Translucent Quartz-fiber Post Luted in vivo with Self-curing Composite Cement: Case Report and Microscopic Examination at a Two-year Clinical Follow-up

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Summary: A maxillary central incisor with mild periodontitis and extensive loss of coronal tooth structure was endodontically treated and restored with a translucent quartz-fiber post and a composite core. Treatment was completed with the cementation of full-ceramic crowns on teeth 11 and 21. Informed consent was obtained from the patient.

Due to the extent of the periodontal disease, tooth 11 was extracted two years later. With the patient's consent, the tooth was used for research. The tooth was sectioned at 11 levels perpendicularly to the long axis and investigated by means of optical microscopy and scanning electron microscope (SEM). The visual examination showed perfect adhesion between the various interfaces (restoration-dentin-post) at both the coronal and root levels.

The adhesion between the post and dentin appeared to be free of gaps, and even where the composite cement showed a nonhomogeneous thickness, voids were not apparent.

The tooth under examination allowed the authors to check the effectiveness of the adhesion and the integrity of the hybrid layer after exposure to the oral cavity for two years. The results of this investigation show that there were no gaps between the adhesive resin and dentin and no hydrolysis of the adhesive bond. This case suggests that it is possible to obtain good results in the short term from the cementation of quartz-fiber posts with composite resin cements.

Keywords: quartz-fiber posts, composite cements, post-endodontic reconstruction.

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Previous studies have suggested the use of materials with a modulus of elasticity very close to that of dentin to restore endodontically treated teeth. This treatment is achieved by using fiber-reinforced posts luted with composite cements and restored with composite resins for core buildup, creating a tooth-post-core monoblock to protect the residual dental structure from masticatory stress and root fracture risks.[6,24] Many studies reported very good clinical results when carbon-fiber endodontic posts were used.[21]

Quartz-fiber post systems have been recently introduced as an alternative to carbon-fiber posts and to improve esthetics in metal-free restorations.[2] Medium-term examinations showed excellent results with no fracture of the post and/or the root, no decementation, and acceptable esthetic results with no interference caused by the presence of the post.[17]

Regarding the biomechanical characteristics of quartz-fiber posts, recent studies have shown a mean tensile strength of 2200 MPa and an elasticity modulus of 14 GPa. Quartz-fiber posts were subjected by one manufacturer (RTD, St. Egreve, France) to fatigue tests conducted with the following procedure: 5,000,000 cycles, 3-point bending method, maximum load 100 N, minimum load 25 N, distance between the two supports 9 mm. The posts reached the end of the fatigue cycles without breaking. The considerable resistance of quartz-fiber posts to loading appears to have been confirmed by recent studies conducted with photoelastic analysis.[34] The use of quartz-fiber posts was clinically evaluated after 18 months in a prospective study,[16] the results of which are very encouraging, ie, no fracture of posts used for the reconstruction of 124 anterior and 56 posterior teeth was observed.

The adhesion of composite resins to quartz-fiber posts seems to be very high. Recent investigations[8] compared the

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adhesion of two dual-curing and two light-curing composite cements to the surface of both carbon- and quartz-fiber posts. Quartz-fiber posts were incorporated into cores made out of the above-mentioned composites. The cores with the posts were cut perpendicularly to the long axis of the posts to generate 2.5-mm-thick slices. Pullout tests with an Instron testing machine were then performed, and the following results were obtained: (1) The adhesion of composite resin to quartz-fiber posts was higher than to carbon fiber posts. (2) Cementation of quartz-fiber posts with dual-curing composites led to a stronger adhesion than when light-curing composites were used. (3) Using carbon-fiber posts, only negligible differences existed between dual and light curing composites.

On the basis of SEM investigations, other authors[23] have suggested that when resin composites are used to build up a core onto a quartz-fiber post, a better post-core adhesion is achieved if the buildup is done using flowable materials.

