Preliminary Results Using a Friction-Fit Crown to Abutment Connection

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One of the chronic problems with traditional cement or screw retention of crowns to implants is the development of biologic and technical complications, including soft tissue complications, bone loss, screw loosening, loss of retention, and veneering material fractures. The purpose of this case series report is to document preliminary results, specifically crown retention, using a friction-fit connection of crown to abutment. A sample composed of patients who had one or more implants restored between July 1, 2019, and October 30, 2019, were enrolled in this retrospective case-control series. Each patient had their crown connected to the implant abutment using a friction-fit system. Patients were seen for routine follow-up for documentation of crown retention, and 24 crowns were followed. After 6 months of follow-up, 100% of the crowns retained retention and did not become loose under normal masticatory function. The use of a friction-fit connection provided excellent retention of the crown to the abutment over the 6-month follow-up period. Int J Periodontics Restorative Dent 2021;41:217–224. doi: 10.11607/prd.5146

As more and more implants are placed by dentists, the number of patients having complications due to traditional connection methods will increase. Clinical complications can include peri-implant disease secondary to cement excess, crown/abutment loosening secondary to loss of screw retention, and fractured screws resulting from loosening and fatigue of the screws.

Cement extravasation from the crown abutment connection has been shown to result in an inflammatory reaction that can lead to significant bone loss. Eliminating the cement excess from the crown abutment connection can be achieved by cementing the crown to the abutment out of the mouth, with subsequent removal of the cement. This cemented complex is then screw-retained to the implant. This solution eliminates excess cement but does leave a hole in the occlusal aspect of the crown, which must be filled after the restoration has been seated. The filling material within the hole of the crowns may be lost, wear away affecting occlusion, or need to be replaced over time. If the emergence of the implant is through an incisor edge or through an unfavorable cuspal incline, angled screw channels may be necessary. This will increase the cost of crown fabrication as well as increase the difficulty for the prac-
Screw fracture, loosening, and misfits of the retaining screw do occur.4 When the screw loosens, the restoration becomes mobile, which can result in an accompanying inflammatory reaction or screw fracture. When a screw-retained restoration needs to be removed for a variety of reasons, the material covering the screw access hole must be removed and the screw removed. This procedure takes time and adds cost to the patient. In order to eliminate this problem, a friction-fit connection devoid of cement- or screw-retention has been designed (Acuris, Dentsply Sirona).

The concept of friction-fit connections is not new. Abutments have been friction-fit–retained in the past and have done well over time.5–8 Early friction-fit parts were designed to be removed by the patient. However, the lack of an ideal frictional coefficient between the use of dissimilar metals may prevent adequate single-crown retention.9–11

A friction-fit connection relies on the friction between components, the angle between components, and the length of the contact.12 Insertion force is related to the angle of the contact, the length of the contact, the inner and outer radii of the components that contact each other, and the elastic moduli of the materials. When considering the efficiency of the interference fit, there is a critical insertion depth that causes plastic deformation, which affects retention. Retention force is greater when the taper angle is < 6 degrees when the friction coefficient is 0.3.12

Early applications of this concept started with abutments that were cone-shaped, with a titanium coping made to match the taper of a stock abutment. The implants were placed in edentulous patients, and a frame was fabricated using intraoral welding of the titanium copings for custom-shaped titanium bars. The restoration was completed and tapped into place, with minimal problems of prosthesis self-loosening.13,14 A back-action crown-removal instrument was used to remove the prosthesis for professional cleaning, and the prosthesis was replaced with minimal problems. A fixed partial-denture “conometric” application used two or more implants in a quadrant, and no prostheses loosened. The retention of this system was based on previously manufactured abutments made for a friction-fit application.15–17

In order to have significant retention for single crowns, an abutment system was designed specifically for single-tooth applications.18 The titanium alloy abutment has a 5.9-degree slope with an index on its occlusal aspect, and it has a hexagonal shape on its coronal surface. This is indexed to the final coping (cap) to provide anti-rotational conditions and also to align the final crown to the abutment in a predictable position (Fig 1). The abutment is placed into the implant and torqued appropriately for retention.

An impression is made at the abutment level, not the implant level. The manufacturer used the term “cap” to identify two different copings. The coping that acts onto the analog for the laboratory portion is called the “lab cap,” and the coping that acts as an interface between the crown and the friction-fit abutment is called the “final cap.” For consistency with the supplied parts, the term “cap” will be used in this article. The lab cap is used to provide space for a final cap. The final cap is made of titanium nitride metal, which is friction-fit to the abutment. The first report of using the current friction-fit system for restoration of a single-implant crown utilized a lithium disilicate crown cemented to the final cap. The crown was then placed on an integrated implant using activation force. The crown did not loosen throughout the report period.18

With the current system, the crown is cemented to the final cap either in the lab or chairside, and then the cement is cleaned from the crown abutment connection. After adjustment of contacts and occlusion, the crown with the final cap is placed back onto the abutment and “activated” by applying a force via a specific activation tool. The interface between the final cap and the abutment is virtually seamless (Fig 2), and the retention achieved is significant.

