Clinical Evaluation of the Use of Fiber Posts and Direct Resin Restorations for Endodontically Treated Teeth

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Purpose: Restoration of root-treated teeth is routinely performed in clinical practice with a choice of therapeutic options, considering many factors to provide optimal mechanical properties, esthetics, and longevity. The aim of the present work was to present a preliminary clinical report on the use of fiber posts and direct resin composites for restoring root-treated teeth. ***Materials and Methods:*** Thirty-eight anterior and 62 posterior endodontically treated teeth were selected from 3 private prosthodontic offices. The protocol used included endodontic treatment, with translucent fiber posts (DT post) bonded to the post-space using a '1-bottle' adhesive (One-Step, Bisco) and a dual-cure resin cement (DuoLink, Bisco). Direct resin restorations were performed using a micro-hybrid resin composite (Gradia Direct, GC) and a layering technique. Both opaque dentin and enamel and translucent enamel shades were used. ***Results:*** Patients were recalled after 6, 12, 24, and 30 months, and the restorations assessed according to predetermined clinical and radiographic criteria. These clinician-mediated evaluation methods confirmed the good clinical performance of the restorations. ***Conclusion:*** Restoration of endodontically treated teeth with fiber posts and direct resin composites is a treatment option, that in the short term conserves remaining tooth structure and results in good patient compliance. *Int J Prosthodont 2005;18:399–404.*

The potential for utilizing fiber-reinforced materials in restorative dentistry has been appreciated for some time.[1] The introduction of carbon fiber posts in 1990[2] provided the dental profession with an alternative to cast or prefabricated metal posts for the restoration of endodontically treated teeth, as the elastic moduli of these fiber posts are closer to that of dentin than that of metal posts.[3]

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However, early promising results from clinical trials[4–6] also emphasized the limitations of the material's radiolucency and masking difficulties under all-ceramic or resin composite restorations.[7]

The more recent introduction of radiopaque and more esthetic quartz- and glass-fiber post systems was an improvement,[5,8] as reflected in studies on the adhesion of fiber posts to root dentin,[9–11] different luting procedures,[12,13] and abutment build-up.[14–17] Clinical trials also showed an absence of tooth fracture when fiber posts were used for restoration of endodontically treated teeth.[18,19]

The need for crown coverage after root canal treatment is still conjectural, and no recent clinical study is available to confirm the indications given in the literature.[20,21] Since post placement and root canal treatment are regarded as major causes of root fractures, crown coverage has been routinely highly recommended[20–22] as a protective measure. An association between crown placement and the survival of endodontically treated

teeth was observed when the loss of tooth structure was remarkable[23,24]; however, the mode of failure or deflection of bonded fiber-reinforced composite posts demonstrated that they may protect the remaining tooth structures, particularly since fracture occurs at loads that rarely occur clinically.[21] Although retrospective studies reported good clinical performances when a crown was used after tooth buildup,[18,19] the performances of fiber posts when they are used in conjunction with direct resin composite restorations remain largely unreported. The aim of this preliminary report was to evaluate the results of root-treated teeth that were restored using fiber posts and direct resin composite restorations without additional crown coverage.

Materials and Methods

Eighty-one patients (45 men and 36 women) treated in the private sector and who required endodontic treatment and restorations on 38 anterior teeth and 62 posterior teeth (33 premolars and 29 molars) were recruited for this study (n = 100 teeth overall). The mean age of the patients was 35.17 years (range, 15 to 56 years; mode, 31 years). Inclusion criteria included clinical and radiographic confirmation of the need for root canal treatment. Anterior teeth were included if at least 50% of residual sound tooth structure was present, and posterior teeth were included if they showed 2 to 3 sound residual coronal walls. Following placement, consecutive patients satisfied with esthetics and function who had chosen to not have a crown were selected. Treatment and recall protocols were approved by the ethical committee at the University of Siena, Italy, and the patients' informed consent was obtained before enrollment in the clinical evaluation.