Studies have been performed using the "push-out test" on single-rooted teeth with a quartz-fiber post[27] (Aestetipost, RTD, St. Egrève, France) cemented with a self-curing adhesive (All-Bond 2, Bisco, Schaumburg, IL, USA). Slices 2.2 mm thick were obtained from the root portion of each tooth. The test showed a mean force of 29.8 MPa needed to detach the post from the dentin. The debonding took place in every case at the resin-dentin interface. This mean value of 29.8 MPa was slightly higher than that registered with an analogous test conducted on single-rooted teeth restored with carbon-fiber posts (Composipost, RTD), which resulted in shear bond strength values of 27.1 MPa.[19]

Recently, new quartz-fiber translucent endodontic posts have been introduced in order to allow the use of light cured and/or dual cured composite cements instead of the self-curing cements previously used. Short-term examinations have shown excellent results, such as no fracture of the post and/or the root, no decementation, and acceptable esthetic results with no interference caused by the presence of the post. Our clinical experience with this kind of post in the restoration of the anterior teeth consists of 272 cases over 5.8 years, with 84 reconstructions made using a direct technique, and 76 preprosthetic post-and-core reconstructions completed with the cementation of a full-ceramic crown; no failure has been observed so far.[32]

Therefore, the resistance and reliability of new translucent quartz-fiber posts may be considered certain, whereas the possibility of effectively polymerizing light-curing and/or dual-curing composite cements in the root canal with transillumination through the post is still under discussion. Some authors[3] deem it feasible to cement the quartz-fiber posts with light-curing composite cement, using the fiber post as a light transmitter. This technique is based on the measurements of the residual quantity of unconverted monomers obtained via high-performance liquid chromatography (HPLC). The composite was cured with light transmitted through a translucent post. However, other in vitro studies showed that self-curing materials performed better than light-cured adhesive cements, based on results from Vickers microhardness studies,[4] FEM (finite element model) evaluation of the force of adhesion between a quartz-fiber post and different composite cements,[26] and SEM observations which showed a composite layer that was significantly better and more uniform when a self-curing material was used for the cementation.[14]

This paper presents a clinical report on the in vivo cementation of a translucent quartz-fiber post (Light Post, RTD, St. Egrève, France). The post was inserted and cemented in the root canal of a maxillary right central incisor with an extensive loss of coronal structure. A composite core was used for the buildup and a full-ceramic crown was cemented. The tooth was extracted after 2 years due to worsening periodontal disease. The incisor was further studied by using an optical microscope and a scanning electron microscope.

CASE REPORT

A 49-year-old male suffering from moderate periodontal disease and an extensive loss of coronal structure on tooth 11 was treated at the first author's practice.

The tooth was endodontically retreated and reconstructed with the insertion of a translucent quartz-fiber post (Light Post, RTD, St. Egrève, France) (Fig 1). The coronal portion was restored with a light-curing composite core (Light-Core, Bisco, Schaumburg, IL, USA) (Fig 2).

A medium-sized post was employed, with a diameter of 1.8 mm in the coronal portion and 1.2 mm in the apical portion. The post was pretreated with hydrofluoric acid etching (Ultradent Porcelain Etch; Ultradent, South Jordan, UT, USA) for 12 s. The post was etched, thoroughly washed and dried, and a layer of Primer A+B (All-Bond 2, Bisco) was applied to the post surface, similar to the technique described for carbon-fiber posts.[6]

The treated post was inserted into the canal to a length of 9 mm and cemented with self-curing composite adhesive and cement (All-Bond 2, C & B, Bisco). The manufacturer's instructions were followed, which included etching the canal walls with 32% ortho-phosphoric acid, followed by thorough washing for 40 s using an endodontic syringe. The root canal was dried with paper points, and 2 layers of Primer A+B were applied along with one layer of Pre-Bond resin (All-Bond 2, Bisco). The bonding agent was left in situ for 20 s and then spread by using a light blast of air.

Reconstruction of the core was carried out by encompassing the post which protruded from the root with the composite core buildup material; the procedure was completed by placing consecutive increments of the core buildup composite (Light Core, Bisco): each increment was light cured for 30 s with a halogen curing light (VIP, Bisco).

The restoration was completed by placing a metal-free ceramic crown and cementing it with a dual-curing composite cement (Choice, Bisco) (Figs 3 and 4).

Evaluation and clinical controls were carried out after 3, 6, 12, and 18 months, during periodic check-ups and routine professional hygiene appointments.

Two years later, due to the worsening of the periodontal disease which led to the mobility of the tooth and discomfort to the patient, tooth 11 was extracted and new prosthetic treatment was planned. With the patient's consent, the extracted tooth was studied in microscopic and ultramicroscopic investigations.

Fig 1

Fig 2

Figs 1 and 2 Rebuilding tooth 11 with a composite core onto a quartz-fiber endodontic post.

