Clinical Assessment of Preload Maintenance in the Abutment Screws of Single Posterior Implants After 1 Month of Use

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Purpose: Abutment screw loosening is a frequently encountered prosthetic complication in implant dentistry. Due to the detection of preload loss soon after initial torque application, abutment screw retightening 10 minutes after initial tightening has been recommended. The aim of this clinical study was to assess preload maintenance in the abutment screws of single posterior implants after 1 month of use by employing screw-cement-retained prostheses and a clinical assessing method, with the ultimate goal of helping to improve the clinical workflow of implant-based restorations.

Materials and Methods: In total, 158 patients treated using three implant systems were divided randomly into two groups in which abutment screws were and were not retightened, respectively, approximately 10 minutes after initial torque application. Screw-cement-retained prostheses, which permitted the assessment of abutment screw preload maintenance and screw retightening after 1 month of use, were used. Preload loss at 1 month was defined as the failure to achieve the torque recommended for the abutment screws after 90-degree clockwise rotation of the screwdriver. The data were analyzed using binary logistic regression, with a significance level of $P \leq .05$.

Results: No preload loss was detected 10 minutes after initial screw tightening. Preload loss was detected in 16 (10.13%) cases at 1 month after initial tightening, with no significant difference according to the implant system used, the presence or absence of retightening at 10 minutes after initial tightening, or implant position (premolar or molar).

Conclusion: Under the experimental conditions of this study, abutment screws in some bone-level, internal tapered–connection, platform-switching implant systems showed preload loss at 1 month after abutment placement for single posterior implant-based restorations, regardless of implant system or whether abutment screws had been retightened 10 minutes after abutment placement, or implant position (premolar or molar). It is necessary to retorque the abutment screws 1 month after initial torque. The screw-cement-retained prostheses used in this study permit abutment screw retightening at that time and have advantages over traditional methods. Int J Oral Maxillofac Implants 2021;36:177–181. doi: 10.11607/jomi.8316

Keywords: dental implant, dental prosthesis, preload, settling effect, torque

With progress in oral implant technology, implant-based restorations have become a successful approach for patients with single missing posterior teeth. However, mechanical and biologic complications may lead to implant failure if they are not treated in a timely manner. Prosthetic abutment screw loosening, especially in the first year of loading, is encountered frequently in implant dentistry and may cause loosening of the abutment and prosthesis, and/or fracture of the screw or abutment. Abutment and prosthesis loosening increase micromotion and the microgap at the implant-abutment interface, contributing to microleakage and ultimately causing biologic complications. Thus, abutment screw loosening must be addressed in clinical practice.

When an abutment is screwed to an implant, the screw is tightened using a recommended torque. Torque application produces a force within the screw called the preload. The screw elongates as it is tightened, and a clamping force that is equal in magnitude to preload pulls the two parts together.

Despite being tightened at first, some abutment screws loosen over time. Factors contributing to this issue in functioning prostheses include off-axis centric contacts, parafunctional habits, cantilevered restorations, crestal bone loss, occlusal imbalance, abutment screw design, the crown/implant ratio, and use of removable prostheses.

Settling effect is also a contributing factor. This effect occurs because implant surfaces are not completely smooth despite careful machining, so that the convex points between the inside of implants and

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outside of abutments are the only contact surfaces during screw preloading and initial tightening, and subsequently wear down under loading, resulting in the loss of 2% to 10% of the preload.2,13–18

When using the two-piece abutment, loosening of the abutment screw and axial displacement of the abutment might occur under long-term functional loading in the oral cavity.19,20 Thus, tightening of the implant-abutment joint after initial screw insertion has been recommended.21 Some studies have revealed preload losses in the first 2 seconds after initial torque application, which can be compensated by early retorquing; a longer interval before retightening might allow further reduction of the preload.22 Although some authors have recommended retorquing at 21 or 23,24 minutes after the screw has been tightened, most studies have demonstrated that retightening at 10 minutes permits recovery of the preload, and this practice has become routine clinical procedure for some implant systems.7,12,14,18

The aim of this clinical study was to assess preload maintenance in the abutment screws of single posterior implants after a longer period of time—1 month of use—by employing screw-cement-retained prostheses (SCRPs) and a clinical assessing method. The authors believe that the findings will help to improve the clinical workflow of implant-based restorations.

