Screw Joint Stability in Conventional and Abutment-Free Implant-Supported Fixed Restorations
Stefan Scherg, Dr Med Dent¹/Matthias Karl, PD, Dr Med Dent²

Purpose: Procera Implant Bridges (PIBs) do not engage supporting implant shoulders and are fixed using comparably long retention screws. The aim of this in vitro clinical study was to determine the detorque values in PIBs and conventionally fabricated fixed dental prostheses (FDPs). Materials and Methods: Two groups of screw-retained implant-supported three-unit FDPs (n = 10) were fabricated by means of conventional casting or computer-aided design/computer-assisted manufacture to fit an in vitro situation with two implants. Following fixation, the restorations were subjected to masticatory simulation (100,000 cycles, 100 N) and subsequent detorquing of the retention screws. In the clinical part, a total of 10 patients received PIB restorations in the premolar/molar region that were detorqued after 2, 4, and 6 months. One-sample t tests adjusted for multiple testing by the Bonferroni-Holm method were applied for statistical analysis based on percentage detorque values (α = .05). Results: 60% of the initial torque values were maintained in screws directly retaining restorations, while the abutment screws used in the conventional restorations showed detorque levels in the range of 80%. No significant difference in detorque levels between screws retaining PIBs and conventional FDPs could be detected (P = .5186). The abutment screws showed significantly greater detorque values compared with screws directly retaining restorations (P = .0002; P = .0000). In vivo, a significant increase in detorque values ranging from 21.64 Ncm after 2 months to 27.81 Ncm after 6 months was recorded. Conclusion: Prosthetic screws retaining implant-supported FDPs show torque loss during the initial period of service. Retightening reduces the amount of future torque loss. Int J Prosthodont 2016;29:142–146. doi: 10.11607/ijp.4458

Using screw retention for implant-supported fixed dental prostheses (FDPs) offers the advantage of retrievability¹ and avoids the risk of cement-related peri-implant inflammation.² However, loosening of retention screws³,⁴ has been reported as a clinically relevant problem with an incidence of 6.7% after 5 years.⁵ To maximize mechanical stability at the prosthetic interface, implant manufacturers have developed force-fit and form-fit components.⁶ To benefit from these features, prefabricated implant components have been advocated for achieving maximum precision of fit and longevity in conventional restorations.

Besides providing a multitude of restorative options, computer-aided design/computer-assisted manufacture (CAD/CAM) fabrication techniques for implant-supported restorations have been repeatedly shown to achieve unprecedented levels of fit.⁷,⁸ Given that the antirotational features of dental implants can hardly be reproduced with sufficient levels of precision,⁹ few CAD/CAM systems offer the possibility of fabricating screw-retained restorations such as Procera Implant Bridges (PIBs) (Nobel Biocare). Such restorations have flat-on-flat prosthetic interfaces that do not take advantage of the implant shoulders’ retentive features.¹⁰ Therefore, it was the goal of this study to compare the removal torque levels of retention screws in conventionally fabricated FDPs and PIBs following masticatory simulation.¹¹ Additionally, removal torque values in 10 patients restored using PIBs were repeatedly measured.

Materials and Methods

Part I: In Vitro

A polyurethane model duplicating an existing patient situation with two implants placed in the region of a mandibular left first premolar and first molar (Standard Plus Implants, 4.1 mm diameter, 10-mm bone sink depth, Straumann) was fabricated. Using the implant manufacturer’s transfer components

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of 3°C.12–14 Following loading, the restorations were
removed from the implants and the removal torque
needed was measured (Fig 1).15–18

Similarly, patterns were obtained for the remaining
10 master casts, which served as a basis for the
fabrication of CAD/CAM restorations. Starting from
scanning the master casts and patterns, all fabrica-
tion steps for the CAD/CAM restorations were carried
out by Nobel Biocare. Identical designs were chosen
for all restorations with respect to overall dimensions,
shape, and connector design, and 10 frameworks
were fabricated from titanium (PIB, Nobel Biocare).
These restorations could be fixed directly on the im-
plant shoulders without placing abutments.

Prior to fixation of the restorations on the polyure-
thane model, visual and tactile evaluation using mag-
nifying glasses and a dental explorer was performed
to ensure a clinically acceptable fit.1,8,10 The conven-
tional restorations were fixed on the implant manufacturer’s abutments for screw-
retained restorations (synOcta screw-retained abut-
ments, Straumann).