Fig 3

Fig 4

Figs 3 and 4 Full-ceramic crowns luted onto teeth 11 and 21 with dual-curing composite cement.

Optical and Scanning Electron Microscopic Examination Methods

The extracted central incisor was carefully stripped of periodontal residue and stored for 1 week in physiological saline solution at a temperature of 4°C. The tooth was then embedded in self-curing resin for processing.

Using a diamond wheel for hard tissues (Leitz 1600), the tooth was sectioned to yield 9 1.5-mm-thick specimens, 3 from the coronal portion and 6 from the root of the tooth. All sections included a portion of dental tissue, the resin cement, and the innermost part of the quartz-fiber post.

At the crown level, sections were taken at three different levels: (a) 1.5 mm from the incisal edge; (b) at the middle of the crown; (c) 1.5 mm from the junction between the enamel and the root cement.

Each coronal section included (from the exterior towards the interior): ceramic from the metal-free crown, dual-cured composite cement used to cement the crown to the core buildup, light cured composite used for the core buildup, the bonding agent, and the translucent quartz fiber post.

At the root level, sections were taken from six different regions: two in the coronal third, two in the middle third, and two in the apical third, all 1.5 mm apart. Each section included (from the exterior towards the interior): cementum, dentin, the hybrid layer, the self-cured adhesive cement, and the quartz-fiber post (Fig 5). All slices were subjected to microscopic investigation using an optical microscope (Axio-

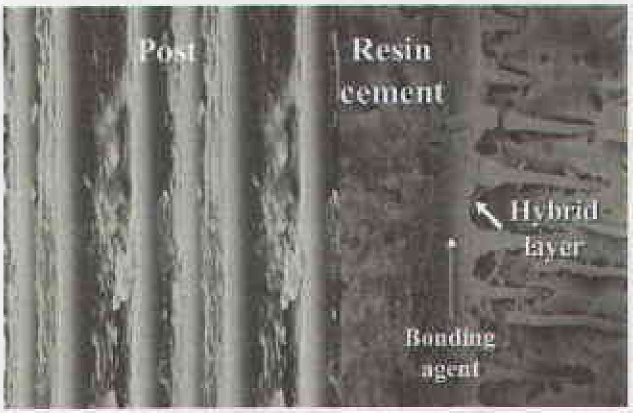

Fig 5 SEM image, 4000X. Moving from the right to the left side, the dentin, hybrid layer, bonding agent, self-curing adhesive cement, and the quartz fiber post are evident.

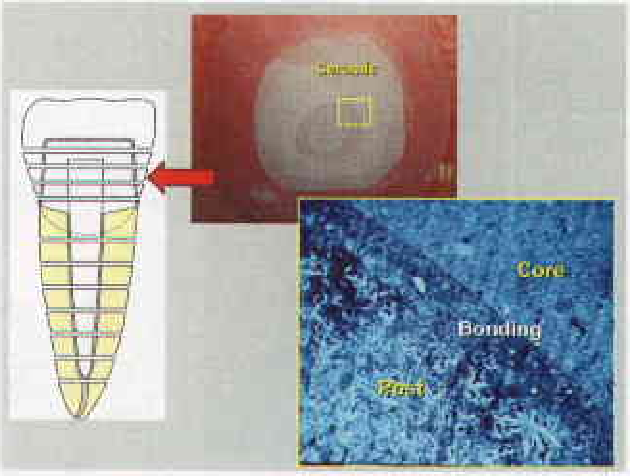

Fig 6 SEM image, 1000X. No gap was visible between post, bonding agent, and composite core.

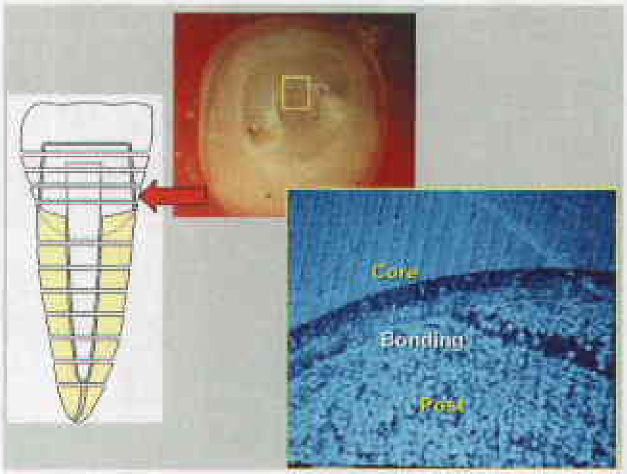

Fig 7 SEM image, 800X. No gap between the interfaces was observed.