MATERIALS AND METHODS

Participant Selection
This study was registered and designed as a randomized controlled clinical trial. It was approved by the Institutional Review Board of Peking University Shenzhen Hospital (ref. JCYJ 2018–018). One hundred fifty-eight participants were referred to the Division of Prosthodontics from the Division of Implantology, Center of Stomatology, Peking University Shenzhen Hospital, who had undergone surgical placement of single posterior implants 3 to 6 months previously and demonstrated satisfactory osseointegration, as determined by clinical and CBCT examinations. The inclusion criteria were full-mouth plaque and bleeding scores < 25%, no active periodontal disease, no missing posterior tooth other than that replaced by the implant-supported prosthesis, multipoint uniform contact in intercuspal position, canine-protected or group function lateral occlusion, two or four incisors inducing protrusive occlusion, and healthy and sufficiently restored adjacent and antagonist teeth. Participants provided written informed consent and agreed to participate throughout the entire study period. All the patients satisfying the inclusion criteria and agreeing to participate in the research in the past year were enrolled. For bruxers, soft rubber bite plates protecting teeth were made.

Restoration Procedures
Cases were restored with Ankylos (Dentsply Sirona), Straumann, or Zimmer implant systems. Ankylos system is a bone-level, Morse-tapered, internal-connection, platform-switching implant system. Straumann Bone Level Implant System is a 15-degree tapered, internal-connection, platform-switching implant system. Zimmer Tapered Screw Vent Implant System is a bone-level, 1-degree tapered, 1.5-mm-height internal connection, platform-switching implant system. A platform-switching implant system is designed as follows: The diameter of the abutment is smaller than the implant, so that the joint platform of the abutment and the implant is switched from the lateral surface to the top of the implant, in order to reduce possible marginal bone loss. The differences of the three systems in this research are as follows. At the joint platform of the Ankylos system, the diameter of the abutment is much smaller than the implant. The taper angle of abutments is different in the three systems. The impression technique was used at the implant level, and the definitive restorations were delivered to the patients with no provisional restorations.

Screw-cement-retained prostheses were adopted in this research: Zirconia crowns (Cercon, Dentsply Sirona) were fabricated and stuck to the titanium abutments by self-adhesive resin cement (RelyX Unicem, 3M) in the laboratory before placement in the clinic, with a channel for the screwdriver left in the occlusal surface, so that the crown-abutment could be screwed together to the implant (Fig 1). The abutment screws were tightened to the manufacturers’ recommended torque.

Participants were divided randomly into two groups. In one group, the abutment screws were retightened 10 minutes after the first tightening. In the other group, the abutment screws were not retightened. The screw

Fig 1 Screw-cement-retained prosthesis (SCRP).
channels were temporarily sealed (Systemp, Ivoclar Vivadent).

The restorations were reexamined 1 month later. In both groups, the abutment screws were retightened to the recommended torque. The screw channels were permanently sealed with Z350 composite resin (3M ESPE).

Assessment of Preload Maintenance in the Abutment Screws

Preload maintenance in the abutment screws was assessed at the 10-minute retightening time point for one experimental group and at the 1-month retightening time point for both groups.

The measurement was performed manually in the clinic. There is a torque gauge in the screwdriver wrench of the Straumann system, showing the torque applied to the abutment screw, so that it is easy to judge whether the set torque (35 Ncm) is reached. A special “click” sound can be heard when the set torque (15 Ncm) is reached for the Ankylos system. When the set torque (30 Ncm) is reached for the Zimmer system, the joint of the screwdriver wrench will bend immediately. The clinicians retightened the screws by rotating the screwdriver wrench clockwise, and judged the maintenance of preload in the abutment screws at the same time. If after 90-degree rotation of the screwdriver wrench the set torque was still not reached, it was obvious that preload loss occurred in that case.

Statistical Analysis

Statistical analysis was performed using IBM SPSS software (version 22.0 for Windows, IBM). Categorical data were presented as frequencies and percentages. A binary logistic regression model was constructed to test the effects of implant system type, screw tightening time point for both groups.

