Strain Development of Screw-Retained Implant-Supported Fixed Restorations: Procera Implant Bridge Versus Conventionally Cast Restorations

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The aim of this study was to quantify the strain development of screw-retained three-unit implant-supported Procera Implant Bridge restorations. Two groups of screw-retained implant-supported restorations (n = 10) were fabricated by means of casting or computer-aided design/computer-assisted manufacture (CAD/CAM) to fit an in vitro cast situation with two implants. During fixation of the restorations, the emerging strains were recorded using strain gauges attached to the cast material mesially and distally adjacent to the implants. Absolute mean strain development ranged from 29.35 μm/m to 2,665.80 μm/m at the different strain gauge locations. Fabrication method had a significant effect on strain development (multivariate analysis of variance, $P = .000$), with the cast restorations showing significantly higher strain levels compared to the CAD/CAM-fabricated superstructures. CAD/CAM fabrication of screw-retained implant-supported restorations provides greater passivity of fit compared to conventional fabrication methods such as casting. *Int J Prosthodont 2012;25:166–169.*

Nonpassively fitting implant-supported superstructures are still considered to be a potential cause for the high incidence of technical complications associated with these restorations.[1] Various authors have shown that with conventional fabrication methods, three-dimensional distortions of the restorations do occur, thus preventing a passive fit.[2,3] However, computer-aided design/computer-assisted manufacturing (CAD/CAM) of restorations has been shown to result in greater accuracy compared to traditional fabrication techniques such as casting.[3,4] In particular, the concept of using CAD/CAM-fabricated superstructures that can be directly attached to the implant shoulder, such as the Procera Implant Bridge (Nobel Biocare), has been described as a simple, cost-effective treatment alternative in which optimum fit can be achieved.[5]

The purpose of this investigation was to quantify the strain development of three-unit screw-retained superstructures fabricated using CAD/CAM according to Procera technology. Conventional three-unit screw-retained implant-supported fixed partial dentures (ISFPDs) fabricated by means of casting served as a control.

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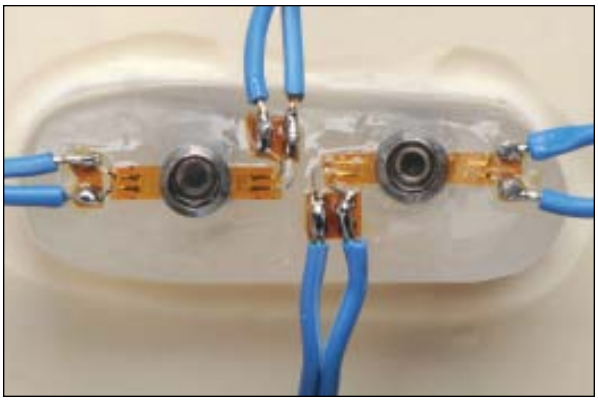
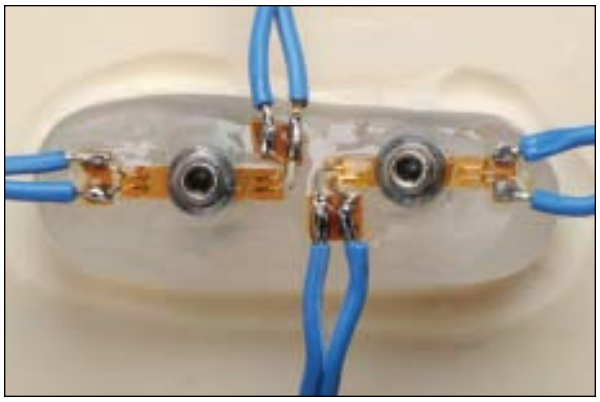
Materials and Methods

A patient situation with two implants (4.1-mm diameter, 10-mm bone sink depth; Standard Plus Implants, Straumann) was transferred to an in vitro acrylic resin cast (Acryline clear, Anaxdent). For each restoration to be fabricated, a pickup impression was made using transfer copings, custom-made trays (Palatray XL, Heraeus Kulzer), and polyether impression material (Impregum, 3M ESPE), and a master cast with individual dies was poured using type IV stone (Fujirock, GC) and the respective implant analogs (Figs 1a and 1b).

