Short Communication

Fracture-Load Values of All-Ceramic Cantilevered FPDs with Different Framework Designs

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The purpose of this study was to evaluate the fracture-load values of cantilevered all-ceramic fixed partial dentures (FPDs). Fifty FPDs were manufactured using a zirconia frame to replace a missing molar. The FPDs were divided into five groups, each with a different framework design. After thermocycling and mechanical loading, the load to fracture was measured. The Mann-Whitney *U* test was used for statistical analysis. The mean fracture-load values for the test groups ranged from 346 to 548 N. Reinforcement of the shoulder on the oral side of the occlusal wall resulted in higher fracture load values, while increasing the wall thickness of the distal abutment did not improve fracture resistance. The results indicate that all-ceramic cantilever FPDs cannot yet be recommended for clinical replacement of a missing molar. *Int J Prosthodont 2009;22:49–52.*

In patients with posterior endentulous ridges, cantilevered fixed partial dentures (FPDs) are a treatment consideration for prosthetic restoration, although there are conflicting opinions about their use. While some investigators have demonstrated an increased risk of failure, others have failed to confirm these negative results. It seems, however, that cantilevered FPDs offer advantages in terms of patient comfort and acceptance, and the increased demand for metal-free restorations has focused attention on all-ceramic cantilever FPDs. However, there are little data available on all-ceramic cantilevered FPDs.[1–3] Although the first promising results for anterior[3] and posterior[1] FPDs have been reported, framework fracture remains a risk factor and replacement of a missing molar remains questionable.

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The objective of this study was, therefore, to evaluate fracture-load values for cantilevered FPDs manufactured using a zirconia framework and to test the effect of the framework design on fracture-load values.

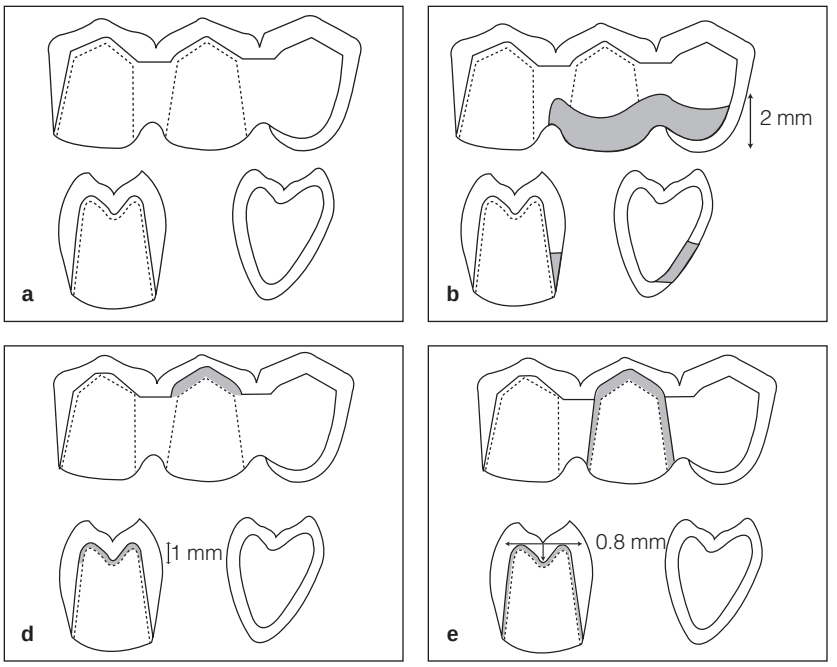
Materials and Methods

Fifty cantilever FPDs were made with a zirconia framework (Lava; 3M ESPE) and veneered with the appropriate veneering ceramic (Lava Ceram). The FPDs were designed as three-unit FPDs, replacing one mandibular molar with a reduced span length of 7 mm and a connector area of 12 mm^2.

Full-crown preparation (chamfer with a depth of 1.2 mm and a 6-degree angle of convergence) was performed on the first and second mandibular premolars of the Frasaco study model. To ensure preparation was standardized, tooth preparations were made with diamonds with a 3-degree angle of incidence using a parallelometer.

