Clinical Evidence of OsseoSpeed EV Implants: A Retrospective Study and Characterization of the Newly Introduced System

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This retrospective study sought to compare a new implant (Astra Tech OsseoSpeed EV, Dentsply Sirona) with its predecessor (Astra Tech OsseoSpeed TX) by scanning electron microscopy and interferometry. Radiographic data from 19 patients who underwent implant restoration with EV (n = 49) with a median follow-up of 16 months were evaluated for mean bone level (MBL) changes from delivery of the definitive prosthesis. EV and TX did not differ in surface roughness, and both systems had a tight seal at the implant-abutment interface. The median MBL change of the EV was −0.02 mm mesiodistally after a median follow-up period of 16 months. Greater maintenance of MBL was found in the screw-retained restorations (n = 17) compared to cemented (0.35 ± 0.33 mm and −0.38 ± 0.76 mm, respectively; P = .03). The data suggest that EV shows minimal levels of bone loss and high implant survival. Int J Periodontics Restorative Dent 2019;39:863–874. doi: 10.11607/prd.2549

Over the past 30 years, the biologic and clinical performance of implant systems has constantly improved.1 The key challenges in the design of implant systems have been addressed to increase mechanical robustness and long-term implant survival and to improve ease of use.2,3 To date, most clinical trials have reported comparable high implant survival rates along with long-lasting function and esthetics, which fully satisfy clinical expectations and patient requirements.4,5 The optimal goals for implant treatment at present are to maintain marginal bone around the implant and to establish healthy and stable soft tissue.5–7 A large body of literature has identified key elements of potentially preserving the bone level and the health status of the soft tissue surrounding an implant.8–10 The interaction of different biologic, biochemical, and biomechanical features (ie, surface treatment, thread profiles and dimensions, implant-abutment connection, and diameter-reduced abutments, namely platform switching) have been suggested to influence the bone regeneration/remodeling pathway.11–14

When considering the evolution of implant surface topography, the moderately roughened implants generated via numerous methods have contributed to the preservation of marginal bone, which naturally

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results in long-term clinical success.\textsuperscript{15}

Several retrospective observational and cross-sectional studies have shown implant survival rates ranging from 98.3\% to 100\% after 5 years in function.\textsuperscript{14} Furthermore, some studies reporting on the frequency distribution of marginal bone level (MBL) changes in periodontally compromised patients have shown that between 64\% and 88\% of the implants had \( \leq 1.5 \) mm change after 3 to 10 years in function.\textsuperscript{17,18} Prospective clinical studies have reported mean MBL changes around new generation implant systems after 1 year of function ranging from 0.06 to \(-0.54 \) mm, after 2 years of function ranging from 0.12 to 0.6 mm, after 3 years of function ranging from 1.6 to \(-0.88 \) mm, and after 5 years of function ranging from 0.1 to \(-0.16 \) mm.\textsuperscript{11,19–23} An authoritative meta-analysis of 10 clinical trials further confirmed these results by reporting a mean MBL of 0.24 mm and an average survival rate of 98\% after 5 years in function.\textsuperscript{1}

In addition, several studies have shown good esthetics and high patient satisfaction.\textsuperscript{5,24–26}

One of the crucial factors for implant success is the primary stability of the implant. It has been reported that primary stability is solely a mechanical interlocking of the implant and the bone resulting from the interplay between surgical procedures (drilling protocols), implant macrogeometry, and microtopography.\textsuperscript{27,28} Halldin et al.\textsuperscript{28} have reported that the bone can be compressed far beyond the theoretical yielding point and the implant can maintain high levels of stability without negative biologic response by altering the interplay between drilling protocols and implant macrogeometry. Thus, based on the preclinical scientific evidence, the recent trend in implant design has been to optimize drilling protocols and implant macrogeometry, aiming to increase the primary stability.\textsuperscript{27,28}

