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Washington State PROSTHODONTICS and Dental Implant Center

Bellevue • (425) 455-4993 • web-WSPDIC.com

Michael W. Johnson, DDS, MS, FACP
Board Certified in Prosthodontics

Russell I. Johnson, DDS, MS, FACP
Board Certified in Prosthodontics and Periodontics

Washington State Prosthodontics specializes in fixed, removable and implant Prosthodontics as well as being highly trained in fully edentulous immediate implant provisionalization (aka all on 4) options for your patients with failing or missing dentitions.



The Angled Screw Channel: Latest Findings

In the past, labial implant projection in the anterior maxilla might have required prosthetic screw access through facial or incisal restoration surfaces. Introduction of the angled screw channel (ASC) concept permitted prosthetic screw tightening using a hexalobular, sphere-shaped driver that engages the screw at various angles. This allows the screwdriver and the restoration's screw channel to follow an orientation different than the implant's long axis to emerge more esthetically through the restoration's palatal surface. While the ASC design may have solved the esthetic concern, other problems may arise. This issue of Prosthodontics Newsletter looks at recent research on the ASC.

Esthetic Results with ASC Restorations

While screw-retained implant prostheses have several advantages over cement-retained prostheses, when placing a screw-retained prosthesis in the esthetic zone, it may be difficult to avoid screw channel projection on the vestibular side or on the margin of the future crown. One solution is the employment of the angled screw channel (ASC).

The question of how esthetic and implant health outcomes compare in restorations using cement or an ASC remains open. To evaluate this question, Nastri et al from the University of Campania "Luigi Vanvitelli," Italy, designed a retrospective study

evaluating the esthetic results and peri-implant health in 20 patients who received implants in an area not suitable for a straight screw-retained crown. The implants of half these patients were restored with a cemented restoration on a personalized abutment, while the other half were restored using an ASC-retained crown. After a minimum of 24 months follow-up, probing depth and bleeding on probing (BOP) were measured, periapical x-rays were taken, marginal bone loss was calculated and the restorations and peri-implant tissues were evaluated using the pink esthetic score (PES) and the white esthetic score (WES).

No technical complications occurred in either group, nor were there any unplanned interventions. Peri-implant probing depth remained stable for both groups, and no significant differences were seen between the groups in BOP or marginal bone loss. PES scores were significantly higher in the cement group than in the ASC group;

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Esthetic Results with ASC Restorations

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however, the scores were also significantly different at baseline, perhaps due to the difference in the number of augmented sites between the 2 groups (Table 1). Moreover, the WES and PES scores remained fairly consistent between baseline and follow-up.

Comment

This small study showed that ASC restorations are a suitable alternative to customized abutments and cemented restorations in cases with less-than-ideal implant axes in the esthetic zone. Because of this study's retrospective nature, which did not allow for selecting cases with matching characteristics, larger, more controlled prospective studies should be undertaken to confirm these findings.

Nastri L, Nucci L, Grassia V, Miraldi R. Aesthetic outcomes and peri-implant health of angled screw retained implant restorations compared with cement retained crowns: medium term follow-up. J Funct Biomater 2021;12:35.

Effect of Screwdriver Angle

Achieving the benefits of the angled screw channel (ASC) approach to implant restoration requires the use of a hexalobular screwdriver that can engage the screw at different angles and functions as a gear mechanism, transmitting its motion through a series of toothed wheels that allow for a change in angle. This directional

Table 1. Esthetic findings in the angled screw channel (ASC) group and the cemented crown (CC) group.

	White esthetic score		Pink esthetic score	
	Baseline	Follow-up	Baseline	Follow-up
ASC group	8.7	8.5	7.9	7.7
CC group	8.3	8.3	9.0	8.8

change could result in a loss of torque transmitted to the screw. To evaluate the extent of this potential problem, Opler et al from the University of Washington School of Dentistry conducted a series of tests to measure the effect of maximum angulation on the abutment-implant screw connection and torque values using the hexalobular screwdriver, as well as to determine how the angle of the screwdriver affects any variation in the input torque vs the output torque.