The prepared teeth were duplicated and in each case, 50 identical abutment teeth were cast from a Cr-Co alloy (Remanium Star, Dentaurum). To simulate physiological tooth mobility, the metal teeth were covered with heat-shrink tubing and embedded in PMMA resin using a preoperatively prepared key of autopolymerizing acrylic resin for exact location.

Individual impressions were made with a polyether impression material (Impregum, 3M ESPE). Fifty stone



Figs 1a to 1e *Top*: longitudinal section through the FPD. *Bottom left*: cross-section through the terminal abutment. *Bottom right*: cross-section through the pontic. **(a)** Control group: framework thickness: 0.7 mm; **(b)** group 1: additional unveneered shoulder 2 mm high on the oral side; **(c)** group 2: additional unveneered shoulder 3 mm high on the oral side; **(d)** group 3: occlusal framework thickness of the terminal abutment 1 mm; **(e)** group 4: axial and occlusal framework thickness of the terminal abutment 0.8 mm.

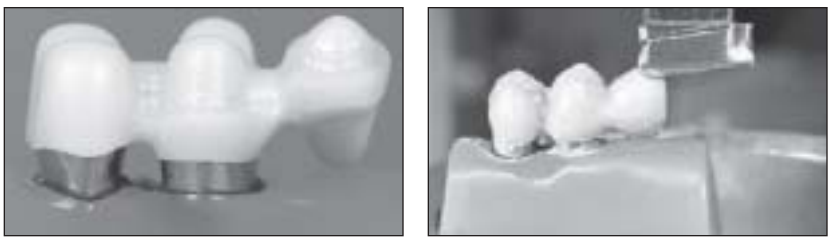


Fig 2 *(left)* Framework reinforced by an additional shoulder (oral view).

Fig 3 *(right)* Loading element.

dies were then cast with suprastone material (Fujirock, GC America) for fabrication of the FPDs.

The models were divided into five groups (n = 10) according to framework design:

- *Control group:* Axial wall thickness of the zirconia cores was constant at 0.7 mm (Fig 1a).
- *Group 1:* An unveneered shoulder 2 mm high and 1 mm wide on the oral side of the FDPs (Fig 1b).
- *Group 2:* An unveneered shoulder 3 mm high and 1 mm wide on the oral side of the FDPs (Fig 1c).
- *Group 3:* Occlusal wall thickness of the distal abutment increased to 1 mm (Fig 1d).
- *Group 4:* Complete wall thickness of the distal abutment increased to 0.8 mm (Fig 1e).

In comparison with the control group, the framework of the FPDs in the 4 test groups was reinforced (Fig 2).[4]

The frameworks were made on stone dies from prefabricated zirconia blanks made from 3 mol% yttrium-stabilized zirconium, by use of the Lava scanning and milling machine (Lava Scan, Lava Form, 3M ESPE), and sintered at 1,500°C (Lava term). The frames were veneered with feldspathic ceramic using a prefabricated silicone key to ensure an identical thickness of 1 mm.

After completion of the FPDs, they were positioned on their metal abutments with hybrid cement (Rely X Unicem, 3M ESPE) by use of finger pressure, in accordance with the manufacturer's instructions. The FPDs were subjected to 10,000 thermocycles between 6 and 60°C (Willytec thermocycler) and 600,000 cycles of 50-N mechanical loading at a frequency of 1.8 Hz (Willytec Dual-axis chewing simulator) at the distal fossa of the pontic. After mechanical loading, the FPDs were evaluated under a stereomicroscope to detect fracture lines in the veneer. The fracture-load values were then determined by loading to failure in a universal testing machine (1445, Zwick). For all specimens, the force was applied to the distal aspect of the pontics (Crosshead speed: 0.5 mm/min^{-1}, fracture threshold for shutoff: 100 N) with 0.3 mm of tin foil between the loading element and the pontic to avoid local force peaks (Fig 3). The load was measured with a load cell (type U2A), including strain gauges, and was recorded by use of Zwick PC software.