Recently, an internal connection implant system, advertised by the manufacturer to possess higher primary stability than its predecessor, has been introduced. The basic concept of the system is that the implants are placed in a stepwise undersize osteotomy, which provides higher insertion torque values. Although this system is promising owing to the preclinical evidence that undersize drilling to a certain extent does not negatively affect the osseointegration cascade, there is a lack of clinical evidence regarding the system’s performance.\textsuperscript{29}

Thus, the aim of this retrospective study was to assess the survival and marginal bone stability of the newly introduced system, which provides higher insertion torque values than its predecessors. Based on a case series of 19 patients, 49 implants were placed and the outcomes were retrospectively analyzed by radiographic examination in terms of MBL changes during a median follow-up of 16 months.

**Materials and Methods**

**Implant Characterization**

To evaluate the features of the new system, the implants were characterized morphologically and topographically.

**Characterization of the Implant Connection**

Three OsseoSpeed EV (Astra Tech, Dentsply Sirona) and, for comparison, three OsseoSpeed TX (Astra Tech, Dentsply Sirona) were connected to prefabricated TiDesign abutments (Astra Tech, Dentsply Sirona) with a torque of 25 Ncm for EV and 20 or 25 Ncm for TX, according to the manufacturer’s recommendations, to investigate the fit of the conical connection of the screw-retained abutment into the implants.

The assembled specimens were positioned inside cubical plastic molds with the aid of a parallelogram to orient their vertical axes parallel to the walls of the mold and then embedded in epoxy resin poured into the molds (Technovit Epox VLC, Heraeus Kulzer). After polymerization, the embedded samples were removed from the molds and ground using a grinding machine (EXAKT) with SiC papers of descending grit size (250, 400, 500, 800, 1,000, 1,200, and 2,500) under constant water cooling to expose the implant-abutment assemblies. To minimize the sample angulation, the specimens were ground with uniform pressure and always with the longitudinal axis of the implants parallel to the grinding plate. All the implant-abutment blocks were ground until the center of the implant diameter was reached. The prepared specimens were observed with a scanning electron microscope (SEM) (JSM 6060 LV, JEOL) at a high magnification to investigate the fit of the conical abutment and the implants. The marginal gaps between the implant and the abutment...
in the conical region were measured in four areas of the inner connection, as shown in Fig 1 (A, B, C, D), following the reported protocols.\textsuperscript{30,31} Freeware image analysis software (Image J, National Institutes of Health) was used for the calculations. Two independent operators performed the calculations.

To classify the degree of fit, a score was assigned to each measurement following the criteria of Albertini et al.\textsuperscript{32} A score of 0 was assigned to gaps not exceeding 2 µm (perfect adaptation), a score of 1 was assigned to gaps > 2 µm but not exceeding 5 µm (suboptimal adaptation), a score of 2 was assigned to gaps > 5 µm (no complete adaptation), and a score of 3 was assigned to gaps > 10 µm (clear evidence of no adaptation).

**Topographical Characterization**

The surfaces of three OsseoSpeed TX implants and three OsseoSpeed EV implants were examined using white light optical interferometer (MicroXAM, PhaseShift). Three macrothread tops, three macrothread valleys, and three flanks were measured for each implant, with a scan area of 120 × 197 µm for the tops and valleys and 155 × 197 µm for the flanks, and a vertical range of 100 µm. In addition, three microthread tops and three microthread valleys were analyzed for each implant, with a scan size of 65 × 197 µm. The acquired data were reconstructed using Mountain Map software (Digital Surf), and a Gaussian filter 50 × 50 µm was applied to separate the surface topography from form and waviness. The surface topography was described by three parameters: the arithmetic mean roughness ($S_a$), the developed area ratio ($S_{dr}$), and the density of the peaks ($S_{ds}$), and visual renderings of the surfaces were obtained.