The endodontic procedure was performed using a crown-down technique. A portable E-Master (VDW) endodontic motor was used, and speed rotation and torque were adjusted according to manufacturer's indications. A chelating agent (FileCare EDTA, VDW) and 2.5% sodium hypochlorite (NaOCl) were used to clean the pulp chamber at the beginning of instrumentation. In addition, 2 mL of NaOCl were delivered to the pulp chamber after the use of each file. All teeth were instrumented with Flexmaster instruments (VDW). The employed protocol is based on the crown-down approach and includes an "introfile" for the enlargement of the coronal end, a 35.02 file, and 3 different tapers (0.6, 0.4, 0.2) for 30, 25, and 20 files. The working sequence, proposed by the manufacturer, is based on the degree of the curvature, with canals classified as wide, medium, or narrow. For all of them, a guiding path for the insertion of a size 10 manual file to the working length was created. The sequence varied, depending on the size of the canals.

- Wide canals: intro file, 30.06, 25.06, 20.06, 30.04
- Medium canals: intro file, 25.06, 20.06, 30.04, 25.04 (then 25.02, 30.02, and 35.02, if needed)
- Narrow canals: intro file, 20.06, 30.04, 25.04, 20.04 (then 20.02, 25.02, 30.02, and 35.02, if needed)

The prepared canals were obturated with gutta-percha points (Mynol, Block) and an epoxy resin sealer (Pulp Canal Sealer, Kerr) using a warm vertical compaction technique. Then the root canal walls were enlarged with a low-speed bur provided by the manufacturer. The depth of the post space preparation was 9 to 10 mm. The root canal walls were etched with 37% phosphoric acid (Bisco) for 15 seconds, washed with water spray, and then gently air-dried. The excess water was removed from the post space using paper points (Mynol). Subsequently, One-Step adhesive (Bisco) was applied with a microbrush in 2 consecutive coats and gently air-dried; the pooled adhesive left in the post space was removed using a paper point before light curing for 20 seconds. A dual-cure resin cement (DuoLink, Bisco) was used to perform the luting procedure with translucent glass fiber posts (DT post, RTD). According to the diameter of the canal, DT size 1, 2, or 3 was used. The cement was applied with a lentulo spiral into the post space, and the post was inserted into the canal. Excess resin cement was removed with a clean microbrush and the cement was light-cured for 40 seconds. The restorative procedure was completed by building up the tooth with a direct resin composite restoration (Gradia Direct, GC) using the appropriate shades. For anterior teeth, opaque dentin and enamel and translucent enamel shades were used with a layering technique to achieve the aesthetic results of the restorations. For posterior teeth, the restorative procedure was carried out using a centripetal technique,[25,26] and the layering procedure also included opaque dentin and enamel shades.

The patients were recalled at 6, 12, 24, and 30 months for clinical and radiographic evaluation of the endodontically treated and restored teeth. All restorations were placed between January and February 2002. The patients were recalled before the end of July 2002 for first evaluation, before February 2003 for the second evaluation, before February 2004 for the third evaluation, and before August 2004 to complete the final evaluation.

During the recall appointments, an assessment of the stability and longevity of the restorations was performed with the following criteria: *(1)* presence or absence of periapical lesions; *(2)* marginal leakage and integrity; *(3)* color stability; *(4)* surface staining; and *(5)* loss of retention due to fracture of the post or fracture of the composite build-up material. The restorations were evaluated by 2 operators who were not involved

Table 1 Recall Data on Periapical Lesions for 100 Teeth Treated with Fiber Posts and Direct Resin Composite Restorations

Time	A	B	C
Baseline	100 (100%)	0 (0%)	0 (0%)
1 month	100 (100%)	0 (0%)	0 (0%)
6 months	97 (97%)	3 (3%)	0 (0%)
12 months	97 (97%)	3 (3%)	0 (0%)
24 months	96 (96%)	3 (3%)	1 (1%)
30 months	96 (96%)	3 (3%)	1 (1%)

A = Absent; B = present but without symptoms; C = present, to be retreated.

Table 2 Recall Data on Retention for 100 Teeth Treated with Fiber Posts and Direct Resin Composite Restorations

Time	A	B	C
Baseline	100 (100%)	0 (0%)	0 (0%)
1 month	100 (100%)	0 (0%)	0 (0%)
6 months	97 (97%)	3 (3%)	0 (0%)
12 month	96 (91%)	4 (9%)	0 (0%)
24 months	95 (95%)	5 (5%)	0 (0%)
30 months	95 (95%)	5 (5%)	0 (0%)

A = Present; B = partial loss; C = complete loss.