Fracture sites of the framework were evaluated macroscopically.

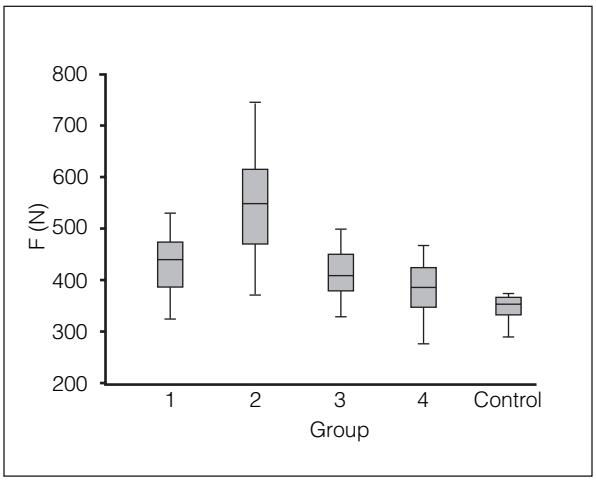
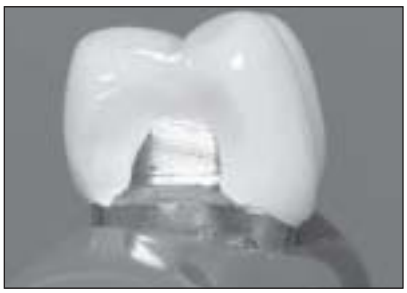


Fig 4 *(left)* Effect of framework design on fracture-load values. Group 1: additional shoulder 2 mm high; group 2: additional shoulder 3 mm high; group 3: occlusal framework thickness increased to 1 mm; group 4: axial and occlusal framework thickness increased to 0.8 mm.

Fig 5 *(below)* Fracture of the distal crown abutment.



Statistical analysis was performed by use of the Kruskall-Wallis test and the Mann-Whitney *U* test (SPSS Version 14.01S), with the level of significance set at .05.

Results

None of the FPDs became unbonded after thermocycling or mechanical loading and no fracture lines were observed in the veneer.

In the control group, fracture-load values ranged from 291 to 376 N with a mean of 346 ± 27 N. For FPDs in group 1 (441 ± 65 N), group 2 (548 ± 113 N), and group 3 (417 ± 52 N), the mean fracture-load values were significantly higher ($P \leq .001$) than values for the control group (Fig 4).

In contrast, the mean fracture-load value for group 4 (385 ± 55 N) was not significantly higher than that of the control group ($P = .063$).

Most of the fracture lines (n = 43) were within the distal wall of the terminal abutment crown (Fig 5).

Discussion

If all-ceramic cantilever FPDs are to be used as a treatment consideration for replacement of a missing molar, they must withstand posterior mastication forces of approximately 700 N.[5] Although data for end-to-end FPDs with a zirconia framework are indicative of values up to 1,200 to 1,400 N, none of the cantilevered FPDs in this study met those expectations. One reason for this result might be the experimental arrangement, including force only being applied at the distal aspect of the pontic, which was believed to be the arrangement resulting in the greatest stress.

In contrast with similar studies reporting values of 291 N,[2] the values in this study were higher. However, apart from using different materials and preparation design, the abutment material also affects load values. Thus, the application of metal abutments in this study may have led to overestimation of the load values.[6]

Regarding the fracture mode, most of the FPDs in the study of Koutayas et al[2] fractured at the connector area, which differs from results seen in this study.