The conventional screw-retained restorations (n = 10), based on screw-retained synOcta abutments (Straumann), were waxed using the implant manufacturer's burnout plastic copings and cast in high noble metal fused to ceramic alloy (Jensen Expert, Jensen). For standardization purposes, one restoration resembling a mandibular left first premolar and molar as retainers and a mandibular second premolar as a pontic was fabricated and subsequently duplicated using a silicone mold (Silaplast, Detax) (Fig 2a).

Similarly, patterns were obtained for the remaining master casts (n = 10), which served as a basis for the fabrication of CAD/CAM restorations. Starting from scanning the master casts and patterns, all fabrication steps for the CAD/CAM restorations were carried out by Nobel Biocare. After choosing identical designs for all restorations with respect to the overall dimensions, shape, and connector design, 10 frameworks were fabricated from titanium (Procera





Figs 1a and 1b In vitro casts of an existing patient situation with two implants in the mandibular left quadrant. A total of four strain gauges were attached mesially and distally adjacent to the implants to capture the strains occurring as a consequence of superstructure fixation. **(left)** CAD/CAM-fabricated restorations were fixed directly on the implant shoulders, whereas **(right)** screw-retained synOcta abutments were attached to the implants for conventionally cast superstructures.

Fig 2a Example of a conventionally cast ISFPD framework where screw-retained synOcta abutments were additionally attached to the implant shoulders.

Fig 2b Example of a CAD/CAM-fabricated titanium ISFPD framework and the screws used for fixing the restoration directly on the implant shoulders.

Implant Bridge). These restorations could be fixed directly on the implant shoulders (Fig 2b).

Prior to fixation of the restorations, visual and tactile evaluation was performed to ensure a clinically acceptable fit. Four strain gauges (SGs) were mounted on the in vitro cast mesially and distally adjacent to the implants (120 Ω reference resistance; LY11-0.6/120, Hottinger Baldwin Messtechnik). The SGs were named according to their positions: Am, mesial SG at the anterior implant; Ad, distal SG at the anterior implant; Pm, mesial SG at the posterior implant; and Pd, distal SG at the posterior implant. A measurement amplifier (Spider 8, Hottinger Baldwin) combined with analyzing software (BEAM for Spider 8, AMS Gesellschaft für Angewandte Mess-und Systemtechnik) recorded the strains resulting from superstructure fixation (Figs 1a and 1b).

For the conventionally cast restorations, screw-retained synOcta abutments were attached to the implants on the in vitro cast applying a torque of 35 Ncm using the implant manufacturer's torque wrench. The occlusal screws retaining the superstructures were tightened to 15 Ncm using an electric torque-controlling device (Surgic XT, NSK Europe). For the CAD/CAM-fabricated restorations, the screw-retained synOcta abutments were removed, and the specimens were fixed directly on the implant shoulders applying the recommended torque of 35 Ncm (Surgic XT). For each restoration, the SGs were set to 0, the restoration was placed on the implants, and the screws were tightened starting with the anterior retainer. The final strain values were recorded after a total of 7 minutes.

The absolute strain values served as the basis for statistical analysis (SPSS version 19, IBM) applying multivariate analysis of variance (MANOVA) with the Pillai trace. The level of significance was set at $\alpha = .05$.

Table 1 Mean Absolute Strain Development (μm/m) Occurring at the Different Strain Gauge Locations

	Am	Ad	Pm	Pd
Cast restorations	29.35 ± 17.96	2,553.22 ± 762.87	2,665.80 ± 436.15	134.86 ± 31.45
CAD/CAM restorations	140.81 ± 363.57	549.24 ± 682.80	625.30 ± 749.39	165.19 ± 127.81

Table 2 Between-Subject Effects for Fabrication Method (Cast, CAD/CAM) on Strain Development at the Different Strain Gauge Locations

Dependent variable	Sum of squares	*df*	Mean of squares	F	*P*
Am	62,112.200	1	62,112.200	0.938	.346
Ad	20,079,599.043	1	20,079,599.043	38.313	.000*
Pm	54,156,564.406	1	54,156,564.406	55.382	.000*
Pd	4,601.364	1	4,601.364	0.531	.475

*Significant difference ($P < .05$).

Results

The mean absolute strain development at the different SG positions ranged from 29.35 μm/m to 2,665.80 μm/m (Table 1). MANOVA revealed a significant influence of the factor fabrication method on strain development of an ISFPD ($P = .000$). Subsequent tests of between-subject effects (Table 2) revealed significant differences in strain development for the different ISFPD types at SG locations Ad and Pm ($P = .000$), whereas at positions Am ($P = .346$) and Pd ($P = .475$), no significant differences could be observed.