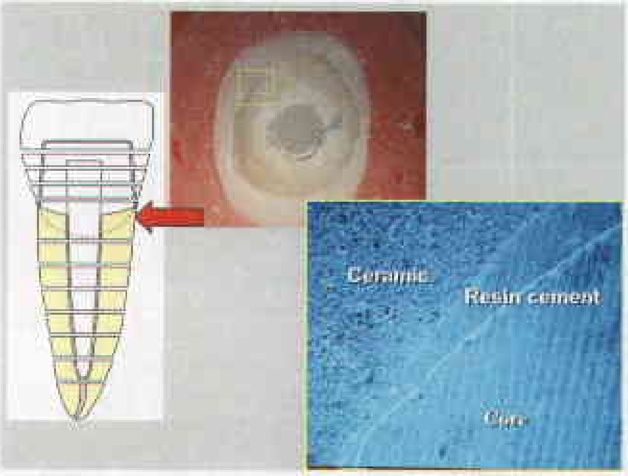

Fig 8 SEM image, 1000X. Perfect adhesion was observed between the composite core, the composite cement, and the full-ceramic crown.

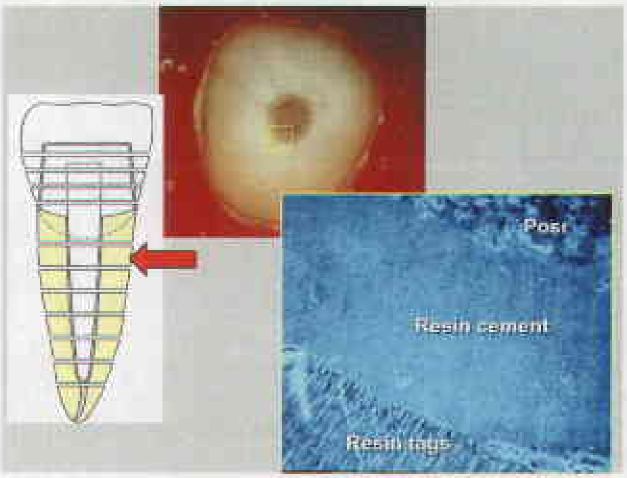

Fig 9 SEM image, 250X, showing the presence of a well-formed and uniformly distributed hybrid layer. The cement appeared to be of homogeneous density everywhere, and no filling defects were visible.

scop 2 Plus, Zeiss, Germany) to identify any defects in the interfaces between the various components of the specimens. The samples were then carbon coated and examined using a scanning electron microscope (Cambridge stereo-scan 250; Cambridge, UK), four magnifications per section (250X, 500X, 800 to 1000X, and 2000X). Critical point drying was not performed.

RESULTS

Incisal Section of the Crown

Observation with the optical microscope did not show any gaps between the ceramic crown and the cement used to bond the crown. Neither was any gap noticed between the composite core and the quartz-fiber post. Observation with the SEM (Fig 5) showed a complete adhesion between the interfaces just mentioned. No gaps were visible between the various materials used to build up the core (Fig 6).

Middle-level Cross Section of the Crown

The optical microscope at 40X magnification showed that the ceramic was thinner than in the previous slice, while the composite core was seen to be wider than in the previous section. At this level also, no gaps between the interfaces were observed with SEM (Fig 7).

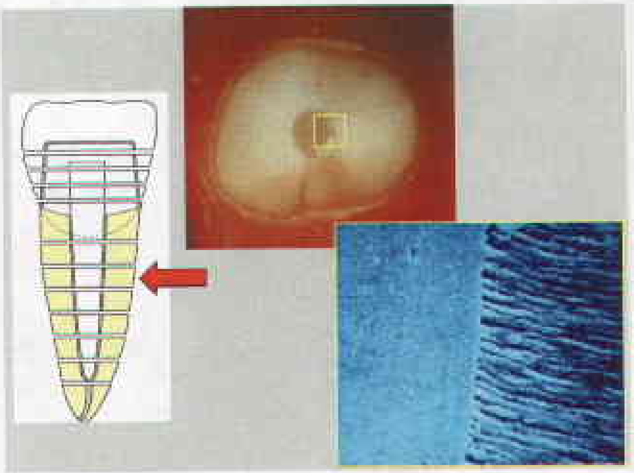

Fig 10 SEM image, 1000X, showing good adhesion and massive penetration of resin tags into the dentinal tubules. Notwithstanding the presence of a thicker layer of cement, no air bubbles, gaps or other filling defects were visible.