**Clinical Examination**

At the follow-up re-examinations, the following clinical parameters were recorded:

- Pain from implant region and implant mobility
- Presence of plaque scored as plaque index (Pl)—namely, the percentage of sites with plaque present as determined at four surfaces per restored tooth after staining solution (> 40% = PI+)
- Mucositis scored as bleeding on gentle probing (BoP+) at the four surfaces of all implants
- Probing pocket depth (PPD) (probing pressure 0.35 N) measured in millimeters with a manual CP15 periodontal probe (Hu-Friedy) to the closest millimeter

The assessments of Pl, BoP, and PPD were performed at four sites of each implant (mesial, distal, buccal, lingual, and occlusal).
and lingual). Data on the same parameters were retrieved for the baseline examination (ie, delivery of the definitive prosthesis) when available, and further compared.

Radiographic Examinations

Radiographic assessment of the MBLs was performed on periapical radiographs made with an x-ray apparatus supplied with a long cone. A Rinn centrator was used to ensure reproducibility in the measurement of MBL change.

Radiographic baseline was the connection of permanent abutments and final prosthesis installation. Subsequent radiographic examinations were performed at the follow-up visits. The distance between the reference point (implant shoulder) and the first visible bone-to-implant contact was measured. Bone level was measured at mesial and distal sites for each implant. Mesial and distal values were analyzed individually.

Special attention was given to clear imaging of implant threads on both sides of the implant. To correct dimensional distortion, the apparent dimension of each implant was measured on the radiograph and compared with the actual implant size. To ensure reproducibility between examinations, intraoral radiographs were taken, applying the paralleling technique using film holders.

Two independent experienced clinicians not involved in the study interpreted the radiographs and assigned the scores. In case of different scores, the case was re-evaluated until agreement was found.

The radiographs were evaluated using Image J software. Radiographic success was evaluated according to Albrektsson et al’s success criteria.33

Patient Satisfaction

The patients evaluated the esthetic and functional outcomes at a follow-up visit using a 10-cm visual analog scale (VAS) labelled “satisfied” at 10 cm and “unsatisfied” at zero. The distance in millimeters between the zero point and the patient’s response was measured.

Statistical Methods

Differences in average surface parameters between implant systems were evaluated using Student t test.

The clinical/demographic data of the included patients and the features of the related implants expressed as continuous variables were reported as mean ± SD after checking the normality of distribution, or alternatively as median and 25th to 75th percentiles.

Data reported as dichotomous variables (ie, smoking: yes/no) were shown as absolute frequency (n) and percentage.

Mann-Whitney test was used to evaluate statistically significant differences between continuous variables (ie, differences between MBL measured at baseline and at last follow-up visit and MBL between cemented and screw-retained reconstructions).

Multiple regression models were computed to evaluate the effect of patient characteristics (ie, age, sex, follow-up) and implant features (ie, implant diameter and length, maxillary or mandibular placement, cemented or screw-retained restoration) on MBL changes detected at mesial and distal sites. Before multiple regression models were performed, original data underwent logarithmic conversion if data distributions were significantly skewed on visual inspection. Even in this case, P < .05 was considered statistically significant. Bland-Altman test was performed to evaluate agreement between measurements of bone level at mesial and distal sites.

The R program (www.r-project.org) was used to perform all statistical analysis and to compute multiple regression models.

Results

SEM Characterization of the Implant Connection

Results from SEM analysis on three EV and three TX implants connected with a torque of 25 Ncm and 20/25 Ncm, respectively, are reported in Table 1.

According to the Bland-Altman test, no evidence of disagreement was found. In two EV and two TX implants (Table 1), SEM evaluation demonstrated mean internal gaps < 2 µm and consequently a zero score was assigned to them.
In one TX 5 × 9-mm and one EV 4.2 × 9-mm, one and two gaps, respectively, of around 4 μm were found. No statistically significant difference was found in median gap detected in EV compared with TX implants (1.2 vs 0.78 μm, \( P = .37 \)) (Figs 2 and 3).

Surface Topography

The results of the topographic examination are summarized in Tables 2 and 3 and Fig 4.