To conduct this in vitro study, the researchers fabricated 20 abutment-to-implant test specimens that used hexalobular screws. All specimens were tightened to 25 Ncm, 10 at 0° (minimum angulation) and 10 at 28° (maximum angulation), and the peak torque required to unscrew was recorded. Then 50 hexalobular screws were randomly divided into 5 groups and placed using 5 screwdriver angulations:

- 0°
- 10°
- 15°
- 25°
- 28°

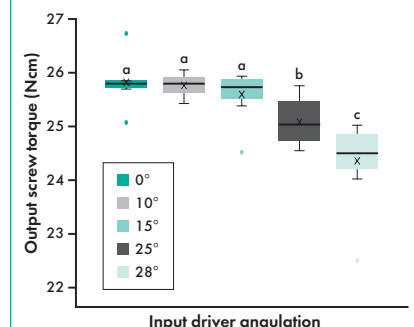
As per the manufacturer's instructions, an input torque value of 25 Ncm was applied, and the output torque value was measured.

The mean reverse screw torque obtained when unscrewing the implant fixtures varied significantly between the 0° group and the 28° group, with a reduced torque recorded for the angled group. Despite consistent input torque values among the 5 angled groups, the output torque values were significantly reduced in the 20° and 28° groups; the 28° group showed a reduction of ~23% compared with the 0° group (Figure 1). Post-test photographs also showed more scratches and greater wear on screws tightened at the 28° angulation.

Comment

A reduction in output torque could compromise the screw joint and lead to loosening of the abutment-fixture joint, potentially resulting in a failure

Figure 1. Box plot of mean output torque value (Ncm) measured at screw body and values at different angulations recorded. Angulations with similar superscript letters not statistically different ($p > .05$).



of the restoration. The study results suggested that the hexalobular screw system, when used at an angulation of no more than 15°, provided a satisfactory result, but the reduced output torque at 25° and above could be clinically relevant in areas with high occlusal load.

Opler R, Wadhvani C, Chung K-H. The effect of screwdriver angle variation on the off-axis implant abutment system and hexalobular screw. J Prosthet Dent 2020; 123:524-528.

Torque Changes After Functional Loading

While the advantages of screw-retained crowns in general and angled access screw-retained crowns in the esthetic zone have been established, various manufacturers make restorations with different abutment screw surface coatings, thread screw designs, screwdrivers and recommended torque values; therefore, some of the findings around restorations with angled screw channels (ASCs) cannot be universally applied. To address this question, Swamidass et al from Loma Linda University, California, designed an in vitro study to compare torque differences before and after simulated functional loading among restorations of different types and manufacturers.

Using 50 standard implants as a base, the authors created 5 groups of 10 screw-retained crowns based on ASC angulation and manufacturer:

► **NB-20:** zirconia crown with a 20° ASC design and a titanium base implant connection; recommended

torque 35 Ncm (Nobel Biocare Angulated Screw Channel)

► **DA-20:** zirconia crown with a 20° ASC design and a titanium base implant connection; recommended torque 25 Ncm (Dynamic Abutment Solutions)

► **C3d-20:** zirconia crown with a 20° ASC design and a titanium base implant connection; recommended torque 20 Ncm (Core3dcentres Angulation Correction)

► **NB-0:** zirconia crown with a straight access channel design and a titanium base implant connection; recommended torque 35 Ncm (Nobel Biocare Straight Channel)

► **GA-20:** high-noble metal cast crown and abutment with a straight access channel design; recommended torque 35 Ncm (Nobel Biocare Gold-Adapt)

After thermocycling, all crowns were tightened and retightened according to the manufacturer's recommendations. Then, each specimen was mounted in a universal testing machine that simulated the functional loading of a maxillary central incisor and subjected to the equivalent of ~1 year of masticatory cycles.

When the groups were combined into a straight access channel group and an ASC group, no significant difference was seen in the percentage change between initial and final screw torque values. Group NB-0 reported a median torque loss approaching 0%, while both groups DA-20 and C3d-20 showed a greater median percentage loss of torque than did group NB-20. The noble-metal cast crowns with straight access channels demonstrated the greatest percentage loss of torque.

Comment

This study showed that, after cyclic loading, ASC crowns performed comparably with straight access channel crowns with regard to percentage torque values. The ASC crowns that had the highest recommended torque values retained a greater percentage of torque than did those with lower recommended torque values.

Swamidass RS, Kan JYK, Kattadiyil MT, et al. Abutment screw torque changes with straight and angled screw-access channels. J Prosthet Dent 2021;125:675-681.

