Ten-Year Results of a Prospective Cohort Study on Acid-Etched and Airborne Particle–Abrided Implant Surfaces: A Comparative Study

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Dental implants are intended to provide long-term reliable dental restorations. Limited data exist on the comparison between different implant surfaces. This study aims to clarify whether there is a difference between airborne particle–abraded and acid-etched (SLA implants) and only acid-etched surfaces (Osseotite) in healthy and periodontally compromised patients. After comprehensive evaluation of all 109 patients, including nonsurgical and surgical therapy for the treatment of periodontal disease, 109 implants were placed according to the manufacturer’s guidelines. Each treatment site was examined radiographically 3 to 6 months after the final coronal restorations were placed. Patients were enrolled in the follow-up maintenance program, and radiologic evaluations were carried out at 5 and 10 years. Data recorded from 91 patients who completed the final 10-year follow-up were included in the analysis (SLA: n = 50; Osseotite: n = 41). At 10 years, the difference between bone-to-implant distances (DIBs) for SLA and Osseotite was significantly different (P = .001; 95% confidence interval: 0.55, 1.89 mm). Mean ± SD DIB for SLA implants was 2.1 ± 1.1 mm and 0.9 ± 2.1 mm for Osseotite implants. The overall survival rates of SLA and Osseotite implant surfaces were high during the observation period. History of previous periodontal disease plays an important role in the incidence of complications, regardless of the surface type.


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observed dental implants, and it was shown that SLA implants offer predictable long-term results in the treatment of complete and partially edentulous patients.

In two articles, Roccuzzo et al showed how previous or preexisting periodontal disease may negatively affect the success rate of dental implants.

The question that remains unanswered is whether etched surfaces (less rough) or airborne particle- abraded ones (more rough) can perform better in different clinical indications, especially in periodontally compromised patients. The aim of the present study was to compare the most visible coronal bone-to-implant distance (DIB) and to analyze the effect of gender, periodontal disease experience, bone augmentation provided, type of prosthesis provided, and prosthesis connection for SLA and Osseotite (Zimmer Biomet) implants after 10 years in service.

Materials and Methods

Study Population

All 109 patients attending the principal investigator's (N.D.A.) practice for dental implant therapy between January 2007 and January 15, 2008, were screened for possible inclusion in the study.

The criteria used for excluding patients were as follows: (1) complete edentulism; (2) presence of previously placed dental implants; (3) mucosal diseases; (4) alcohol and drug abuse; (5) pregnancy; (6) uncontrolled metabolic disorders; (7) aggressive periodontitis; (8) no interest in participating in the study; (9) patients for whom additional bone augmentation procedures, such as sinus elevation and horizontal augmentation, was indicated; and (10) sites with < 2 mm of keratinized mucosa. Patients were informed that their data would be used for statistical analysis and gave their informed consent to the treatment. No ethical committee approval was requested to begin this observational study, as it was not required by national law. The study was performed in accordance with the principles stated in the Declaration of Helsinki.

Pretreatment Examination

Gender, date of birth, smoking habits, and medical history at the time of the initial visit to the practice (baseline) for diagnosis and treatment planning were obtained. Additionally, subjects were clinically and radiographically screened at baseline. To assess patients' periodontal status prior to any implant treatment, full-mouth plaque score (FMPS), full-mouth bleeding score (FMBS), and pocket depths (PDs) were measured at 6 sites for all teeth using a periodontal probe (XP23/UNC15, Hu-Friedy).

At baseline, two groups were formed: Group A, consisting of periodontally healthy patients where the maximum PD was 3 mm; and Group B, consisting of periodontally compromised patients, exhibiting sites with PDs > 5 mm.

Periodontal Treatment

Individual treatment was discussed with the patients and established according to their personal need and wishes, and consent obtained. All patients received appropriate initial therapy, oral hygiene instruction, and scaling and root planing with the aim to reduce the level of periodontal pathogens to a minimum. Teeth considered hopeless were recorded and extracted. Periodontal surgery was performed as needed after the reevaluation phase (35 to 40 days after the initial therapy).

The number, position, and type of implants in each patient were determined after a thorough diagnosis of the anticipated needs for the planned prosthesis and the presence of anatomical limitations.

SLA transmucosal dental implants and Full Osseotite Tapered Implants were placed under local anesthesia by the same operator (N.D.A.) according to the manufacturer's instructions. All transmucosal SLA implants were placed using a standardized surgical procedure. The implants were placed with the border of the rough surface along the alveolar bone crest, leaving the machined-neck portion within the transmucosal area. The decision to use one or the other implant system was at the discretion of the operator, according to clinical and anatomical indications.

