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Prosthodontics Newsletter™

Focusing on Dental Implants

Critical Considerations for Implant Restoration Fit

The clinical performance of dental implant restorations may be influenced by many factors, not the least of which is the fit/adaptation between the prosthesis and the supporting implants. In turn, implant prosthesis fit may be influenced by impression and scanning accuracy, prosthesis design, components used, a wide variety of manufacturing elements, clinical placement of the definitive restoration and subsequent prosthesis maintenance. While reams of literature have been published on the topic of implant restoration fit, this issue of the Prosthodontics Newsletter *will review select studies of a few critical considerations that will help practitioners improve the delivery of care.*

Original vs Nonoriginal Abutments

The proliferation of implant manufacturers has been accompanied by the appearance of after-market replacement components designed to be used with the original implants. Few clinical studies have looked at whether the long-term performance of these third-party abutments equals that of the original abutments.

Alonso-Pérez et al from the University Complutense of Madrid, Spain, conducted an in vitro study to evaluate the internal fit and mechanical properties under dynamic load of 3 cast-to-gold abutments made by 3 different manufacturers for cement-retained restorations connected to the same brand of internal hexagon connection implant.

The researchers divided 48 implants into 3 groups. One group of implants was connected to the cast-to-gold abutment supplied by the implant manufacturer; the other 2 groups were connected to after-market cast-to-gold abutments from 2 different manufacturers. After metal–ceramic crowns were cemented to the abutments, 4 specimens from each group were cut along the longitudinal axis to evaluate proximal contact. The remaining specimens underwent a dynamic load test until failure or until the equivalent of 8 years of simulated function was reached.

In the platform area, all 3 implant–abutment configurations showed similar minimal (<4 µm) gaps; however, smaller gaps were seen in the original abutment group at the internal and abutment screw areas, with significantly tighter proximal contacts when compared with the nonoriginal abutment groups. Similar results were found for the cyclic fatigue test, as the original system demonstrated a lower fatigue degradation rate.

(continued on next page)

Inside this Issue

Original vs Nonoriginal Abutments
(continued from front page)

Comment

Since variations in abutments can lead to modifications in the mechanical behavior of an implant restoration, the practitioner needs to strive for the best possible fit between implants and abutments. Based on this study, the use of the manufacturer's original cast-to-gold abutments is recommended.

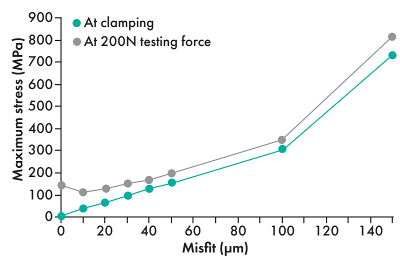
Alonso-Pérez R, Bartolomé JF, Fraile C, Pradíes G. Original versus nonoriginal cast-to-gold abutment-implant connection: analysis of the internal fit and long-term fatigue performance. J Prosthet Dent *2021; 126:94.e1-e9.*

Misfit and Veneer Fracture

Although implant therapy is a proven successful treatment, complications occur in implant-supported fixed dental prostheses (FDPs) at ≥2× the rate that they occur in tooth-supported FDPs. The greatest cause is veneer fractures, reported in one-third of full-arch implant-supported FDPs at 5 years and in two-thirds at 10 years.

While the cause of veneer fractures is multifactorial, the absence of a good fit between the implant and the restoration may be a key factor. Janda et al from the University of Hong Kong, China, conducted a finite element analysis (FEA) to understand the impact of different misfit values between an FDP and the supporting implant on the risk of porcelain veneer fractures in screw-retained implant-supported metal–ceramic FDPs.

Figure 1. Maximum stress for each setup.



The researchers created an FEA model that reproduced a 5-unit screw-retained implant-supported metal–ceramic FDP mounted on 3 implants (2 end abutments on 1 side and 1 end abutment on the other). Misfit, defined as the discrepancy between the abutment's transversal axis and the FDP's transversal axis at the end supported by 1 abutment, was set at 0 µm, 10 µm, 20 µm, 30 µm, 40 µm, 50 µm, 100 µm and 150 µm. After the maximum stress for each misfit was analyzed, a load of 200 N was applied to the prosthesis, and maximum stress was again measured.