The mean \( S_d \), \( S_{dr} \), and \( S_{ds} \) values differed significantly between the macro and microthreads, with the microthreads showing a rougher surface topography for OsseoSpeed TX and EV. The \( S_d \) values (mean ± SD) of the microthreads were 1.52 ± 0.22 μm and 1.49 ± 0.14 μm for TX and EV, respectively, while for the macrothreads they were 1.42 ± 0.18 μm for TX and 1.35 ± 0.17 μm for EV. The microthreads \( S_d \) values for were 50.48% ± 14.39% for TX and 43.64% ± 9.39% for EV implants, and the macrothreads \( S_{dr} \) results for the same implants were 40.83% ± 8.04 and 39.97% ± 7.97, respectively. The \( S_{ds} \) values (mean ± SD), expressed as μm–2, were comparable between micro and macrothreads and are listed in Tables 2 and 3.

The statistical analysis revealed that the differences in average surface parameters between OsseoSpeed TX and EV did not reach a statistically significant level for macrothreads or microthreads.

Patients

A total of 19 consecutively treated patients fulfilled the inclusion criteria. All the patients had been treated between November 30, 2011, and April 30, 2013, by the same surgeon (M.T.). Median patient age was 50 years (range: 25–82 years). Of the patients, 58% were men and 15.7% were smokers.

All the patients were treated with the same surgical procedure and were excluded if any of the following conditions was present: bone defects associated with severe knife-edge ridges, bone defects resulting from tumor resection, tobacco abuse (> 10 cigarettes/day), severe renal kidney and liver disease, history of radiotherapy in the head and neck region, chemotherapy for treatment.
of malignant tumors at the time of the surgical procedure, uncontrolled diabetes, active periodontal disease involving the residual opposing dentition, mucosal disease in the areas to be treated, or poor oral hygiene with a PI of > 70%.

All patients received antibiotic prophylaxis (amoxicillin 1 g) 1 hour prior to surgery and after implant placement until suture removal, with 1 g three times a day.

The surgical treatment was performed under local anesthesia. In case of remaining teeth, they were extracted with conventional technique before implant placement. The implants were placed according to the manufacturer’s specifications as described in the OsseoSpeed EV surgical manual (Astra Tech,

Table 2  Surface Topography Parameters for OsseoSpeed TX and EV Microthreads

<table>
<thead>
<tr>
<th>Microthreads</th>
<th>$S_a$</th>
<th>$S_{dr}$</th>
<th>$S_{ds}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>OsseoSpeed TX</td>
<td>Mean 1.52</td>
<td>50.48</td>
<td>0.06</td>
</tr>
<tr>
<td>SD 0.22</td>
<td>14.39</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Max 1.99</td>
<td>86.73</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Min 1.15</td>
<td>31.66</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>OsseoSpeed EV</td>
<td>Mean 1.49</td>
<td>43.64</td>
<td>0.06</td>
</tr>
<tr>
<td>SD 0.14</td>
<td>9.39</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Max 1.78</td>
<td>68.16</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Min 1.24</td>
<td>29.89</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

$S_a$ = arithmetic mean roughness; $S_{dr}$ = developed area ratio; $S_{ds}$ = density of the peaks. $P$ values were obtained with Student $t$ test for independent samples.

Table 3  Surface Topography Parameters for OsseoSpeed TX and EV Macrothreads

<table>
<thead>
<tr>
<th>Macrothreads</th>
<th>$S_a$</th>
<th>$S_{dr}$</th>
<th>$S_{ds}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>OsseoSpeed TX</td>
<td>Mean 1.42</td>
<td>40.83</td>
<td>0.06</td>
</tr>
<tr>
<td>SD 0.18</td>
<td>8.04</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Max 1.91</td>
<td>63.11</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Min 1.10</td>
<td>25.42</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>OsseoSpeed EV</td>
<td>Mean 1.35</td>
<td>39.97</td>
<td>0.06</td>
</tr>
<tr>
<td>SD 0.17</td>
<td>7.82</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Max 1.66</td>
<td>55.89</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Min 1.03</td>
<td>29.78</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