All Osseotite implants were platform-switched, and the entire implant body was placed within the bone. An appropriate healing abutment was placed to allow soft tissue
healing immediately after implant placement.

For SLA transmucosal implants, the flap suture was performed to achieve a close adaptation of the wound margins to the implant shoulder without submerging it.

Primary stability was achieved for all implants included in the study (35 Ncm with a minimum ISQ of 60 at four sites on each implant).

Connecting the abutment with an appropriate prosthesis was carried out 3 to 6 months postsurgery and torqued, according to the manufacturer instructions, down to 35 Ncm for tissue-level implants and 20 Ncm for double-etched implants. Patients received either a cemented or screw-retained final crown. Abutments for cemented restorations were selected according to the intermaxillary space. All patients were provided with porcelain-fused-to-metal implant-supported fixed restorations and were not connected to adjacent natural dentition. All restorations were fabricated in order to facilitate both oral hygiene procedures and access to probing along the full circumference.

Baseline Measurements

After implant placement and delivery of the final crown/partial denture restoration, a baseline (T0) intraoral radiograph was obtained using the parallel long-cone technique with personalized acrylic bite. For transmucosal SLA implants, the distance between the implant shoulder and the most coronal visible DIB was measured and recorded in millimeters both at the mesial and distal aspects of each implant. Osseotite implants were completely inserted into the bone, and any distance from the implant shoulder was noted. A fixed reference point was used on both systems: the most coronal edge of the transmucosal implant for SLA and the shoulder of the bone-level implant for Osseotite. In order to avoid bias in the measurements between the two designs, the distance from the reference point and the most-coronal bone was decreased by 1.8 mm for all SLA implants as a fixed dimension (provided by the manufacturer) of the smooth transmucosal neck. The same criteria were used for all follow-up measurements (Figs 1 and 2).

Follow-up

Patients were recalled at regular 6-month intervals for supporting periodontal therapy (SPT). All efforts were addressed to minimize the risk of bias, though in a clinical study, some subjective variables can occur. Nonetheless, the cohort of patients has been made homogeneous through the duration of the study.

Motivation, reinstruction, instrumentation, and treatment of re-infected sites were performed as needed. Patients were placed on an individual maintenance care program, including continuous evaluation of the occurrence and the risk of periodontal disease progression. If a patient expressed the desire not to attend follow-up examinations,
he/she was classified as a drop-out. Reasons for dropping out were death, moving, etc. The names of those individuals were then eliminated from the data collection and inserted in the drop-out list, which was not considered for the final statistical evaluation.

At the 5-year follow-up (T1), an other intraoral radiograph was obtained using the same technique as at T0.

**Final Clinical/Radiographic Examination**

At 10 years (T2), one calibrated examiner (E.C.), blinded to each patient’s surgical treatment, assessed the intraoral radiograph to determine implant success or failure. The 5- to 10-year DIB values were compared with the baseline values (abutment connection). Sites showing radiographic bone loss ≥ 3 mm adjacent to implant during SPT were identified and recorded.

**Statistical Analyses**

The means and 95% confidence intervals (CIs) of the distance between the implant shoulder and the visible coronal-most DIB were calculated for both SLA and Osseotite implants, and the difference between the two implants assessed using independent Student t test. Repeated measures analysis of variance was used to analyze the DIB at T0, T1, and T2. The level of significance was set at < .05, and the confidence level at 95% for all tests. Association of gender, experience of periodontal disease, additional bone augmentation, type of prosthesis (single or multi-unit) and prosthesis connection (screw- or cement-retained), and arch location were compared for SLA and Osseotite implants using independent t test and Spearman ranked correlation on SPSS 23 Software (IBM).

**Results**

A total of 109 SLA and Osseotite implants were placed at the beginning of the study. Data recorded from 91 patients (91 implants) who completed the T2 follow-up were included in the final analysis (SLA: n = 50; Osseotite: n = 41). At T2, the mean difference in DIB between SLA and Osseotite was 1.2 mm and was significantly different (P = .001; 95% CI: 0.55, 1.89 mm). Mean ± SD DIB for SLA implants was 2.1 ± 1.1 mm compared to 0.9 ± 2.1 mm for Osseotite implants, indicating greater remodeling for the SLA implants (Table 1).