RESULTS

Sixty men and 98 women participated in the study (77 maxillary implants and 81 mandibular implants), with a mean 37.9 years of age (range: 20 to 72 years). Of the 158 cases, 63 cases were restored with the Ankylos implant system (16 premolars and 47 molars), 53 cases were restored with the Straumann implant system (13 premolars and 40 molars), and 42 cases were restored with the Zimmer implant system (11 premolars and 31 molars). At baseline, no preload loss was detected in the group (79 cases) in which abutment screws were retightened 10 minutes after initial torque application. At 1 month, preload loss was detected in 16 (10.13%) cases, consisting of 7 (11.11%) participants with Ankylos implants, 5 (9.43%) participants with Straumann implants, and 4 (9.52%) participants with Zimmer implants. The rate of preload loss did not differ significantly among the three bone-level, internal tapered-connection, platform-switching implant systems (P = .943). In 7 of these 16 cases, the screws had been retightened 10 minutes after initial torque (loosening rate = 8.86%); in the remaining 9 cases, no retightening had been performed (loosening rate = 11.39%). The rate of preload loss 1 month after initial torque did not differ significantly according to the presence or absence of retightening 10 minutes after initial torque (P = .596). The rate of preload loss 1 month after initial torque in premolars (loosening rate = 10%) did not differ significantly from that in molars (loosening rate = 10.17%; P = .963; Table 1).

DISCUSSION

Internal tapered connection is favored for the stability of prostheses. Platform-switching is favored for reducing possible marginal bone loss. That is why the three implant systems were used in this research.

It was easy to judge preload maintenance in the clinic. If the preload was maintained, the recommended torque would be reached easily, so that the rotating angle of the screwdriver would be far less than 90 degrees. If the recommended torque was not reached even after 90-degree rotation, there would be no doubt that preload loss occurred.

In contrast to previous in vitro studies,11,25,26 no preload loss was detected 10 minutes after initial tightening, possibly due to the assessment criterion used. The set torque could not be reached even after 90-degree rotation of the screwdriver, which means obvious preload loss.

In vitro studies have documented wear of convex points in the course of daily use, reducing preload

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<th>Table 1</th>
<th>Frequency and Percentage of Preload Loss in 1 Month</th>
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<td>Implant system</td>
<td>Position</td>
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<tr>
<td>Ankylos</td>
<td>Premolar</td>
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<td>Ankylos</td>
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At the same time, a coordinated relationship must be established between the prostheses and muscles and joints. During mastication and continuous adaptation, the position of the prostheses will be adjusted under occlusal force, aggravating preload loss as well. When diminished preload reaches a critical point, screw loosening and axial displacement of the abutment might occur.20,21

Long-term follow-up is very important, and visits are typically scheduled at 1, 3, 6, and 12 months after prostheses placement, and then annually.27 After 1 month of functional loading, the settling effect has manifested and the occlusion is relatively stable, and some time has been allowed to expose problems with the prostheses. Thus, the 1-month time point is suitable for assessment of preload maintenance and retightening of abutment screws. Although several authors have recommended screw retightening after a predetermined interval to overcome the problem of preload loss,5–7,11,12,18,21,28,29 others suggested that repeated torquing has little or no effect, and can even overflatten the mating surfaces, potentially causing slippage between the screw threads and leading to significant preload loss.17,30–34 Scanning electron microscopy has revealed substantial distortion of the internal hexagonal slot of the screw head after successive tightening.35,36 Butkevica et al37 suggested the screws could be retightened safely in some systems, whereas it should be avoided with other systems. Some studies have shown that a certain degree of preload loss due to lack of long-term periodic retightening would not affect the stability of the implant-abutment joint when loads were not large.38–41 At the same time, if periodic retightening is recommended routinely in the clinic, whether the patients will follow the advice will be a problem. Thus, the present study did not assess preload maintenance and retighten the screws periodically.

Screw-cement-retained prostheses have some advantages over traditional cement-retained and screw-retained implant prostheses: Prebonding of the crown to the abutment can avoid the problems caused by residual cement and can be easily removed when necessary. Compared with traditional screw-retained prostheses, it is easier to fabricate and cheaper. However, since the abutment and the crown are screwed together, it is more difficult to make sure the prosthesis is fully seated to the implant. It is important to make sure the screw channel is in the middle of the occlusal surface and to ensure the long axis of the implant is parallel to the insertion path of the prosthesis.42

Although the results may be affected by technical errors in manufacturing the superstructure or different oral conditions, the purpose was to imitate the real clinical conditions, so that the results of this research may provide suggestions to daily clinical work.

CONCLUSIONS

Under the experimental conditions of this study, abutment screws in some bone-level, internal tapered-connection, platform-switching implant systems showed preload loss at 1 month after abutment placement for single posterior implant-based restorations, regardless of implant system or whether abutment screws had been retightened 10 minutes after abutment placement, or implant position (premolar or molar). It is necessary to retorque the abutment screws 1 month after initial torque. The screw-cement-retained prostheses used in this study permit abutment screw retightening at that time and have advantages over traditional methods.

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