Discussion

As could have been expected based on previous investigations, none of the ISFPDs revealed a true passive fit.[2–4] This may be explained by the fact that all restorations were fabricated on conventional casts with inherent inaccuracies resulting from impression taking and master cast fabrication. Nevertheless, CAD/CAM fabrication resulted in significantly greater accuracy compared to conventional casting, where extremely high strain values were recorded. This difference could be revealed despite the greater fixation torque applied in the CAD/CAM restorations. Also, the distribution of stresses was more homogenous in the CAD/CAM-fabricated superstructures than in the conventionally cast restorations, which showed very low strain values at SG locations Am and Pd but extremely high strain values at Ad and Pm. It can be argued that the use of plastic burnout copings for fabricating the conventionally cast restorations may have had a negative impact on the level of fit in these restorations. However, in a previous study, it was shown that no difference in passivity of fit exists between restorations fabricated using burnout plastic or prefabricated gold copings.[6]

Regarding the clinical significance of the findings presented, it has to be kept in mind that based on visual and tactile evaluation, all restorations were rated as clinically acceptable. Given the strain magnitudes evoked by superstructure fixation, it can be confirmed that clinical tests for fit assessment are incapable of detecting three-dimensional inaccuracies inherent in a specific restoration.[7,8] This is supported by Hegde and coworkers, who showed that the presence or absence of a microgap between the restoration and implant is not necessarily indicative of passivity.[9] Similarly, a finite element analysis on the effect of different misfit configurations found that rotational errors inherent in a restoration may lead to much greater strain development compared to longitudinal errors.[10]

It has been pointed out by different authors that the clinical significance of misfit strains in implant-supported restorations is not yet known.[7,8] Based on the good long-term success rates and repeated in vivo strain measurements on a specific restoration showing a decrease in strain development over time, it may be argued that there is a certain level of misfit stress that can be tolerated by alveolar bone.[11] However, as long as threshold values for acceptable misfit are unknown, it should be the goal of each clinician to strive for maximum passivity of fit.

In addition to the limitations of the analyzing technique used, it has to be kept in mind that only ISFPD frameworks have been investigated. For clinical application of these restorations, a veneering material would have to be added, which may further increase the strain levels resulting from superstructure fixation. Further investigations should address the long-term stability of the screw joint in Procera Implant Bridge restorations.

Conclusion

Based on this in vitro study, it can be concluded that Procera Implant Bridge restorations exhibit greater passivity of fit as compared to conventionally fabricated superstructures.

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Literature Abstract

Influence of dental esthetics on social perceptions of adolescents judged by peers

Many studies have documented the relationship between physical appearance and social attractiveness. A study among orthodontists and general dentists found that the psychosocial gains from orthodontic treatment were greater than dental health gains. The purpose of this study was to determine if dental esthetics affected the way adolescents judge their peers in terms of athletic, social, leadership, and academic abilities. Ten orthodontic teen patients participated in the study. For nine of the subjects, a frontal facing smiling photograph was digitally altered to create two images: one with ideally aligned teeth and one with a nonideal arrangement of teeth. One subject was only given a nonideal arrangement of teeth and served as the control. Two parallel surveys were constructed, each containing one photo of each test subject. If the ideal smile appeared in one survey, then the nonideal smile appeared in the other survey. A total of 221 peer evaluators successfully rated the photos by indicating their agreement or disagreement with the following statements: *(1)* this person is good at sports, *(2)* this person is popular, *(3)* this person is a good leader, and *(4)* this person is smart. The results of this survey showed that teens with an ideal arrangement of teeth were consistently perceived to be better at sports, more popular, and better leaders by their peers. The difference was not significant for academic performance. Based on this study, it would appear that orthodontic treatment for adolescents to improve their smile may be socially beneficial for them.

Henson ST, Lindauer SJ, Gardner WG, Shroff B, Tufekci E, Best AM. *Am J Orthod Dentofacial Orthop* 2011;140:389–395. **References:** 31. **Reprints:** Steven J. Lindauer, Department of Orthodontics, School of Dentistry, Virginia Commonwealth University, PO Box 980566, Richmond, VA 23298-0566. Email: sjlindau@vcu.edu—*Clarisse Ng, Singapore*