Part II: In Vivo

Ethics commission approval (medical faculty,
University of Erlangen-Nuremberg, Project 296_13B)
was obtained prior to starting the in vivo part of the
study. After informed consent was obtained, a total of
10 patients were enrolled in a private practice setting
(Figs 2a to 2d). All patients had been treatment planned
with a restoration mounted on the implants, the
implants were cleaned with 0.2% chlorhexidine solution
(Clorhexamed, GlaxoSmithKline), and the restora-
tions were fixed on the implants again. During this
phase, the screw access holes were filled with a foam
pellet and light-curing temporary filling material (Clip,
Voco). As part of the final recall session, new reten-
tion screws were used to mount the restorations on
the implant shoulders and the screw access holes
were restored with foam pellets and composite resin
(Tetric Evo Ceram, Ivoclar Vivadent).

With a restoration mounted on the implants, the
polyurethane model was positioned in the water bath
of a masticatory simulator (Kausimulator, Härch
d Elektrohandwerksbetrieb) at an angle of 135 degrees
in relation to the long axis of the implants and cyclic
loading of the specimens was performed for 100,000
cycles11 at 100 N (2 seconds of loading followed by 1
second of unloading) at a constant water temperature
of 37°C.12–16 Following loading, the restorations were
removed from the implants and the removal torque
needed was measured (Fig 1).15–18

Fig 1 Sample of a Procera Implant Bridge directly fixed on the shoul-
ders of two supporting implants and mounted in the water bath of a
masticatory simulator at an angle of 135 degrees in relation to the long
axis of the implants.
**Screw Joint Stability in Implant-Supported Fixed Restorations**

**Fig 2a** Clinical situation of two bone-level implants used to support a three-unit FDP.

**Fig 2b** Sample of a screw-retained Procera Implant Bridge made from titanium onto which a ceramic veneer was bonded adhesively.

**Fig 2c** Clinical situation of a three-unit Procera Implant Bridge supported by two implants in the area of the first premolar and first molar.

**Fig 2d** Periapical radiograph showing two implants directly supporting a screw-retained Procera Implant Bridge.

### Table 1
Mean (Standard Deviation) Detorque Values Measured in Vitro

<table>
<thead>
<tr>
<th>Restoration type and recommended tightening torque (Ncm)</th>
<th>Premolar</th>
<th>Molar</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional restoration synOcta abutment (35)</td>
<td>27.45</td>
<td>28.58</td>
<td>28.08</td>
</tr>
<tr>
<td>Conventional restoration occlusal screw (15)</td>
<td>9.47</td>
<td>8.69</td>
<td>9.08</td>
</tr>
<tr>
<td>PIB (35)</td>
<td>20.21</td>
<td>20.19</td>
<td>20.20</td>
</tr>
</tbody>
</table>

**PIB** = Procera Implant Bridge.

### Table 2
Mean (Standard Deviation) In Vitro Detorque Values Given as Percentage of the Tightening Torque Used

<table>
<thead>
<tr>
<th>Restoration type and recommended tightening torque (Ncm)</th>
<th>Premolar</th>
<th>Molar</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional restoration synOcta abutment (35)</td>
<td>78.30</td>
<td>81.54</td>
<td>80.10</td>
</tr>
<tr>
<td>Conventional restoration occlusal screw (15)</td>
<td>63.13</td>
<td>57.96</td>
<td>60.55</td>
</tr>
<tr>
<td>PIB (35)</td>
<td>57.57</td>
<td>57.65</td>
<td>57.60</td>
</tr>
</tbody>
</table>

**PIB** = Procera Implant Bridge.

### Table 3
Statistical Comparisons Between the Different Screw Types Based on the Percentage Detorque Values Measured In Vitro at the Premolar and Molar Positions

<table>
<thead>
<tr>
<th>Occlusal screw</th>
<th>PIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>synOcta abutment</td>
<td>.0002</td>
</tr>
<tr>
<td>Occlusal screw</td>
<td>.5186</td>
</tr>
</tbody>
</table>

1One-sample t tests, P values adjusted for multiple testing by the Bonferroni-Holm method.

**PIB** = Procera Implant Bridge.

### Statistical Analysis

Based on the percentage detorque values measured in vitro at the premolar and molar positions, one-sample t tests adjusted for multiple testing by the Bonferroni-Holm method were performed for comparing screw joint stability between the two restoration types investigated. Pairwise comparisons of in vivo detorque values measured after 2, 4, and 6 months following delivery of the restorations were performed using the same test method. The level of significance was set at $\alpha = .05$ for all comparisons conducted.