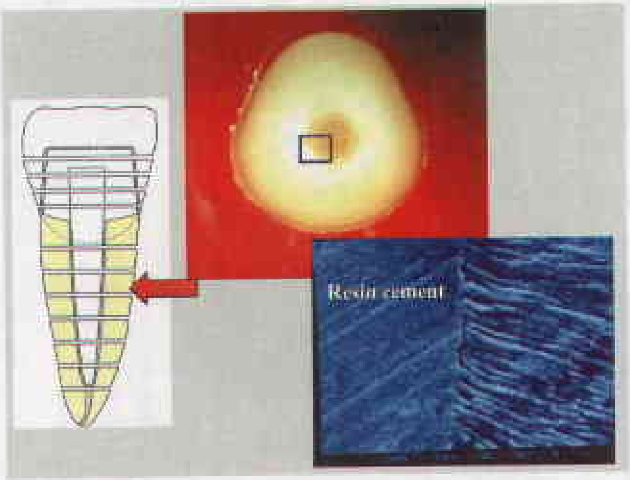

Fig 11 SEM image, 1000X, depicting some adhesive defects between the composite cement and the dentin. However, the hybrid layer was evident, with a large number of resin tags deeply penetrating the dentinal tubules.

Section at the Transition Area Between the Coronal and Root Portions

At 40X magnification, the slice taken 1.5 mm from the junction between the crown and root showed a further increase in the thickness of the composite core and a corresponding reduction in thickness of the ceramic crown. Furthermore, an uneven thickness of the dual-curing composite cement was noted. However, this did not appear to have affected the adhesion between the post and the cement. SEM observation showed complete adhesion between the materials at this level also, which together formed a single indivisible block (Fig 8).

Root Sections from the Soronal Third

At low magnification (40X), a good fit between the post and the canal wall was evident in the first section (1 mm from the opening of the root canal). Corresponding to the buccal surface of the post, the thickness of the cement was greater than that observable at the other points, but no filling defects were visible and the cement appeared to be of homogeneous density everywhere. In this section, which included the root dentin, observation with the SEM revealed the presence of the hybrid layer, which appeared to be well-represented and uniformly distributed across the entire circumference of the endodontic wall, in which the resin tags penetrate deeply into the dentinal tubules. No gaps were observed (Fig 9).

In the second section, 2.5 mm from the opening of the root canal, the optical microscope showed a more homogeneous thickness of the cement around the post; no gaps or filling defects were visible. SEM observations at this level showed a considerable thickness of composite cement between the dentinal wall and the quartz-fiber post. Good adhesion and massive penetration of resin tags into the dentinal tubules were present. It should be noted that notwithstanding the presence of a thicker layer of cement than observed in other sections, no air bubbles, gaps or other cement filling defects caused by curing shrinkage were present (Fig 10).

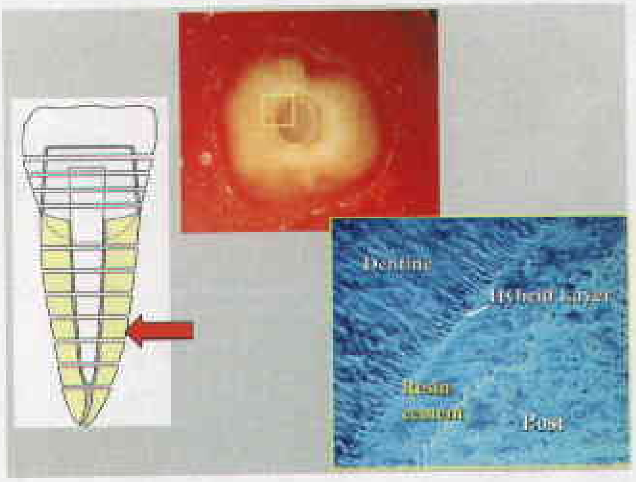

Fig 12 SEM image, 500X. The composite/dentin gaps were no longer observable, and a good post:cement:hybrid layer:dentin ratio was evident.