Estimated DIB was compared between T0, T1, and T2 (Table 2). There was no significant difference in the DIB between T0 and T1 for either implant type (P > .05). However, DIB was significantly different between T0 and T2 for both implant types (P < .05), indicating that significantly more remodeling occurred after 5 years in the SLA implants group. The Osseotite implant group did not show the same pattern (Table 2).

When all 91 implants were pooled together, a significant association was seen between experience of periodontal disease and mean bone level for both implant types (P = .016). Those with a history of periodontal disease had a higher DIB compared to periodontally healthy patients. Additionally, for both SLA and Osseotite implants, there was a significant association between additional bone augmentation and mean bone level (P = .020). Patients who had not undergone additional bone augmentation had higher DIB than patients who had those procedures done. There was no significant association between mean DIB and gender, type of prosthesis, or type of prosthesis connection in both anterior and posterior arches for both SLA and Osseotite implants. However, it can

### Table 1 Comparison of T2 Bone Levels Between SLA and Osseotite Implants (N = 91)

<table>
<thead>
<tr>
<th>Implant</th>
<th>Mean DIB (SD), mm</th>
<th>MD (95% CI), mm</th>
<th>Independent t test (df)</th>
<th>Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA</td>
<td>2.1 (1.1)</td>
<td>1.2 (0.55, 1.89)</td>
<td>3.412 (56.314)</td>
<td>.001*</td>
</tr>
<tr>
<td>Osseotite</td>
<td>0.9 (2.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T2 = 10-year follow-up; DIB = bone-to-implant distance; MD = mean difference; CI = confidence interval.

*Statistically significant (P < .05).
be seen overall that multi-unit prostheses had greater DIB than single-unit prostheses, and screw-retained prostheses similarly had greater DIB than cement-retained ones (Tables 3 and 4).

When data for SLA and Osseotite implants were analyzed separately, it was evident that there was no significant association between mean DIB and gender, experience of periodontal disease, additional bone augmentation, type of prosthesis, and type of prosthesis connection in both anterior and posterior arches for SLA implants. The Osseotite findings were similar, with the exception of a significant association between additional bone augmentation and DIB (P = .031): Those with previous bone augmentation had lower DIB compared to those without it.

**Discussion**

This prospective cohort study evaluated the survival rates of differently surfaced implants (acid-etched [Osseotite] vs airborne particle-abraded and acid-etched [SLA]). Different clinical values, such as implant survival rate and radiographic bone loss, were recorded.

This study was carried out on a study group with a high number of implants and patients, and the results were collected from a group of 91 implants at 10 years in order to achieve a statistically significant long-term results.

One of the aims of the present study was to evaluate the efficacy of the implant treatment in a periodontally compromised patient. Clinicians are aware that, when treating a partially edentulous patient, natural teeth have a better long-term survival rate and change in marginal bone loss than dental implants. This is the same for teeth that have received treatment for periodontal disease.\(^9\)

In two different publication, Roccuzzo et al\(^4,5\) demonstrated that a previous history of periodontitis may affect both survival and success rates. However, in the more recent study\(^6\) (2014), the authors concluded that SLA implants placed under strict periodontal control offer predictable long-term results.

The key factor for a good long-term prognosis of implants is the patients’ management of plaque control efficiency. Further, the role of the clinician is important in order to deliver appropriate follow-up treatment and SPT and also to instruct the patient in good home care; these factors will predispose patients to healthy peri-implant tissue and a good long-term prognosis for their treatment.\(^1\) Additionally, it is notable that the soft tissue condition (thickness and width) is crucial in preserving the integrity of the underlying bone.\(^11–18\) In the present study, only cases with an initial keratinized tissue width of at least 2 mm were included in order to avoid additional variables in the results.

A risk of bias is present due to the clinician’s decision to place one or the other implant system at their own discretion, and, as mentioned...
earlier, clinical variables cannot be fully predetermined. Moreover, the two implant systems have also a different thread design (SLA transmucosal implants are straight non-tapping bodies, while Osseotite Tapered Implants are the opposite), and this difference played an important role for the clinician when evaluating the patient’s bone density and quality at the time of the surgery.