Table 3 Recall Data on Marginal Leakage for 100 Teeth Treated with Fiber Posts and Direct Resin Composite Restorations

Time	A	B	C
Baseline	100 (100%)	0 (0%)	0 (0%)
1 month	100 (100%)	0 (0%)	0 (0%)
6 months	98 (98%)	2 (2%)	0 (0%)
12 months	96 (96%)	4 (4%)	0 (0%)
24 months	95 (95%)	5 (5%)	0 (0%)
30 months	94 (95%)	6 (6%)	0 (0%)

A = Excellent continuity at the restorative-tooth interface, no discoloration; B = slight discoloration at the interface; C = moderate discoloration at the restorative-tooth interface measuring 1 mm or greater or recurrent decay at margins, and need for replacement.

Table 4 Recall Data on Color Stability for 100 Teeth Treated with Fiber Posts and Direct Resin Composite Restorations

Time	A	B	C
Baseline	100 (100%)	0 (0%)	0 (0%)
1 month	100 (100%)	0 (0%)	0 (0%)
6 months	100 (100%)	0 (0%)	0 (0%)
12 months	98 (98%)	2 (2%)	0 (0%)
24 months	97 (97%)	3 (3%)	0 (0%)
30 months	96 (96%)	4 (4%)	0 (0%)

A = No mismatch; B = slight discoloration not requiring replacement; C = discoloration requiring replacement.

with the restorations, and who were not revealed at the time of recall (single-blind trial).

Results

Tables 1 to 5 show the recall data obtained after 1, 6, 12, 24, and 30 months.

At the 1- or 2-year recall appointment, endodontic retreatment was performed on those patients with persisting periapical lesions and/or clinical symptoms. Only 4 teeth exhibited periapical lesions after 30 months of clinical service, and in 1 case, retreatment was performed without replacing the direct restoration. After 30 months, 5 of 100 teeth showed a partial loss of the restoration. This was manifested as "chipping" of the resin composite. The restorations were repaired using the same resin composite used for the initial restoration. Six of the 100 teeth examined exhibited slight marginal staining. They were also successfully refurbished using the same material used for the initial restoration. After 2 years of clinical service, 4 teeth showed slight discoloration that did not require restoration replacement. Surface staining was present in 8 of 100 teeth after 2 years of clinical service and was readily removed with polishing.

General results are demonstrated in the following 2 brief clinical examples.

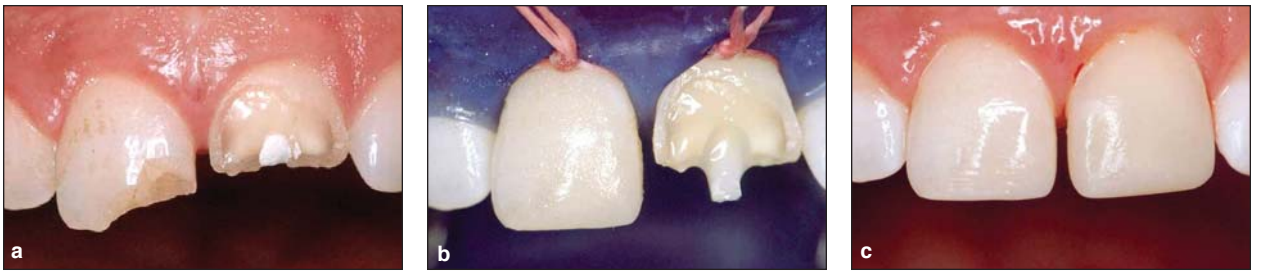
Table 5 Recall Data on Surface Staining for 100 Teeth Treated with Fiber Posts and Direct Resin Composite Restorations

Time	A	B
Baseline	100 (100%)	0 (0%)
1 month	100 (100%)	0 (0%)
6 months	97 (97%)	3 (3%)
12 months	94 (94%)	6 (6%)
24 months	93 (93%)	7 (7%)
30 months	92 (92%)	8 (8%)

A = Absent; B = present.