Based on this review, a series of patients were treated with this friction-fit system (Acuris). A retrospective evaluation of 24 implants was conducted. The primary endpoint variable evaluated was crown loosening after activation of the retentive features.
Materials and Methods

The investigators implemented a retrospective case series evaluation and enrolled a sample composed of patients who had one or more implants restored with the friction-fit system between July 1, 2019, and October 30, 2019.

Institutional Review Board–exempt approval was obtained for this medical chart review (IRB# 20-895, LSU Health Sciences Center, New Orleans). A spreadsheet was created to de-identify patient identifiers from the data for analysis. In order to evaluate these questions, a retrospective chart review was performed in two offices.

The case group included patients who had at least one implant restored using the friction-fit system by one of the authors from July 1, 2019, to October 30, 2019. All restorations utilizing the friction-fit system were included. No exceptions were made, and no patients were excluded.

Study Variables

The variables recorded included: age, gender, date of implant abutment placement, impression success or failure, and the status of crown retention immediately after initial activation and at the 6-month follow-up.

The spreadsheet included these variables coded as 1 or 0 for each variable for each patient. The patient names and actual dates of service were removed from the spreadsheet, per IRB guidelines.

Implant Placement

The implant was placed and oriented into the core of the tooth to be replaced. There was no need to angle the implant toward the cingulum because there was no screw channel in the final restoration. The implant was placed subcrestally or at the level of the crestal bone, per the clinician’s preference. The surgeon measured the distance from the implant platform to the opposing occlusion for later selection of an abutment.

After the crown was cemented to the final coping, excess cement was removed from the margin. The interface between the final coping (cap) and the abutment was virtually seamless. As such, the margin of the crown could be placed more than 1 mm subgingival, if needed due to interocclusal space limitations. After implant placement, a healing abutment or final abutment was placed. The final abutment was placed at the time of implant placement when an immediate provisional restoration was planned (Fig 1).

Final Abutment Placement

After the implant integrated, the healing abutment was removed, and the final abutment placed. The gingival heights and diameters of the abutment were chosen depending on the location of the restoration.

At the time of surgery, the implant was placed to ensure that the distance from the implant platform to the opposing occlusion was at least 9 mm, providing appropriate space for the abutment and crown. This distance is calculated from the following measurements: the abutment height (ie, 4.1 mm); the need for 2 mm of interocclusal clearance for a ceramic restoration; and the transgingival height (ie, 1, 2, or 3 mm). The abutment was torqued according to manufacturer’s recommendations.

Impressions

An impression cap was placed and seated on the index, at the abutment’s occlusal aspect. The impression cap was securely seated to ensure an accurate impression. Using conventional methods, the impression material was placed around the impression cap followed by a heavy- or medium-body material in a tray. The desired shade was obtained.

In the laboratory, the impression was poured with an abutment analog in place. A lab cap was placed onto the abutment, and the models were scanned. Software was used to design a ceramic crown, which was then milled and finished. If it is discovered that the initial impression was not accurate, there is an alternative approach: One may decide to cement the crown to the final coping (cap) in the mouth to ensure a perfect fit. This does not require additional time, unlike...
having the cementation done in the laboratory.

The provisional restoration or the healing cap was then removed, as it was placed over the abutment after impressions were taken. The surfaces of the abutment and internal surface of the final cap were dried. If necessary, they can be cleaned with alcohol in the mouth using a cotton pledget. The final crown/cap combination was placed using gentle thumb pressure, indexing the final cap to the abutment index. The retention achieved using gentle pressure is adequate for the crown's pre-activation trial: The crown is placed over the final coping in the mouth, and adjustments are made to contacts and occlusion. Because activation moves the final cap less than 0.1 mm, these adjustments can be made prior to activation. The crown was then cemented to the final coping in the mouth with the final cap indexed to the abutment. The activator tool was used to apply force to the crown, achieving sufficient retention for routine function (Figs 3 and 4).
Fig 3 (a) Occlusal view of a friction-fit abutment in place prior to placing final crown. (b) Final crown placed by activating the friction-fit system, which is the only form of connection used for the crown to the abutment. (c) Radiographic view of the crown connected to the abutment and implant.

Fig 4 (a) A 15-degree angled friction-fit abutment is placed into an implant in the maxillary left central incisor site. A provisional restoration placed at the time of surgery was used to shape the gingival sulcus. The abutment was placed and torqued appropriately. (b) Occlusal view showing how the angle-corrected abutment places the bulk of the abutment within the core of the final crown. (c) Impression of the final abutment. An impression cap was placed, and the impression was taken to transfer the abutment orientation to the lab. (d) The lab cap is placed on the abutment analog prior to fabrication of the final crown (an abutment analog was placed into the impression cap, and the impression was poured in the lab). (e) The final restoration is placed, adjusted as needed, and secured to the abutment by activation of the friction-fit system.
After activation, the crown with final coping can be retrieved, if necessary. Using forceps with rubber protection, grasp the crown and then gently rock it to deactivate the friction-fit attachment. It is important to use specific forceps designed for this system to avoid damage to the crown. Approximately 8 to 10 retrievals can be performed prior to loss of the system retention.