$S_a$ = arithmetic mean roughness; $S_{dr}$ = developed area ratio; $S_{ds}$ = density of the peaks. $P$ values were obtained with Student $t$ test for independent samples.
Dentsply). According to the specific clinical situation, immediate (n = 4) or conventional (n = 15) loading was applied. At the end of the healing process, all patients received the final rehabilitation from the same prosthodontist. All patients had been instructed to rinse with chlorhexidine 0.12% mouthrinse three times a day for 2 weeks. The patients were advised to take NSAIDs for pain relief at their own discretion.

Liquid and semisolid food were prescribed for the first postoperative week, after which the sutures were removed. The temporary prostheses were designed to allow normal hygiene procedures. All prosthetic procedures were performed following the manufacturer’s instructions.

A total of 20 prostheses were included in this retrospective examination (median loading time of 3 months after implant reconstruction). These prostheses were supported by 49 abutments (median 2 per patient; 25th–75th percentile: 2 to 3 per patient), all on OsseoSpeed EV implants (Astra Tech, Dentsply). The implant positions were 38 maxillary (7 incisors, 2 canines, 15 premolars, and 14 molars) and 11 mandibular (4 premolars and 7 molars). Most patients received one implant in the premolar or molar area (81.6% of sites), and 77.6% of the implants were placed in the maxilla. The diameters of the implant restorations were 3.6 (n = 19), 4.2 (n = 18), 4.8 (n = 10), and 5.4 mm (n = 2). Implant length ranged from 9 to 13 mm, with the majority being 9 mm (n = 25; 51%).

Accounting for the type of the abutments, 18 were TiDesign (Dentsply) and 14 were Atlantis CAD/CAM (Dentsply) (9 milled in titanium, 4 in zirconia, and 1 in titanium gold hue). These abutments were used to support cemented reconstructions, in particular 2 porcelain-fused-to-metal single crowns, 3 all-ceramic single crowns, 3 all-ceramic fixed partial dentures (FPDs), and 6 porcelain-fused-to-metal FPDs. Furthermore, 17 33-degree UniAbutments (Dentsply) were used to support 5 screw-retained Atlantis ISUS milled cobalt-chromium-porcelain frameworks and 1 Atlantis ISUS milled Ti-acrylic FPD (Dentsply).

The span length for porcelain-fused-to-metal FPDs varied from one to three units supported by one to three abutments. The span length for all-ceramic FPDs varied from three to four units supported by two to three abutments. One metal-acrylic FPD was supported by six abutments.

All 20 restorations were in function for 6 to 26 months, and the mean follow-up was 16 ± 9 months.

At the first follow-up visit, most patients presented an optimal periodontal condition. PPD measured at the mesial, buccal, distal, and lingual surfaces of all teeth/implants ranged from 3.6 to 4.0 mm. The PI resulted positive in only one patient, whereas 9 patients demonstrated positive BoP at the mesial, buccal, distal, or lingual surfaces of all implants. No mobility of prosthesis was recorded.
Marginal Bone Level

Mesial and distal measurements performed at baseline (permanent restoration delivery) and follow-up visits as well as the related differences are reported in Table 4. Due to the non-normal distributions, median levels and percentiles may appropriately summarize the marginal bone measurements and the related differences in all patients.

MBL did not significantly change at 16 ± 9 months after functional loading considering distal and mesial measurements (Mann-Whitney test; \(P = .704\)). No statistically significant difference was found between median differences at mesial or distal surfaces, respectively.

Bland-Altman test confirmed the good agreement between the differences detected at mesial and distal surfaces (Fig 5). The distributions of implants according to mean MBL changes detected at mesial and distal surfaces are reported in Fig 6. In particular, 53% of the implants presented no bone loss but a median slight gain of 0.21 mm.