Clinical Case 1

This 21-year-old patient was treated as an emergency case after an automobile accident (Fig 1a). The maxillary right central incisor was asymptomatic, apart from the enamel and dentin fracture, and was restored with direct resin composite. The left central incisor had an irreversible pulp injury and was endodontically treated. After root canal treatment, a fiber post was inserted (Fig 1b). Then the restoration was completed with the same resin composite material used to restore the right central incisor (Fig 1c). The patient did not want to prepare the right central incisor for a full ceramic crown for economic reasons. The restorations were renovated with BisCover (Bisco), a resin composite surface sealant. The



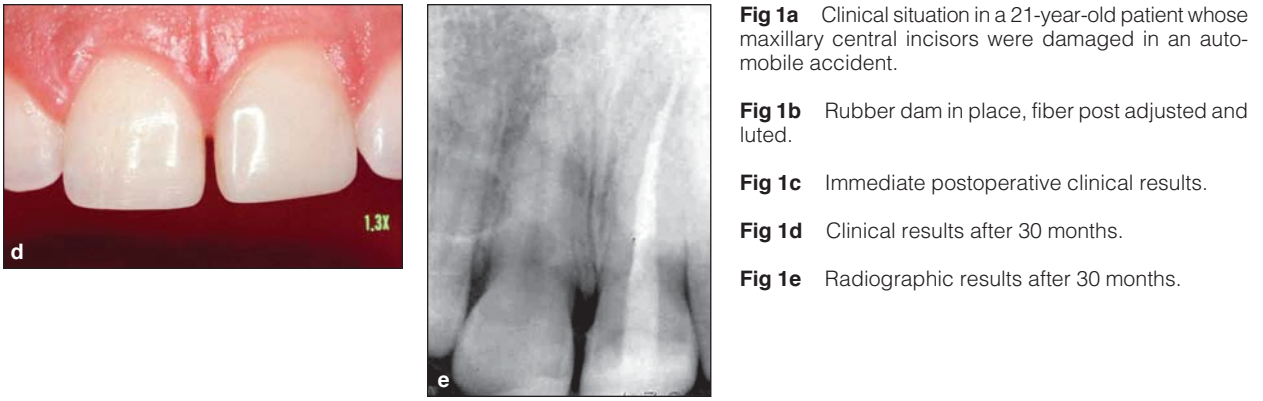


Fig 1a Clinical situation in a 21-year-old patient whose maxillary central incisors were damaged in an automobile accident.

Fig 1b Rubber dam in place, fiber post adjusted and luted.

Fig 1c Immediate postoperative clinical results.

Fig 1d Clinical results after 30 months.

Fig 1e Radiographic results after 30 months.

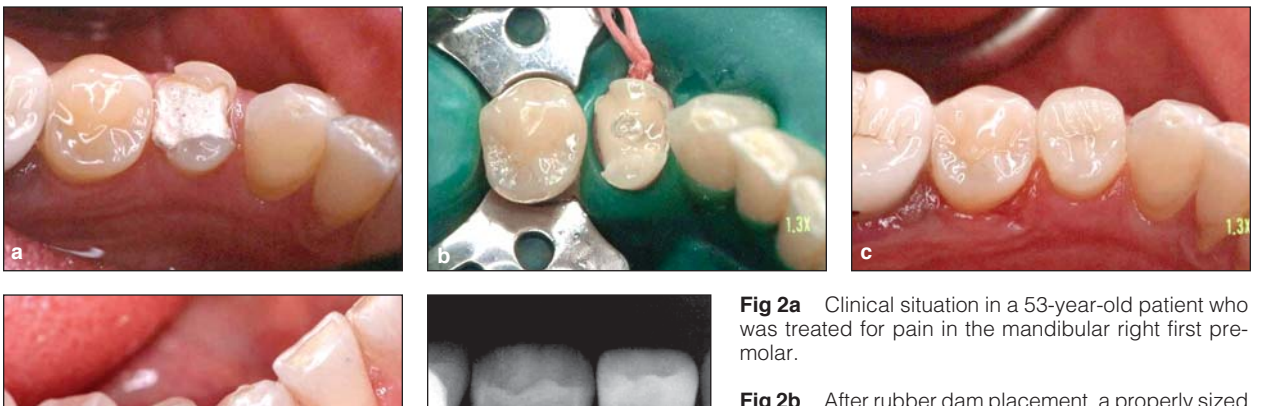


Fig 2a Clinical situation in a 53-year-old patient who was treated for pain in the mandibular right first premolar.