Survival of ASC Systems

Outside of the Swamidass et al study reported in this issue of *Prosthodontics Newsletter*, no other in vitro studies have evaluated reverse torque values of different angled screw channel (ASC) systems set at a fixed angle. To further test how ASC systems function, Mulla et al from Ohio State University designed a study to evaluate the systems' ability to apply a target torque value to their screws at 25°, the effect of cyclic loading on their reverse torque value and their survival compared with crowns cemented on conventional 0° screw channel abutments.

Based on the titanium-base crowns they received, 4 groups of 7 implants were created:

► **DY:** Dynamic Tibase (Dynamic Abutment Solutions)

► **DE:** AngleBase (Dess Dental Smart Solutions)

► **ASC:** Angulated Screw Channel Solutions (Nobel Biocare AG)



► UB (control 0° screw channel): Universal Base (Nobel Biocare AG)

The implants were restored with zirconia crowns for maxillary central incisors; screws were tightened to the manufacturers' specification of 35 Ncm (groups DE, ASC and UB) or 25 Ncm (group DY). After initial and reverse torque values were measured, the implants were mounted on a mastication simulator and subjected to cyclic loading that simulated 5 years of functional loading, after which reverse torque values were again recorded.

Groups ASC and DE demonstrated significantly more deviation in initial torque values than did the control group. All groups showed a significant difference from their original reverse torque values after cyclic loading, but no significant difference was seen among the groups. Three specimens from the ASC group and 1 from each of the DY and DE groups suffered catastrophic fractures during cyclic loading, but no significant difference was found among the groups for the probability of failure in any given cycle.

Comment

This study showed that the Dynamic Tibase system delivered initial torque values at 25° that matched the manufacturer's recommended value, unlike the AngleBase and the Angulated Screw Channel Solutions systems, but it also scored significantly lower reverse torque values than did the other groups. All the angled screw channel restorations showed a similar time-to-failure survival rate similar to that achieved by the control group.

Mulla SH, Seghi RR, Johnston WM, Yilmaz B. Effect of cyclic loading on reverse torque values of angled screw channel systems. J Prosthet Dent 2022; 128:458-466.

Evaluating ASC Prostheses

One difficulty often faced when evaluating the angled screw channel (ASC) implant prosthesis is a lack of large and/or long-term studies. Rasaie et al from Tehran University of Medical Sciences, Iran, conducted a systematic review to evaluate clinical and laboratory outcomes of ASC restorations reported in the literature and to summarize the influencing factors.

The authors searched the relevant literature for English language reports in peer-reviewed publications for prospective or retrospective clinical studies with an observation period after implant restoration of ≥ 1 year that evaluated biological and/or mechanical outcomes in ASC restorations, along with laboratory studies that evaluated ASC performance variables. Fifteen publications published between 2017 and 2021 fulfilled the inclusion criteria: 7 studies were in vitro investigations of the fracture strength of zirconia crowns with ASCs and/or the reverse torque value of nonaxially tightened screws; 8 were nonrandomized cohort studies reporting the outcomes of 281 implants.

Two studies examining the fracture strength of 2-piece CAD/CAM monolithic zirconia crowns with a 25° ACS showed significantly earlier failures than similar straight screw channel crowns; all failures occurred at loads that resembled a parafunctional situation. Another study found no significant difference among the fracture strength values in nickel-chromium crowns placed on implants at 0°, 20° and 28°. Impact of screwdriver insertion angulation evidence was mixed.

Clinical studies showed a high survival rate for ASC restorations (88%–100%), accompanied by low mean marginal bone loss (0.16 mm–0.41 mm). But most of these had a short follow-up, typically 1 year. Seven cases of ceramic fracture were reported along with 4 cases of screw loosening and 1 case of screw fracture.

Comment

These results suggested that ASC restorations are mechanically comparable in the short-term to straight screw-access restorations under expected physiological forces. As the angulation of the screw channel increases, the bulk of the palatal walls of anterior zirconia abutments decreases, which may potentially weaken the restoration. This needs to be considered when developing a treatment plan.

Rasaie V, Abduo J, Falahchai M. Clinical and laboratory outcomes of angled screw channel implant prostheses: a systematic review. Eur J Dent 2022;16:488-499.

In the Next Issue

Screw performance and implant success

Our next report features a discussion of these issues and the studies that analyze them, as well as other articles exploring topics of vital interest to you as a practitioner.

Do you or your staff have any questions or comments about *Prosthodontics Newsletter*? Please write or call our office. We would be happy to hear from you.

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