Root Sections from the Middle Third

In the first section, the optical microscope did not show substantial differences from what was described above. SEM observations (1000X) showed some adhesive defects at the cement composite/dentin junction: however, the hybrid layer and a large number of resin tags deeply penetrating the tubules were clearly evident (Fig 11).

For the second section, 5.5 mm from the opening of the root canal, the optical microscope showed that the post:cement:dentin ratio was also maintained at this level. SEM observation (500X) demonstrated that the small composite cement/dentin gaps present in the previous slice were no longer observable (Fig 12).

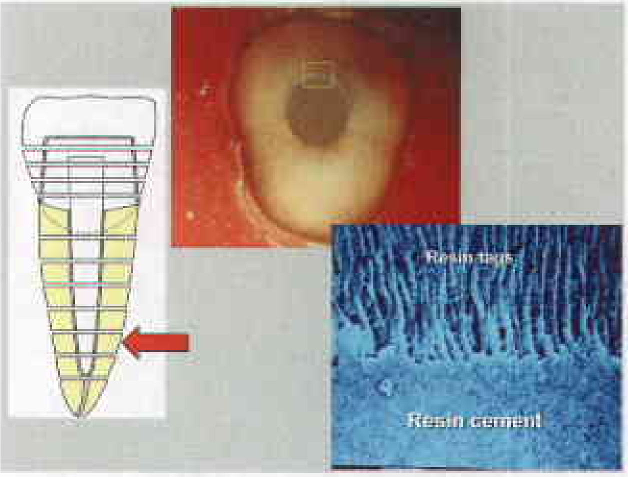

Fig 13 SEM image, 1000X. At this depth, the complete adhesion of composite cement/dentin was evident.

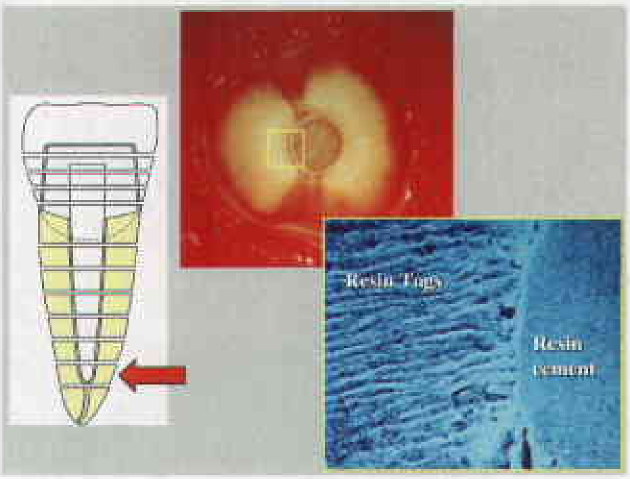

Fig 14 SEM image, 1000X. Some gaps between the cement and the canal wall were observed, but they did not prevent the presence of a well-developed hybrid layer.

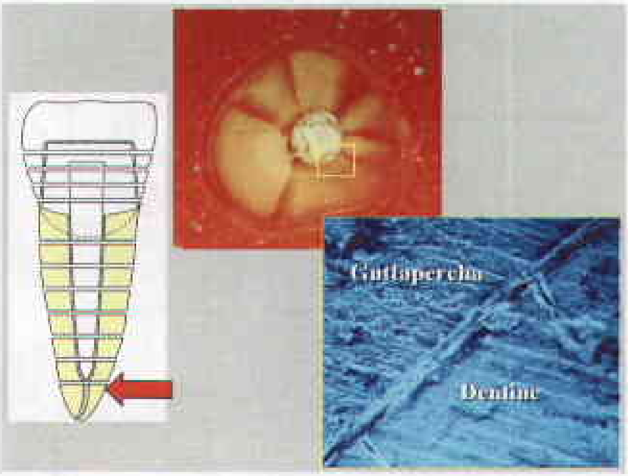

Fig 15 SEM image, 1000X. Complete root canal filling over the quartz fiber post; a good fit between gutta-percha and dentin was evident.

Root Sections from the Apical Third

In the first section, 7 mm from the opening of the root canal, optical microscope observation showed that the interfaces were fully intact. SEM observation confirmed that at this level, the intimate closeness of the post, cement and dentin remained unchanged (Fig 13).

