution according to the type of surface treatments did not follow the normal distribution (Shapiro-Wilk test, $P < 0.05$). The Kruskal-Wallis test showed the presence of statistically significant effect of surface treatments on the removal torque ($P = 0.000$). The pairwise comparison was then performed through the application of Mann-Whitney test (Table 2). The removal torque was lower (statistically significant) for titanium plasma-sprayed implants on comparison with the other surface treatments. The removal torque was the highest (statistically significant) for acid-etched and particle-blasted implants.

Peri-implantitis was the cause of removal of all implants that were titanium plasma sprayed. This was also the case of more than 80% of the acid-etched, particle-blasted, and oxidized implants. About 44% of particle-blasted + acid-etched implants and 67% of turned implants were extracted due to peri-implantitis.

**Complications**

Fracture of 3 implants was reported and the extraction of the implants was continued with a trephine burs (Figure 5). The implants were from Noble Biocare (Gothenburg, Sweden), Astratech (Molndal, Sweden), and Biomet 3I (Palm Beach, Fla). Postoperative pain due to surgical intervention was successfully managed with oral analgesics.

**Postexplantation alveolus**

After the removal of the implants, the granulation tissue was carefully removed and the bony walls were examined with a dental probe. Indentation of implant’s threads was observed to be printed on the alveolar walls indicating the minimally invasiveness of the technique. Immediate implant placement was achieved with adequate primary stability in 13 cases (Figure 6). Extensive bone resorption and or the absence of buccal plate of the alveolus were managed by socket grafting with PRGF clot prepared from F2 that was covered with fibrin plug prepared from F1. The new implant placement was performed in a second surgery after 4 months of bone healing (Figure 7). Worthy of note, the soft tissue closure of the defects in patients affected by BRONJ was successfully achieved.

**DISCUSSION**

Different methods have been described to remove osseointegrated dental implants. Some of them include trephining a bone block in which the dental implant is present, the use of thin bur at low speed with irrigation to separate the implant from the surrounding bone, and, in 2004, Massei et al reported the induction of a localized thermonecrosis at the bone–implant interface through the application of an ultrahigh frequency electrosurgical device.16 These methods have the limitation of being traumatic and of jeopardizing the explantation socket for future implant placement. Less invasive techniques like counter-ratchet technique and reverse screw technique have been developed to preserve available hard and soft tissue. In this study the main cause for implant removal was advanced stages of bone loss due to peri-implantitis. This was the case of all titanium plasma-sprayed (TPS) implants and of more than 80% of acid-etched, particle-blasted, and oxidized implants. However, it was lower for particle-blasted + acid-etched implants. This could be related to the fact that most of the implants included in this study were acid-etched and oxidized implants. Additionally, rough surface implants (TPS) are more likely to develop peri-implantitis than minimally rough implants once exposed to the oral environment.17 Most of the peri-implant bone defects due to peri-implantitis showed advanced horizontal bone loss with broad circumferential vertical bone defect and the loss of at least 1 bony wall.

The explantation method followed in this study allowed the registration of the torque necessary to remove the implant without damaging the implant surface. This latter could serve to study long-term changes to the surface of implants after being in function in the oral cavity. The removal torque was significantly higher for acid-etched, particle-blasted, and oxidized implants. However, the removal torque is influenced by several factors like hosting bone quality, design of the

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**TABLE 1**

Surface treatment type effect on the removal torque and frequency of peri-implantitis as cause of implant removal

<table>
<thead>
<tr>
<th>Surface Treatment</th>
<th>Frequency</th>
<th>Without Trephine Bur</th>
<th>With Trephine Bur</th>
<th>Combined</th>
<th>Peri-implantitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid etched</td>
<td>75</td>
<td>155 ± 46</td>
<td>152 ± 32</td>
<td>155 ± 45</td>
<td>68 (90.6%)</td>
</tr>
<tr>
<td>Particle blasted</td>
<td>18</td>
<td>174 ± 59</td>
<td>150 ± 50</td>
<td>170 ± 57</td>
<td>16 (88.9%)</td>
</tr>
<tr>
<td>Particle blasted + acid etched</td>
<td>16</td>
<td>94 ± 54</td>
<td>200 ± 71</td>
<td>107 ± 65</td>
<td>7 (43.8%)</td>
</tr>
<tr>
<td>Oxidized</td>
<td>31</td>
<td>150 ± 44</td>
<td>158 ± 74</td>
<td>152 ± 50</td>
<td>25 (81%)</td>
</tr>
<tr>
<td>Titanium plasma sprayed</td>
<td>11</td>
<td>89 ± 63</td>
<td>100</td>
<td>90 ± 60</td>
<td>11 (100%)</td>
</tr>
<tr>
<td>Turned</td>
<td>6</td>
<td>150 ± 30</td>
<td>-</td>
<td>150 ± 30</td>
<td>4 (66.7%)</td>
</tr>
</tbody>
</table>