Furthermore, a statistically significant difference was found between mean ± SD MBL measured in cemented (n = 32) and screw-retained (n = 17) reconstructions (−0.38 ± 0.76 vs 0.35 ± 0.33 at the mesial surface and −0.11 ± 0.62 vs 0.06 ± 0.39 at the distal surface; \(P < .001\)). Multiple regression models were used to evaluate the possible influence on MBL changes of age, sex, follow-up, implant diameter, implant length, maxillary versus mandibular placement, and cemented versus screw-retained restoration.

The covariates explaining most of the variance (restricted model) with statistical significance were follow-up, implant length, implant diameter, and cemented versus screw-retained restoration.

### Table 4 Marginal Bone Levels (MBL) Measured at Mesial and Distal Sites and Related Changes

<table>
<thead>
<tr>
<th>MBL Mesial (mm)</th>
<th>MBL Distal (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>0.33 ± 0.87</td>
</tr>
<tr>
<td>Median</td>
<td>0.30 (−0.40; 0.77)</td>
</tr>
<tr>
<td>MD (mm)</td>
<td>−0.12 ± 0.73</td>
</tr>
<tr>
<td>DD (mm)</td>
<td>−0.05 ± 0.55</td>
</tr>
</tbody>
</table>

MD = difference between measurements at mesial site; DD = difference between measurements at distal site.
Therefore, follow-up, implant length, and the type of restoration (cemented/screw-retained) were found to significantly influence the bone maintenance. In particular, the statistical model showed a slight bone gain in the early follow-up (within 6 months from permanent restoration delivery), whereas a certain loss may occur later (after 18 months) \( (P < .0001) \). In addition, the statistical model showed that longer implants seem to limit bone maintenance \( (P < .05) \), probably for the greater invasiveness of the surgical procedure. When considering implant diameter, no statistically significant influence was detected \( (P = .1) \).

The multiple regression model further confirmed the greater maintenance of MBL in screw-retained restorations \( (P = .03) \) compared to cemented.

According to VAS score, the patients’ functional and esthetic satisfaction levels with EV were high. Self-assessed overall satisfaction, especially with regard to chewing, phonetics, and esthetics, was consistently very high \( (VAS = 9.8 \text{ cm}) \) at the follow-up visit. A total of 17 patients stated that they were “very satisfied” and 2 “satisfied” in all regards with their final prosthesis (Figs 7 to 9).
Discussion

This is the first study providing an extensive clinical evaluation of the new internal connection implants, namely the EV implants. In a relatively short follow-up, this investigation gathered clinical evidence that the EV implants presented good clinical performance in terms of survival, MBL maintenance, and patient satisfaction.

MBL was maintained during the follow-up time, with median changes of $-0.03$ and $-0.01$ mm at mesial and distal sites, respectively. In addition, a median gain in MBL around most of the implants of $0.21$ mm was observed. These results confirmed those of a recent publication on MBL maintenance around EV implants, evaluated in a short-term follow-up.34

In the present investigation, a small but statistically significant gain in MBL was observed for the screw-retained reconstructions ($\text{n} = 17$ implants in 6 patients) compared to the cemented restorations ($0.35$ mm and $-0.38$ mm, respectively). This result was further reinforced by the multivariate model showing the positive influence of the initial retention mode on MBL. This evidence supports the hypothesis that screw-retained restorations could have some positive influence with regard to MBL maintenance as compared to the cement-retained restorations.35,36 Although it has been suggested that the use of cemented reconstruction does not affect the survival rate of implants, the risk for biologic and technical complications (ie, bone loss > 2 mm) may be higher than for screw-retained restorations.35,36 Moreover, Linkevicius et al35 suggested that subgingival excessive cement may be a risk factor for marginal bone resorption.37 In their study, 85% of the implants with subgingival cement remnants had marginal bone resorption and 100% of the implants presented MBL if the patient had a history of periodontitis. It was suggested that standard periapical radiographs could not detect the buccolingual remnants, and this was one reason clinicians could not detect the excessive subgingival cement. In another study, Linkevicius et al38 suggested that a deeper subgingival position of the margin could hide undetected cement.