In the second section, 8.5 mm from the opening of the root canal, the optical microscope showed that the post:cement:wall ratio was maintained only until 0.5 mm from the final portion of the post. Some gaps were observed with SEM, which were larger in dimension than those documented at the middle third of the root. The gaps between the cement and the canal wall did not prevent the presence of a well-developed hybrid layer, despite the great distance from the root canal orifice (Fig 14).

The final section showed the root canal filling over the quartz-fiber post, without gaps and/or other defects at the guttapercha/dentin interface (Fig 15).

DISCUSSION

Due to the worsening of the periodontal disease, the central incisor (tooth 11) was extracted two years after crown cementation. Scanning electron and optical microscopic observations made it possible to evaluate the medium-term status of this in vivo restoration utilizing a translucent quartz-fiber post cemented with a self-curing composite.

Several in vitro studies conducted using different methods previously demonstrated that the performance of self-curing composite resins was better than that of dual- and light-curing composite materials. This was in spite of the low predictability of setting time of self-cured cements. However, there was no in vivo control, ie, evaluation of the behavior of these materials under normal clinical conditions and with real mastication in the oral cavity. Adhesive cementation of endodontic posts in the root canal using composite materials involved etching the endodontic dentin in order to demineralize the dentin and expose the collagen fibers, providing the adhesive substrate for current bonding systems. The subsequent application of the adhesive, composite cement, and post integrated the new endodontic structure with the canal walls, which led to the formation of a monoblock, remaining such until deterioration of the collagen, resulting in the formation of the hybrid layer.[13] However, we believe that in spite of the elapsed time and collagen degradation, the bond between the post/cement and the endodontic wall could maintain its original adhesive strength. In comparison with metal posts cemented using phosphate cement, other authors have indicated that this is possible via the resin tags and the adhesive layer, which provided the composite/dentin adhesion.[15,25]

CONCLUSION

The present paper is the first report of a short-term in vivo evaluation of self-curing composite cement used to lute a quartz-fiber post. The results may be used for comparison and a basis for future studies. Obviously, a single case cannot replace systematic research, such as prospective, randomized, clinically controlled studies. However, this case report may contribute to the general clinical knowledge by showing that a certain technique did work well.

