Short Communication

Fatigue Resistance of Restored Endodontically Treated Teeth: A Multiparametric Analysis

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Purpose: To evaluate the failure patterns of teeth restored with both cast metal and fiber posts after fatigue cycling. ***Materials and Methods:*** Thirty-five crownless human teeth subdivided into 5 groups were subjected to 2×10^6 100-N fatigue cycles at 8 Hz under 37°C water. ***Results:*** No root fatigue fractures were recorded. High microleakage values were found in specimens that survived fatigue. No statistically significant relationships were found for fatigue ($P > .4$), fracture strength ($P > .8$), and microleakage ($P > .1$). ***Conclusions:*** Cast-metal and fiber posts undergo insidious microscopic adhesive failures at similar levels. Increasing the post diameter and/or post stiffness could improve the core stabilization.
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The use of fiber posts appears to be a good restorative choice to rebuild endodontically treated teeth.[1,2] Their elastic modulus is claimed to be close to that of dentin. Although this feature could reduce the risk of root fractures,[3] their flexibility is generally greater than that of metal posts,[4] and a flexible post may not be effective in stabilizing the composite core in teeth without their remaining crown. The success of fiber posts relies on the adhesion to dentin of both post and core; thus, it is extremely important to understand how they fail. The aim of this study was to compare the failure pattern of fatigue-stressed teeth restored with both fiber and cast metal posts.

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Materials and Methods

Thirty-five single-rooted human teeth were severed at the cementoenamel junction. Their dimensional variations of root length and buccolingual and mesiodistal diameters were within ± 15% of mean values. Following endodontic treatment, the teeth were subdivided into 5 groups (Table 1). Each post was inserted 10 mm into the canal. The composite core was made using standardized transparent shells. The cast metal post space was shaped with Largo burs and finished using a Batt bur (maximum diameter of 1.8 mm [Dentsply-Maillefer]). The metal posts were air-abraded and passively luted with Fuji Plus cement (GC). Three parameters were evaluated: number of fatigue cycles to failure, ultimate fracture strength, and dye penetration. Two million 100-N fatigue cycles were applied at a 45-degree angulation in 37°C water (Fig 1). After the cycling, the specimens were soaked in 0.5% fuchsin for 24 hours. Subsequently, they were loaded with the Instron machine (Instron, Model 6021) until complete fracture occurred. The fractured surfaces were observed under a stereomicroscope to evaluate the dye penetration (Figs 2 and 3). The data obtained were analyzed using the Kruskal-Wallis test.

Table 1 Materials Used and Results of Multiparametric Evaluation

Group	Posts	Adhesive	Cement/Core	Fatigue cycles to failure (X 1,000)	UFS* (N)	Microleakage (0 to 8)
1	Cast metal post (Pd-Ag alloy, VB 3 Wieland, Pforzheim, Germay)	Resin-modified glass ionomer (Fuji Plus, GC)	N/A	1,431 ± 971	534.7 ± 277	7.9
2	DT Light-Post #2, quartz-fiber (RTD), lot 100US0311	All Bond 2 (Bisco)	C&B Cement/ Bis-Core (Bisco)	871.8 ± 1,056	466.3 ± 46	7.9
3	Millenium Plus Conical White #3, glass-fiber (Sogeva, Krugg), lot 3P60	All Bond 2 (Bisco)	C&B Cement/ Bis-Core (Bisco)	1,090 ± 889	379.5 ± 317	7.5
4	Cabonpost Anatomic ISO 100, carbon fiber (Cabon), lot 0664	All Bond 2 (Bisco)	C&B Cement/ Bis-Core (Bisco)	1,385 ± 870	362.7 ± 120	7.7
5	Cabonpost Anatomic ISO 100, E-glass fiber (Cabon), lot 1414	All Bond 2 (Bisco)	C&B Cement/ Bis-Core (Bisco)	1,715 ± 753	424.1 ± 67	7.9

*Ultimate fracture strength; calculated on specimens that survived fatigue loading.
Note that the metal posts showed the highest ultimate fracture strength (UFS) and showed good fatigue resistance in spite of their non-adhesive cementation. Notwithstanding, the microleakage values were very similar for all post systems.

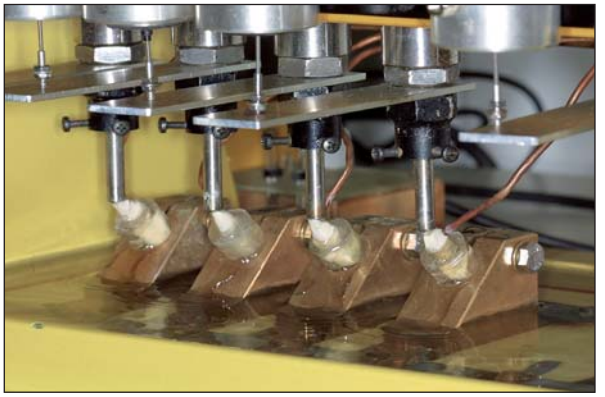

Fig 1 Specimens under cycling loading in wet conditions.

Fig 2 Microleakage pattern at the composite core/dentin interface (DT Light-Post). The highest dye penetration was most commonly observed on the tensile-stressed interface (left side).

Fig 3 Dentin view of the same specimen shown in Fig 2. Note that on the compression-stressed surface, no leakage occurred. Dye penetration was evaluated in its circumferential and centripetal extension on an ordinal scale.

Results

With regard to fatigue loading, no root fractures were recorded. The glass-fiber Cabonposts and metal posts showed the highest fatigue resistance, although this was not statistically significant ($P > .4$).

Metal posts showed the highest values for ultimate fracture strength, but no significant differences were detected ($P > .8$).

All the specimens showed high values of microleakage (Figs 2 and 3), mainly on the tensile areas of the dentin/core interface ($P > .1$).

Discussion

The specimens were loaded simulating a high-stress condition: no crowns, no external bevel for cast metal post, and flat roots without residual coronal tissue, which is useful for core stabilization. Although all the specimens were largely infiltrated by the dye, only 14 of 35 failed macroscopically before 2 million cycles were reached. In an oral environment, the significance of this finding is that bacteria leakage may impair the restored tooth, even if the strength of the restoration is apparently preserved. Subclinical tensile failures of the buildup/dentin interface may cause bacteria penetration and deep caries of the root canal,[5] as suggested by the diffusion of dye into the post space. Since dye penetration was also observed in specimens that survived the fatigue loading, it can be argued that interface adhesive failures of fiber post restorations may occur without causing any macroscopically evident breakdown. The results suggest that it is advisable to increase the post diameter and/or post stiffness to better stabilize the core, avoiding excessive stress on the core/dentin interface. Although the glass-fiber Cabonpost showed the highest fatigue resistance, their microleakage and fracture strength values were not good.

The present results suggest that a multiparametric approach is needed to improve in vitro evaluation of posts and cores. Metal posts, even if luted with a conventional cement, performed fairly well; the use of a resin cement instead of a glass-ionomer could make the cast post the best system to restore crownless teeth.

Acknowledgments

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