The literature focuses on differing characteristics of dental implants and how they may positively affect the survival rate. Many studies have been carried out to compare different implant surfaces and how they behave biologically over a long period of time. The aim of the present study was to compare two different implant surface treatments, particularly between a surface that was fully acid-etched (Osseotite) and an airborne particle-abraded and acid-etched surface (SLA). The SLA surface is produced by a large-grit airborne particle-abrasion process, which produces macro-roughness of the titanium surface. The abrasion is followed by immersion in a strong acid-etching bath, which forms an outer area of 2- to 4-mm micro-pits, superimposed on the abraded surface.

Table 3 Association of Variables and T2 DIB for SLA and Osseotite Implants

<table>
<thead>
<tr>
<th>Variable</th>
<th>SLA (n = 50)</th>
<th>Osseotite (n = 41)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DIB T2 (SD), mm</td>
<td>MD (95% CI)</td>
</tr>
<tr>
<td>Gendera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>2.0 (0.69)</td>
<td>−0.5 (−1.3, 0.3)</td>
</tr>
<tr>
<td>Male</td>
<td>2.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Experience of periodontal disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.9 (0.4)</td>
<td>−1.0 (−2.0, 0.0)</td>
</tr>
<tr>
<td>Yes</td>
<td>2.8 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Bone augmentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No GBR</td>
<td>2.2 (1.1)</td>
<td>0.3 (−0.4, 1.1)</td>
</tr>
<tr>
<td>GBR</td>
<td>1.9 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Type of prosthesisa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-unit</td>
<td>1.9 (0.4)</td>
<td>−0.05 (−1.2, 0.3)</td>
</tr>
<tr>
<td>Multi-unit</td>
<td>2.4 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Prosthesis connectiona</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>2.0 (0.6)</td>
<td>−0.9 (−3.0, 1.2)</td>
</tr>
<tr>
<td>Screw</td>
<td>2.9 (2.3)</td>
<td>0.5 (0.5)</td>
</tr>
</tbody>
</table>

T2 = 10-year follow-up; DIB = bone-to-implant distance; MD = mean difference; CI = confidence interval; GBR = guided bone regeneration.

*Levene test (P < .05).

*Statistically significant (P < .05).

Table 4 Association of Arch Position with Mean DIB for SLA and Osseotite Implants

<table>
<thead>
<tr>
<th>Arch position</th>
<th>SLA (n = 50)</th>
<th>Osseotite (n = 41)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean DIB (SD), mm</td>
<td>Pearson correlation</td>
</tr>
<tr>
<td>Anterior</td>
<td>0.8 (1.3)</td>
<td>0.272</td>
</tr>
<tr>
<td>Posterior</td>
<td>1.2 (1.4)</td>
<td>0.051</td>
</tr>
</tbody>
</table>

DIB = bone-to-implant distance. Spearman/Pearson rank correlation data based on r, DIB.
The Osseotite implants are made of commercially pure titanium treated with a specific, proprietary double acid-etch protocol. The good implant survival rates of the acid-etched surface used have been proven and could promote less interproximal bone resorption during the first period of implant placement.

It is of note that all the SLA implants were transmucosal, and the DIB was calculated from the most coronal level of the implant shoulder to the most coronal position of the bone, including the amount of smooth surface of the implant neck, which is approximately 1.8 mm.

The DIB values obtained show no significant difference between the two implant groups from T0 to T1. However, from T0 to T2, the DIB value was significantly different, showing that there was bone remodeling around the implant in both groups over the 10-year observation; additionally, in the SLA group, there was a remodeling of the bone from T1 to T2. The results obtained from T0 to T2 are in accordance with other studies; in 2012, Buser et al. found a mean DIB value of 3.32 mm at the 10-year follow-up for SLA implants, while in 2015, Menini et al. found a mean bone loss of 1.30 mm at the 6-year follow-up in a study on Osseotite-surface implants.

Looking further at the present results, it is possible to see that there was no significant association between bone remodeling and different parameters, such as gender, type of prosthesis, and type of prosthesis connection correlated to the position. Regarding the association between DIB values and experience of periodontal disease, the results show greater changes in DIB values when compared to healthy patients. However, compared to the results obtained in other studies, it appears that there are similarities in implant survival—particularly, a higher risk for implants in a periodontally compromised patient—that may develop over a prolonged observation period of 5 to 10 years.

Conclusions

Within the limitations of the present study, the findings demonstrate that the overall survival rates of SLA and Osseotite implants are high over the 10-year observation period. A history of previous periodontal disease plays an important role in the incidence of complications, regardless of the surface type. As a consequence, great caution should be exercised when planning an implant placement in those patients, especially if additional bone augmentation is required.

Acknowledgments

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References