REFERENCES

1. Akkayan B, Gulmez T. Resistance to fracture of endodontically treated teeth restored with different post system. J Prosth Dent 2000;87:431-437.
2. Assmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit and strength of newer types of endodontic post. J Dent 1999;27:275-278.
3. Boschian L, Galimberti B, Fadini L, Gagliani M. A new method to evaluate the conversion of a composite resin into the root canal. J Dent Res 2001;80:757.
4. Cadenaro M, Biasotto M, Squor N, Di Lenarda R. Polymerization of 2 composite cements in luting endodontic fiber posts [abstract 10]. J Dent Res 2002;81:B 234.
5. Chalifoux PR. Esthetic restoration of endodontically treated teeth: factors that affect prognosis. J Esthet Dent 1998;10:75-80.
6. Dallari A, Rovatti L. Six years of in vitro/in vivo experience with Composipost. Compendium 1996;17:57-63.
7. Dallari A, Rovatti L. Clinica e ricerca sui DT Light Post. Proceedings VI Internat Symp S. Margherita Ligure 2002:3-4.
8. Dallari A, Rovatti L, Dallari B, Mason P.N. Adhesion of different composite to carbon and quartz fiber endodontic posts; in vitro studies and preliminary report [abstract 1952]. J Dent Res 2003;82:255.
9. Damiani F, Vinello G, Bruno E. Cementazione di perni in fibra di quarzo. Il Dent Moderno 2003;3:57-63.
10. Dietschi D, Romelli M, Goretti A. Adaptation of adhesive posts and cores to dentin after fatigue testing. Int J Prosthod 1997;10:498-504.
11. Dietschi D, Romelli M, Goretti A. Evaluation of post and cores in the laboratory: rationale for developing a fatigue test and preliminary results. Compend Contin Educ Dent 1996;(suppl):S65-73.
12. Duret B, Reynaud M, Duret F. Un noveau concept de reconstitution corono-radiculaire:le Composipost. Le Chir Dent de France 1990;540:131-137.
13. Ferrari M, Vichi A, Garcia-Godoy F. A 4-year retrospective study of fiber-reinforced epoxy resin post vs. cast post and cores. Am J Dent 2000;13:15B-18B.
14. Ferrari M, Grandini S, Fabianelli A, Vichi A. A SEM study on the efficacy of a self-activating adhesive system used for bonding fiber posts into root canal. [abstract 420] J Dent Res 2002;81:B 282.
15. Ferrari M, Mason P.N, Goracci C, Pashley D.H, Tay F.R. Collagen degradation in endodontically treated teeth after clinical function. J Dent Res 2004;85:414-419.
16. Fredriksson M, Astback J, Pamenius M, Arvidson K. A retrospective study of 236 patients with teeth restored by carbon fiber-reinforced epoxi resin posts. J Prosth Dent 1998;80:151-158.
17. Isidor F, Odman P, Brondum K. Intermittent loading of teeth restored using pre-fabricated carbon fiber posts. Internat J Prosthod 1997;9:131-137.
18. Koutayas S.O, Kern M. All-ceramic posts and cores.The state of the art. Quintessence Int 1999;30:283-291.
19. Mannocci F, Ferrari M, Watson T.F. Intermittent loading of teeth restored using quartz fiber, carbon fiber and zirconium dioxide ceramic root canal posts J Adhes Dent 1999;2:153-161.
20. Martelli R. Fourth-generation intraradicular posts for aesthetic restoration of anterior teeth. Pract Periodont Aesthet Dent 2000;12:579-586.
21. Martinez-Insua A, Da Silva L, Rilo B, Santana U. Comparison of the fracture resistances of pulpless teeth restored with a cast post and core or carbon fiber post with a composite core. J Prosthet Dent 1988;80:527-532.
22. Mason P.N. Contributo sperimentale alla ricerca sul legame Composipost-endodonto. Proceedings 1°Internat Symp S.Margherita Ligure, 14-15 March 1995.
23. Monticelli F, Goracci C, Grandini S, Bertelli E, Balleri P, Ferrari M. Scanning Electron Microscope evaluation of Fiber Post-Resin unit [abstract 1953]. J Dent Res 2003;82:255.
24. Motube Y, Maruyama T, Kataoka S. In harmony with nature: esthetic restoration of a nonvital tooth with IPS-Empress all-ceramic material. Quintessence Dent Technol 1997;20:83-106.
25. Pashley DH, Tay F.R, Yiu C, Hashimoto M. Collagen degradation by host-derived enzymes during aging. J Dent Res 2004;83:216-221.
26. Prisco D, De Santis R, Apicella A, Ambrosio L, Rengo S. Glass fiber post adhesion to resin luting cements [abstract 12]. J Dent Res 2002;81:B234.
27. Rovatti L, Mason P.N, Dallari A. I perni endocanalari estetici. Proceedings II° Internat Symp S.Margherita Ligure 1998;12-16.
28. Rovatti L, Mason P.N, Dallari A. Il sistema Composipost: Perni endocanalari di 3°generazione. Ed. Cabon Denit Milano 1999.
29. Rovatti L, Dallari A. Odontoiatria Conservatrice Vol. II°. Edizioni Martina Bologna 2001.
30. Rovatti L, Dallari A, Dallari B. In vitro evaluation of the importance of carbon fiber post shape [abstract 1306]. J Dent Res 2001;80:284.
31. Rovatti L, Dallari A, Dallari B. New translucent endodontic post:further in vitro investigations and 2-year clinical experience [abstract 357]. J Dent Res 2004;81:275.
32. Rovatti L, Dallari A, Dallari B, Mason PN. Restauri estetici con perni endocanalari in fibre di quarzo. Edizioni Martina Bologna, 2004.
33. Scotti R, Monaco R, Malferrari S. Ricostruzioni preprotesiche con perni in fibra di quarzo: esperienza clinica a 18 mesi. Proceedings IV Internat Symp S.Margherita Ligure 2000:21-26.
34. Severino D, Gargari M, Ottria L, Corigliano M, Fiorito R, Barlattani A. Static and dynamic photoelastic analysis of third generation endodontic posts [abstract 124]. J Dent Res 2002;81:246.
35. Sidoli G.E, King P.A, Settchell D.J. An in vitro evaluation of a carbon-fiber based post and core system. J Prosthet Dent 1997;2:785-789.

Clinical relevance: The results demonstrate the excellent effectivity of fiber-reinforced endodontic posts in post-endodontic reconstruction for at least the time period of this study.