The MBL changes of the implants included in the present study (median $-0.02$ mm at distal/mesial surface) were comparable to the results reported by Mertens et al23 and Stanford et al24 and suggested that the OsseoSpeed EV implants performed as well as the TX implants in terms of bone maintenance.

One major changes compared to previous systems is the change in the drilling protocol, which is suggested to increase the primary stability of the implant.34 In brief, the drilling protocol consists of undersized drilling in the central body of the jaw bone, rich in bone marrow, resulting in a final diameter of the implant bed that is $0.5$ mm smaller than the implant diameter. Although undersized drilling has a potential danger of ischemia, a recent review reported that an adequate level of undersized drilling maintains initial stability, which leads to higher secondary stability (osseointegration).28,39 Moreover, compression of the marrow region may avoid the bone resorption and the so-called dieback typically seen in traditional press-fit implants with interfacial remodelling pathways.39 Compression of the marrow region may be ideal since the undersized drilling protocol may increase the bone marrow substance contact to the implant surface, which is known to have greater regeneration capability than cortical bone.40

The SEM analysis showed that EV implant-abutment connections had a completely tight internal seal at all four areas measured, comparable to past studies evaluating the fit of internal connection implants.30,31 The quantitative evaluation and scoring showed that the existing gaps for both tested implants were approximately $4$ µm and were not localized close to the peri-implant tissues. Since some reports indicate that microgaps between the implant and the abutment could act as a reservoir for microbial leakage and could alter the stress distribution at the implant-abutment interface, the tight seal between the implant and the abutment could be a major reason for the well-maintained marginal bone.31,41

The OsseoSpeed surface is produced by blasting with micronized titanium dioxide particles and then etched with acids and successively treated with fluoride ions. The topographic investigation of the implant surfaces in this study showed that both TX and EV implants possessed a moderately rough microtopography, according to the definition given by Wennemerberg and Albrektsen.42 The mean $S_a$ value was $1.46$. 

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μm for the TX implants and 1.41 μm for the EV implants, while mean $S_{dr}$ was 44.7% and 41.4%, respectively. Experimental studies have shown that surfaces in the moderately rough range ($S_d$ of approximately 1.5 μm and $S_{dr}$ of about 50%) yielded the strongest bone response, and those values were comparable to those obtained in the current investigation.\textsuperscript{34,43} However, when the values of roughness were calculated separately for the microthreads and the macrothreads, significantly rougher surfaces were observed on the microthreads for both implant systems. The mean $S_d$ of the microthreads of the TX implants was 1.52 μm, compared to 1.42 μm for the macrothreads of the same implants; and the values were 1.48 and 1.35 μm, respectively, for the micro- and macrothreads of the EV implants. As for average $S_{dr}$, TX implants showed values of 50.5% for the microthreads and 40.8% for the macrothreads, while the EV implants had a mean $S_{dr}$ of 43.6% in the microthreaded region and 39.9% in the macrothreaded. The difference in roughness in the microthreaded region may be due to different geometry of the implants in that portion, which results in a different impact of blasting particles on that area compared to the body of the implants.\textsuperscript{44} Despite the statistical significance, the difference in average values between the microthread and macrothread areas may be not clinically relevant, since the surfaces were still in the range of optimal roughness. This difference in roughness seems not to have negatively influenced MBLs in the present study, in which the levels were maintained during the follow-up period and signs of complications were absent in all implants.

Since the new implant system with an improved drilling protocol and passive fit between the implant and the abutment presented predictable clinical outcomes at a median follow-up of 16 months, the clinical outcomes should be followed further.

Conclusions

This study retrospectively evaluating the clinical outcomes of a new implant system with a modified drilling protocol and a new implant-abutment connection system showed stable MBLs and 100% implant survival at a median follow-up of 16 months. The passive seal of the implant-abutment interface and improved drilling sequence seem to have contributed to the midterm clinical success.

Acknowledgments

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

References