### Results

**Part 1: In Vitro**

Following masticatory simulation, all screw types considered showed lower detorque values compared with the torque levels applied during tightening (Table 1). In the conventional restorations, the occlusal screws tightened with 15 Ncm showed mean detorque values of 9.08 Ncm while the abutments tightened with 35 Ncm required a torque of 28.08 Ncm to loosen the abutment screw. In the PIBs, a mean detorque value of 20.20 Ncm was found. While comparable percentages in the range of 60% of the initial torque values were maintained in those screw types directly retaining the restorations, the abutment screws used in the conventional restorations showed detorque levels in the range of 80% of the tightening torque applied (Table 2). Consequently, no significant difference in detorque levels between occlusal screws and PIB retaining screws could be detected ($P = .5186$). The abutment screws showed significantly greater detorque values compared with occlusal screws ($P = .0002$) and PIB retaining screws ($P = .0000$) (Table 3).
Part II: In Vivo

In vivo, detorque values ranging from 21.64 Ncm after 2 months to 27.81 Ncm after 6 months were recorded (Table 4). Thus the PIB retaining screws maintained between 61.80% and 79.37% of the 35 Ncm tightening torque applied (Table 5). An increase in detorque values over time was observed that was significant at all timepoints (Table 6).

**Discussion**

Detorque values have often been used to evaluate the stability of screw joints in implant dentistry. In a clinical study comparable with the present study, a general decrease of approximately 30% of initial torque values was observed, independent of the implant system used. Similarly, in an in vitro study on implant screw torque loss in single-unit restorations, Piermatti et al found values for torque loss ranging from 10% to almost 100% of the originally applied torque values depending on the implant system considered.

Based on the in vitro study conducted, it can be stated that screws directly retaining a FDP lose about 40% of the tightening torque applied during the first months of service regardless of whether an additional abutment has been used. This seems to be in agreement with a previously performed finite element analysis showing that the loading situation of the screws mentioned was independent from the presence of an abutment.

However, with the abutment screws present in conventional restorations showing significantly less torque loss, it may be claimed that the use of an additional abutment bears a protective effect for the implant shoulder.

Repeated retightening of PIB retaining screws, as carried out in the in vivo study, reduced the level of torque loss over time. This seems to be consistent with Farina et al, who found a positive effect of retorquing retentive screws. Despite the reduced levels of detorque relative to the tightening torque applied, none of the restorations were clinically mobile. It therefore cannot be inferred that a reduction in tightening torque means that the restoration becomes unstable, which is consistent with the existing literature.

Since no uniform guidelines exist on how to perform meaningful in vitro studies involving masticatory simulation, a clinical study was performed as a control. Comparable levels of torque loss were recorded in vitro and in vivo.

**Conclusion**

This report suggests that the in vitro application of 100,000 load cycles had a comparable effect to in vivo detorque levels measured after 2 months.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Mean (Standard Deviation) Detorque Values Measured In Vivo Following Fixation of the Procera Implant Bridges with 35 Ncm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time after delivery of the restoration (mo)</td>
<td>Premolar (Ncm)</td>
</tr>
<tr>
<td>2</td>
<td>21.81 (2.05)</td>
</tr>
<tr>
<td>4</td>
<td>24.59 (3.26)</td>
</tr>
<tr>
<td>6</td>
<td>27.43 (4.90)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Mean (Standard Deviation) In Vivo Detorque Values Given as Percentage of the Tightening Torque Used for the Fixation of the Procera Implant Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time after delivery of the restoration (mo)</td>
<td>Premolar (%)</td>
</tr>
<tr>
<td>2</td>
<td>62.28 (5.82)</td>
</tr>
<tr>
<td>4</td>
<td>70.19 (9.25)</td>
</tr>
<tr>
<td>6</td>
<td>78.27 (13.93)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Pairwise Comparisons of In Vivo Detorque Values Measured After 2, 4, and 6 Months Following Delivery of the Restorations1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (mo)</td>
<td>P-value</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>.00092</td>
</tr>
<tr>
<td>4</td>
<td>.00382</td>
</tr>
<tr>
<td>6</td>
<td>.00382</td>
</tr>
</tbody>
</table>

1One-sample t tests; P values adjusted for multiple testing by the Bonferroni-Holm method.
2Significant difference (P < .05).

**Acknowledgments**

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**References**