For a long time the connector area was regarded as the most vulnerable part of all-ceramic FPDs. Finite element analysis, which shows the highest stress to be in the connector area, confirmed this assumption.[7] From this, one would assume that the fracture lines would occur in the connector area between the pontic and terminal abutment. Contrary to these expectations, most of the connectors in this study withstood the forces and the fracture lines were in the distal wall of the terminal abutment, indicating that the weak point of the cantilevered FPDs is located in the crown wall of the terminal abutment. These observations may be explained on the basis of a rotary motion vector around the center of the FPDs.[8] The axial load on the distal aspect of the cantilever pontic may produce reactive forces distal to the terminal abutment compressive strain in the lower part of the distal crown wall and tensile strain in the upper.

Conclusion

These results indicate that cantilever FPDs made of zirconia cannot be recommended without reservation for replacement of a missing posterior tooth.

Acknowledgment

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Literature Abstract

A retrospective evaluation of a treatment protocol for dental implant periapical lesions: Long-term results of 39 implant apicoectomies

The objective of this retrospective clinical study was to describe a treatment protocol for treating implants with periapical lesions and to present the results of such treatment. Thirty-fve dental implant patients (mean age: 58.3 years) previously treated in a private prosthodontic practice were identified with an implant periapical lesion. There were a total of 39 lesions that were identified either radiographically (radiolucency), by clinical observation (swelling, suppuration, fistula), or by a combination of these. Twenty-six of the 39 lesions (66.7%) showed clinical signs of infection. Patients were excluded if the lesion had spread coronally to the crest of the alveolar ridge, creating oral communication with the lesion, or had caused implant mobility or failure. Using an intraoral approach, local anaesthesia with a combination of bupivacaine hydrochloride and epinephrine and lidocaine hydrochloride was administered, followed by elevation of a flap facial to the implant site, exposing the bone. A periapical film was used to measure the abscess in the area of the implant apical lesion. A carbide bur in a high speed drill was used to open a window in the bone and a curette was used to debride the bony defect. Biopsy samples of excised tissue were sent for histologic analysis. A carbide bur was then used to remove the affected portion of the implant. An average length of 3.6 mm (range: 2 to 6 mm) of implant was removed. The area was then thoroughly debrided and irrigated with tetracycline/saline solution. In most cases, Bio-Oss bovine bone was used to graft the defect, with or without the use of a Bio-Gide membrane. The remaining minority of patients received neither bone grafting nor membranes prior to primary closure. Post-operative antibiotics and pain medication were prescribed for all patients. Panoramic and periapical radiographs were obtained following treatment. Seventeen treated implants were in the maxilla: 9 anterior and 8 posterior. The remaining 22 treated implants were in the mandible: 11 anterior and 11 posterior. 51.28% of the implants were placed in type 3 bone; the remainder were placed in type 1 (2.56%), type 2 (33.33%) or type 4 bone (12.82%). The average length of the implants treated was 15.5 mm. The majority of apical lesions appeared within the first 2 years after initial implant placement. Follow-up time averaged 4.54 years (range: 0.84 to 15.02 years). Thirty-eight of 39 implants treated with the described technique remained stable and in clinical function with no signs of recurrence after clinical and radiographic examination, yielding a cumulative survival rate of 97.4%. The only implant that failed after treatment was previously placed in type 4 bone in the anterior mandible in a 53-year-old man who smoked at least 2 packs of cigarettes per day. Histology reports from 37 of 39 sites showed an infiltrate of inflammatory cells in a stroma of immature collagen fibres interspersed by active fibrocytes and numerous dilated capillaries. None of the biopsies demonstrated malignant features. The authors recommended that it was crucial to treat the implant before the lesion spread coronally since a channel would exist between the oral cavity and osseous environment for bacterial migration, should the lesion reach the portion of the implant that has an internal screw thread. It would be interesting to find out what would be the minimum length of implant required or critical size of periapical lesion present before this mode of treatment can be instituted.

Balshi SF, Wolfinger GJ, Balshi TJ. *Int J Oral Maxillofac Implants* 2007;22:267–272. **References:** 26. **Reprints:** Mr Stephen F. Balshi, Prosthodontics Intermedica, 467 Pennsylvania Ave, Suite 201, Fort Washington, PA 19034. Email: balshi2@aol.com—*Elvin W.J. Leong, Singapore*