# Strain Development of Implant-Supported Fixed Prostheses Copy Milled from Zirconia Ceramic

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The aim of this research was to quantify the strain development of three-unit implant-supported fixed partial dentures (ISFPDs) copy milled from zirconia ceramic. Three ISFPD groups (n = 10) were fabricated by means of casting, copy milling, and computer-aided design/computer-assisted manufacturing (CAD/CAM) to fit an in vitro model with two implants. During cementation 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 85.39 μm/m to 326.83 μm/m at the different strain gauge locations. Fabrication method had a significant effect on strain development (multivariate analysis of variance, $P = .011$), with the cast restorations showing the highest strain development and the CAD/CAM-fabricated ISFPDs showing the lowest. Copy milling leads to ISFPs that are more precise than cast restorations but less precise than CAD/CAM-fabricated restorations. *Int J Prosthodont 2011;24:479–481.*

Passive fit of implant-supported fixed partial dentures (ISFPDs) is difficult to achieve, even with the use of advanced fabrication techniques.[1,2] Recent publications have shown that greater accuracy of ISFPD frameworks can be achieved with computer-aided design/computer-assisted manufacturing (CAD/CAM) as compared to traditional fabrication techniques, such as casting.[3,4] Copy milling of zirconia ceramic has been introduced as a low-cost alternative to CAD/CAM fabrication.[5]

The purpose of this investigation was to compare the passivity of fit of three-unit cement-retained ISFPDs fabricated by means of casting, copy milling from zirconia, and CAD/CAM.

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## Materials and Methods

Similar to a patient situation with two implants (4.1-mm diameter, 10-mm bone sink depth; Standard Plus Implants, Straumann), an in vitro resin cast was fabricated (Acryline clear, anaxdent) (Fig 1).

For each restoration, 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.

Beginning with scanning of the master casts, all fabrication steps for the CAD/CAM restorations were carried out using Straumann CAD/CAM. Choosing identical designs for all restorations with respect to overall dimensions, shape, and connector design, 10 frameworks were fabricated from presintered zirconia ceramic (Zerion, Straumann CAD/CAM).

The CAD/CAM restorations were duplicated using a silicone mold (Silaplast, Detax) and resin (Pattern resin LS, GC) to achieve identical restorations in terms of dimensions. The patterns obtained were used to model the cast restorations on the implant manufacturer's burn-out plastic copings. These frameworks were cast in high noble metal fused to ceramic alloy (Jensen Expert, Jensen).

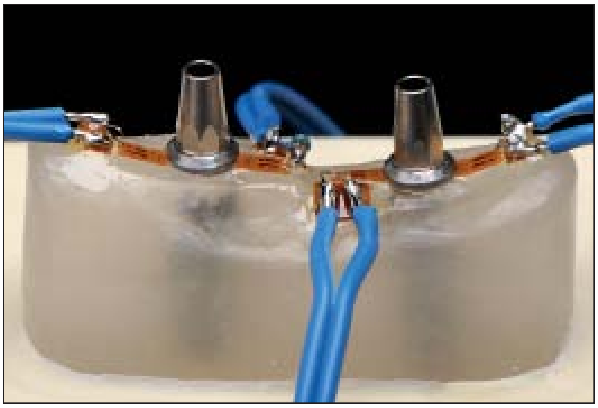


**Fig 1** In vitro model of an existing patient situation with two implants and solid abutments for cementable restorations. A total of four strain gauges, attached mesially and distally adjacent to the implants, captured the occurring strains.

**Fig 2** Sample ISFPD framework copy milled from zirconia ceramic.

Similarly, patterns were created that could be used for copy milling (Ceramill multi-x, AmannGirrbach) of ISFPDs (Fig 2) from presintered zirconia ceramic (Ceramill zi, AmannGirrbach).

Visual and tactile evaluation of the restorations was performed to ensure a clinically acceptable fit.

Four strain gauges 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) (Fig 1). The strain gauges were named according to their positions: Am = mesial strain gauge at the anterior implant, Ad = distal strain gauge at the anterior implant, Pm = mesial strain gauge at the posterior implant, and Pd = distal strain gauge 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.

Cementable abutments (syn Octa abutments "cement-retained," Straumann) were placed on the implants, and temporary cement (TempBond, Kerr) was used for fixation of all specimens. The cement was applied to the abutment cylinders while the strain gauges were set to zero. The specimens were placed on the implants and loaded with a force of 10 N applied to the pontic area for 6 minutes using a universal testing machine (Inspekt mini 3kN, Hegewald & Peschke). Then, the restorations were unloaded and the cement was allowed to set for 1 minute before the final strain values were recorded, after a total of 7 minutes.

The absolute strain values served as the basis for statistical analysis (SPSS 17.0, IBM), applying multivariate analysis of variance (MANOVA) with a Pillai trace. The level of significance was set at $\alpha = .05$.