At the follow-up evaluations, the crown was evaluated for stability and retention using hand pressure. Patients were asked if the crown was stable and if their eating habits were normal. Gingival health was evaluated by direct examination regarding the absence or presence of inflammation, erythema, exudate, and general appearance. Probing was not routinely performed.

Results

A total of 24 restorations were placed in 18 patients (41.7% women; average age: 53.6 years; Table 1). The Astra Tech Implant System EV (Dentsply Sirona) implant was used in all but two sites, which received Ankylos (Dentsply Sirona) implants instead. Two Astra Tech EV implants had a 4.2-mm diameter, and the rest had a 3.6-mm diameter (Tables 2 and 3).

Two of the implants had provisional restorations made at the time of abutment placement. The final cap was cemented in the lab to the crown in six cases. The remaining cases had the crown cemented to the final cap intraorally.

In the first four patients, two of the final crowns did not fit because of improper placement of the impression cap or movement during the impression. For these crowns, a new impression was made, and the orientation of the transfer cap was confirmed by close examination of the impression cap’s internal orientation compared to the abutment’s orientation in the patient’s mouth. The flat surface of the impression cap coincides with the triangle tip on the abutment, and thus it us useful to confirm the positioning.

One final restoration, with a tight mesial contact, came off of the abutment after initial seating. A new crown was fabricated and cemented to a new final cap in the mouth and has been successfully retained during normal chewing.

Following the final seating of the crowns, no loosening of the crowns has occurred. Gingival health has been excellent, with no evidence of abnormal gingival conditions. Patients are pain-free and able to chew a normal-textured diet without restrictions.

Discussion

The Acuris system includes (1) an abutment that is placed and torque-retained on an implant, and (2) a final coping (cap) that utilizes an engineered friction-fit retention system, with the crown cemented
to the final coping (cap) and the cement cleaned outside the mouth. The keys to achieving friction-fit retention include (1) the use of materials with a specific frictional coefficient and a specific interface slope; (2) specific sizing of the parts to enhance the friction-fit; and (3) a specific attachment length. These parts are shown in Fig 1. Scanning electron microscopy showed that these machined parts, when activated, had virtually no seams between the abutment and the final cap (Fig 2). For single crowns, this system can produce reproducible retention as long as the interfaces are meticulously cleaned during the final placement and activation of the friction-fit.

There is no doubt that the friction-fit system works, and there have been no reports of prosthesis loosening. If performed properly, the patient can be restored without biologic or technical complications caused by excess cement or screw loosening.

Mechanical testing was performed in the laboratory using a standard mechanical testing apparatus to confirm stability of the connection to different loading and off-axis conditions. The specific system and setup are explained elsewhere.20 Caps were loaded at 30 degrees at 15 Hz for 5,000,000 cycles. A pull-off test was performed at various cycles, up to 5,000,000 cycles. The data indicated that the connection maintained its stability after 250,000 cycles.19

For the performed mechanical testing, the biting force was defined as the push-in force. The conometric connection was loaded with 200, 400, and 600 N to simulate biting forces. The caps were then pulled off to measure the retention. The preload of 200 N resulted in a lower pull-off force compared to 400-N and 600-N forces. It was concluded that removal force increases with increasing preload but flattens out at higher loads. This supports the concept that higher chewing forces are manageable with this connection.20

Mechanical testing also evaluated dynamic lateral loading of the cap to the abutment. Samples were loaded axially at 0 degrees and then subjected to 100 N loading at 82.5 degrees for 10,000 cycles. The caps were pulled off to measure retention. No caps separated from the abutments during testing. This study implies that the conometric system can be used for restored teeth subjected to off-axis loading, such as anterior incisors.21

This is a paradigm shift in patient care. Changes to traditional methods may be challenging and can be difficult to accept. However, the time it takes to make a transfer impression is approximately the same for any implant. A digital impression method is currently not available but most likely will be in the future.

To avoid postoperative cement problems, there is an alternative option that utilizes a crown cemented to the abutment in the lab. In the lab, the crown can be cemented to the abutment, leaving a screw access hole for placement. As long as the impression is accurate, the restorative dentist only has to check contacts and occlusion, then screw the prosthesis in place, which takes minimal time. The patient will still have long-term problems with screw loosening and access hole coverage, but this is not a day-to-day problem.

However, some teeth have several problems with screw retention, and the implant angulation may be different for a screw-retained restoration. It is often simpler to have complete control of the occlusal morphology of the tooth, which necessitates angled screw channels or cementation used alone. If the lab uses third-party parts, the abutment-implant connection loses precision, and screws can fracture.

The restorative dentist’s acceptance of this new method will be based on their appreciation of avoiding cement- and screw-retention issues; the restorative dentists in the present case series all have appreciated the final result. It will take time and experience for dentists to change to a new method, but they will change if they believe the new method will decrease complications.

**Conclusions**

This friction-fit system is relatively new and does not have long-term results. The long-term results are with a similar system that, if extrapolated and applied to the current system, provides excellent evidence that a friction-fit system has tremendous potential to decrease complication rates associated with cementation and screw-retention problems.
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References