**TABLE 2**

Statistically significant ($P < 0.05$) pairwise comparisons of the effect of surface treatment on the implant removal torque

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid etched</td>
<td>Particle blasted + acid etched</td>
</tr>
<tr>
<td>Particle blasted</td>
<td>Titanium plasma sprayed</td>
</tr>
<tr>
<td>Particle blasted + acid etched</td>
<td>Titanium plasma sprayed</td>
</tr>
<tr>
<td>Oxidized</td>
<td>Titanium plasma sprayed</td>
</tr>
</tbody>
</table>
implant (cylindrical or screw-like), diameter of the implant, and surface roughness.\textsuperscript{18–22} The counter-torque needed to unscrew the implant fixture was below 200 Ncm for 139 implants. But, the use of trephine bur was only needed when the torque value was higher than 200 Ncm (15 implants).

Biomechanical studies have shown that the majority of stress transmitted to the peri-implant bone is concentrated at the crestal bone (the first 2 to 3 mm of implant length) regardless of the implant design,\textsuperscript{23–26} making this area essential to achieve primary implant stability. This has motivated us to limit the use of trephine bur to break the implant–bone contact at the first 2 to 3 threads of the implant. This reduced the removal torque and permitted implant explantation to be continued with the use of counter-torque wrench.

The principle mechanism of implant explantation was the application of a shear stress to break the union between the implant and the bone and allow for implant unscrewing. The result was
FIGURE 6. (a) The implants after removing the prosthesis; we can note the pus exudate around the most mesial implant. (b) Status of the soft tissue after explantation and placement of new implants. (c) The size of the bone defect after implant removal indicated the need for regeneration and the deferral of implant placement. (d) The bone regeneration by PRGF-Endoret after 4 months were almost complete at #19 and bridged about 80% of the defect at #22. (e) Panoramic radiograph showing peri-implant bone loss around all implants before intervention. (f) The new implants supporting a new definitive prostheses.
atraumatic implant explantation and preserving at maximum the available hard and soft tissues. Thus, immediate implant placement was possible in 13 cases, which avoided the need for tissue regeneration before implant placement, reducing time and cost. Postoperative recovery of the patients was uneventful, and pain was successfully managed by oral analgesics.

This study is limited by the absence of a control group where implants have been explanted by different techniques. The time period between implant insertion and explantation could not be calculated for the majority of the removed implants as these implants were placed in other clinical centers. A more conservative approach than implant explantation to treat peri-implantitis could not be followed, as significant bone loss has already progressed.

The protocol followed in this study could constitute a real alternative to other traumatic techniques for the removal of failed implants. The conservation of available hard and soft tissues is possible and permitted resolving implant failure at a shorter time and cost by avoiding advanced tissue regeneration techniques.

**CONCLUSIONS**

Peri-implantitis and malpositioning of the implants were the main causes for implant explantation. Peri-implantitis was the only cause for the explantation of titanium plasma-sprayed implants. The application of shear stress at the implant-bone contact was effective to permit atraumatic implant explantation. The removal torque was higher for acid-etched, particle-blasted, and oxidized implants. The technique preserved at most the available bone tissue and reduced the need for advanced tissue regeneration procedures.

**NOTE**

Eduardo Anitua is the Scientific Director of BTI Biotechnology Institute (Vitoria, Spain). He is the head of the Foundation Eduardo Anitua, Vitoria, Spain. Alia Murias-Freijo has no conflict of interest. Mohammad Hamdan Alkhraisat is scientist at BTI Biotechnology Institute (Vitoria, Spain).

**ABBREVIATIONS**

BRONJ: bisphosphonate-related osteonecrosis of the jaws
PRGF: plasma rich in growth factors
TPS: titanium plasma sprayed
REFERENCES