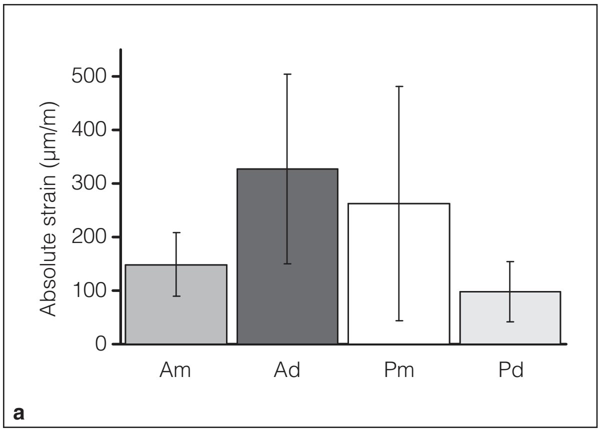
## Results

The mean absolute strain development at the different strain gauge positions ranged from 85.39 to 326.83 µm/m (Fig 3). MANOVA revealed a significant influence of the fabrication method on strain development of an ISFPD *(P* = .011). Subsequent tests of between-subject effects revealed significant differences in strain development for the different ISFPD types at all strain gauge locations, with the exception of strain gauge position Am *(P* = .267, Table 1).

## Discussion

Assuming that passivity of fit is a prerequisite for successful implant rehabilitation, the goal should be to incorporate ISFPDs that cause only minimal amounts of misfit stress, since absolute passive fit currently appears to be impossible to achieve.[1] Within the limitations of this in vitro experiment, where adverse clinical conditions such as difficulties in impression taking and subgingival implant shoulders have not been simulated, previous findings in this field could be confirmed. It appears that the use of CAD/CAM fabrication methods leads to an enhanced passivity of fit compared to ISFPDs fabricated by casting.[3,4] Copy milling of zirconia ceramic leads to less precise restorations compared to CAD/CAM-fabricated superstructures.

Conventional impression taking appears to be a major factor in preventing passively fitting restorations, which probably is more important than the fabrication method itself. Future developments in digital impression taking should therefore be investigated in this context.



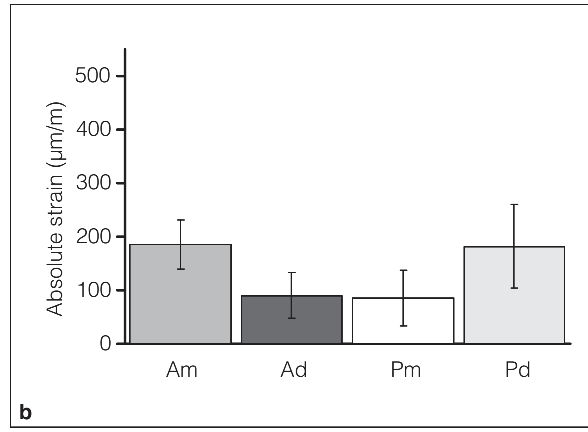
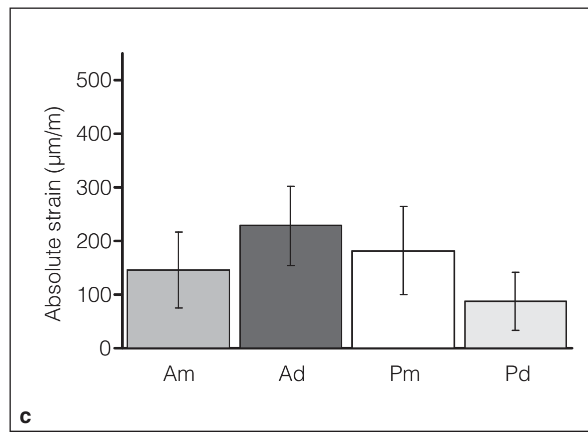




**Fig 3** Mean absolute strain development occurring at the different strain gauge positions. **(a)** Cast restorations, **(b)** CAD/CAM-fabricated restorations, **(c)** copy milled restorations.




## Conclusion

Though constituting an interesting alternative fabrication method, copy milling of implant-supported restorations from zirconia ceramic appears not to allow for superstructures that are as passively fitting as CAD/CAM-fabricated ISFPDs.

**Table 1** Between-Subject Effects for Factor Fabrication Method on Strain Development at the Different Strain Gauge Locations

| Dependent variable | Sum of squares | *df* | Mean of squares | F | *P* |
|---|---|---|---|---|---|
| Am | 9,679.058 | 2 | 4,839.529 | 1.387 | .267 |
| Ad | 282,269.172 | 2 | 141,134.586 | 10.943 | .000* |
| Pm | 157,031.796 | 2 | 78,515.898 | 4.123 | .027* |
| Pd | 53,586.110 | 2 | 26,793.055 | 6.499 | .005* |

*Statistically significant ($P < .05$).

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