Maximum stress increased as the level of misfit and gap size increased in a linear relationship up to a gap size of 100 µm. However, the rate of increase accelerated at gaps >100 µm (Figure 1), showing that stress increase is not strictly proportionate to gap size. Increases in gap size also caused the area of greatest stress within the FDP to shift.

Comment

This study suggested that a misfit between the FPD and its supporting implants creates a risk of implant fracture. At misfit levels <30 µm, that risk appears to be minimal. However, at levels ≥30 µm, the likelihood of veneer fracture increases, with the increase in risk accelerating at misfits ≥100 µm.

Janda M, Larsson C, Mattheos N. Influence of misfit on the occurrence of veneering porcelain fractures in implant-supported metal-ceramic fixed dental prostheses: a finite element analysis replication of in vitro results. Int J Prosthodont *2021;34:458-462.*

Conventional vs Digital Workflow

When creating an implant-supported restoration using a conventional workflow with an analog impression, the probability of a distorted result increases at each step. Although a digital workflow using an intraoral scanner (IOS) may address some of the drawbacks of a conventional workflow, it can introduce other errors at the time of the digital impression and during the CAD/CAM and 3-dimensional printing procedures. Rutkūnas et al from Vilnius University, Lithuania, conducted a study that evaluated fixed partial dentures (FPDs) both in a clinical situation and using scanning electron microscopy (SEM).

Patients included in the study required FPDs supported by 2 implants in the posterior region (14 maxillary, 10 mandibular). A total of 48 zirconia FPD bars were produced:

➤ 24 by conventional workflow (open tray impressions, verification and scanning of master casts, CAD/CAM manufacturing of screw-retained zirconia restorations, cementation of FPDs to non-hex titanium bases on the master cast)

➤ 24 by digital workflow (digital impressions taken using an IOS, CAD/

CAM manufacturing of screw-retained zirconia restorations, cementation of FPDs to titanium bases using a cast-free approach)

All zirconia bars were subjectively evaluated both for fit on the master cast and intraorally. Subsequently, the distance from the top margin of the titanium base to the mesial implant analog was measured using SEM. The cement gap was established as the shortest vertical distance from the inferior edge of the zirconia bar to the top edge of the titanium base.

The misfit was significantly greater in the digital group than in the conventional group both overall and at the 4 measured sites (Figure 1). In contrast, the overall cement gap was greater in the conventional group, although the differences at each individual measurement site were not significant. Differences in fit between maxillary and mandibular restorations were not significant, but values for the cement gap were.

Comment

While conventional workflow resulted in a better fit and digital workflow resulted in a smaller cement gap, the differences were small enough that they were of limited clinical significance. Many factors, including the use of a different IOS and conventional impression system or master cast fabrication technique, could have altered the outcomes. These results suggested that either method can produce adequate results in the clinical setting.

Rutkūnas V, Gedrimiene A, Jacobs R, Malinauskas M. Comparison of conventional and digital workflows for implant-supported screw-retained zirconia FPD bars: fit and cement gap evaluation using SEM analysis. Int J Oral Implantol *(Berl) 2021; 14:199-210.*

Table 1. Median misfit and cement gap in conventional and digital workflows.

	Conventional workflow (μm)	Digital workflow (μm)
Misfit	59.00	78.00
at mesiobuccal	51.50	65.00
at mesiolingual	62.00	96.00
at distobuccal	67.00	78.00
at distolingual	68.00	71.00
Cement gap	38.90	34.90
at mesiobuccal	36.40	40.05
at mesiolingual	40.00	35.30
at distobuccal	41.85	35.80
at distolingual	35.65	31.75

Achieving the Best Possible Fit

A passive fit of the framework on the abutments represents the ideal of prosthetic restorations, facilitating osseointegration and preventing future complications. Unfortunately, achieving a perfect passive fit may prove impossible; thus, the goal should be to create the best possible final fit of the implant framework, which can be facilitated through

- strict control of each step of the fabrication process
- application of extra procedures to improve the fit
- elimination of 1 or more steps in the conventional fabrication of the framework

More than a decade ago, Abduo et al from the University of Otago, New Zealand, reviewed the available literature to evaluate both clinical and laboratory methods for assessing the fit of implant prostheses and to weigh their advantages and disadvantages in achieving the best possible fit.

The researchers outlined several techniques that can help the clinician in the office determine the accuracy of the fit. The simplest technique is a visual inspection by the clinician, but the effectiveness of this method will vary with the clinician's experience. Tactile sensation using a traditional dental explorer appears to be superior to visual inspection for detecting marginal discrepancies but is limited by the size of the explorer; moreover, dental explorers detect horizontal gaps better than they do vertical gaps. The use of finger pressure on alternating abutments can identify a significant misfit between the implants and the framework for longer-span multiple-implant prostheses.

Periapical radiographs are valuable for assessing subgingival framework margins, while the Sheffield test is especially effective for long-span frameworks. Disclosing materials can help record vertical discrepancies in otherwise clinically acceptable implant frameworks.

In vitro methods can be divided into 2 groups:

➤ **modeling techniques**, used primarily in research laboratory settings to assess the effect of inaccuracy of prosthesis fit on the implant–bone complex

➤ **dimensional techniques**, using microscopy, the photogrammetric technique and coordinate measurement machines to assess the fit of implant fixed prostheses.

Comment

Although a perfect passive fit may not be achievable, the clinician's goal should be to reduce the amount of misfit as much as possible. The combination of clinical and laboratory techniques can help create an acceptable fit that provides a predictable outcome.

Abduo J, Bennani V, Waddell N, et al. Assessing the fit of implant fixed prostheses: a critical review. Int J Oral Maxillofac Implants *2010;25:506-515.*

Performance And Implant–Abutment Fit

Complication rates for implant-supported prostheses increase over time. Perhaps the most important factor for long-term prosthesis stability is the implant–abutment connection, where a greater misfit may increase mechanical stress on the connection structures and surrounding tissues. Abutments may be either prefabricated by various industry providers or custom-made using a conventional casting procedure employing universal casting long abutments (UCLA) or through a digital workflow.

Ramalho et al from the University of São Paulo, Brazil, conducted a study that evaluated the 3-dimensional fit of industry- and commercial–laboratory-made abutments and how that fit correlated with stress at fatigue failure of the prostheses.

The researchers created 6 groups of 21 implant-retained maxillary central incisor prostheses:

➤ digitally fabricated screw-retained milled 1-piece monolithic abutment–crown

➤ digitally fabricated milled crown cemented onto a prefabricated titanium (Ti)-base abutment

➤ conventionally fabricated screw-retained crown using a custom-cast UCLA abutment

➤ digitally fabricated milled 2-piece assembly with a screwed monolithic abutment and a cemented crown

➤ digitally fabricated milled coping cemented onto a prefabricated Ti-base abutment to receive a cemented crown

➤ conventionally fabricated screw-retained UCLA abutment to receive a cemented crown

Each specimen was evaluated for misfit using microcomputed tomography (μCT) scanning. Mechanical testing measured fatigue failure under mild, moderate and aggressive stress conditions. Modes of failure were analyzed and classified.

The restorations made using a fully digital workflow had significantly greater misfit than did those made with a fully conventional workflow or a hybrid fabrication process. At the mild level of stress, all groups showed a high level (>97%) of reliability. While the survivability level remained >86% for all groups at the moderate level of stress, the fully digital workflow screw-retained restorations suffered a significantly reduced reliability. Under the aggressive stress conditions, all screw-retained groups recorded reliability of <5%; the reliability of the cemented groups ranged from 21% for the fully digital workflow restoration to 71% for the hybrid restoration. The most common failure mode was abutment screw fracture.

Comment

The results of this study suggested that implant-supported prostheses milled by a commercial laboratory exhibit poorer internal fit at the implant–abutment connection than do industrially cast or fabricated prostheses. Higher misfit values had a negative effect, decreasing the influence on the levels of stress at which the prostheses failed.

Ramalho IS, Bergamo ETP, Witek L, et al. Implant-abutment fit influences the mechanical performance of single-crown prostheses. J Mech Behav Biomed Mater *2020;102:103506.*

In the Next Issue

Esthetics and the anterior single implant restoration

Our next report features a discussion of this issue 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.