Fig 2b After rubber dam placement, a properly sized post is luted.

Fig 2c Immediate postoperative clinical results.

Fig 2d Clinical results after 30 months.

Fig 2e Periapical radiograph of the affected tooth after 30 months.

clinical and radiographic results after 30 months are illustrated in Figs 1d and 1e.

Clinical Case 2

This 53-year-old patient was initially examined for acute pain at the mandibular right first premolar. The tooth was subsequently endodontically treated (Fig 2a), and a direct resin composite restoration was placed after the bonding of a fiber post to the root-treated tooth (Figs 2b and 2c). An all-ceramic crown was suggested as a treatment alternative to the patient. However, for economic reasons, the patient decided to postpone the indirect restoration. Figures 2d and 2e show the clinical and radiographic results of the resin composite restoration after 30 months.

Discussion

In the last decade, metallic posts have been widely used for restoring endodontically treated teeth. Metal posts (ie, alloys or titanium) were used most often because of their physical properties[20]; their stiffness and rigidity were highly appreciated. However, because of their color, they cannot meet the esthetic demands of contemporary direct resin composite restorations. The esthetic requirements for posts and cores became even more demanding following the introduction of more translucent, enamel-like, all-porcelain restorations.

Some authors have emphasized the need to use endodontic posts that exhibit biomechanical properties similar to those of dentin. Fiber posts are the only available materials that have this property.[19] It has been shown that the stresses that are distributed to the residual tooth structure by the presence of a metal post are much higher than when a fiber post is used.[27,28] The important difference between using "stiff" metal posts and flexible resin-based posts is in the transfer of stress (energy) from restoration to tooth. With flexible posts, all stress is located at the top of the root (the root-crown border area), while the stiff post transfers stress to the root canal.

The availability of new esthetic fiber posts has created the need for a systematic evaluation of their mechanical properties and clinical performance. For that purpose, scanning electron microscopy (with or without the use of a tracer[29,30]), transmission electron microscopy (TEM), and fatigue testing[31] may provide specific information on the type of post that would perform best under clinical conditions. The efficacy of adhesive systems used for bonding of fiber posts may be evaluated by observing the uniformity of the resin-dentin interdiffusion zone, resin tags, and adhesive lateral branches,[8] and by recording the presence of voids/bubbles within the luting material or at the interface between the cavity wall and the post.[29]

In this clinical trial, microbrushes were used to place the "1-bottle" adhesive system inside the root canal. The importance of the microbrush in reaching the narrowest and deepest portions of the root canal preparations has been shown.[13,32] The microbrush is also able to reach all the prepared root canal dentin, resulting in a deep diffusion of resin into the tubules and in the formation of lateral branches.[9,10]

The results of this clinical trial may be important in that direct resin composite restorations were performed, whereas previous prospective and retrospectives studies evaluated fiber post/resin restorations that were covered with either full-porcelain or metal-ceramic crowns.[4–6,18] We were therefore able to analyze the clinical performances of fiber post and resin restoration alone. Moreover, the preservation of tooth structure is regarded as the most important aspect in increasing the survival rate of endodontically treated teeth.[33–35] When only adhesive procedures and direct resin composites are used, all the tooth structure remaining after caries removal and the root canal treatment can be preserved. It is readily conceded that a 2.5-year period is indeed a short one; consequently, our clinical evaluation will be continued.

After 30 months, good coronal seals were achieved with the direct resin composites and fiber post restorations, as evidenced by the similar incidence of persistent periapical lesions versus other studies.[4–6] In the only case that was endodontically re-treated, the procedure was performed without removing the direct restoration. The composite material was partially removed until the fiber post was visible. Then the removal of the post was performed using a "removal kit" provided by the manufacturer (RTD). After the new endodontic procedure was completed, a new post was inserted and the restoration was completed with resin composite. The whole procedure was easily performed, according to recent data available in the literature.[36]

Marginal discoloration and "chipping" of the resin material sometimes occurred, and their repair with the same type of resin composite provided acceptable clinical results.[37,38] In 8 of 100 cases, slight discoloration of the restorations was present after 30 months. Refurbishing and polishing were performed, and these procedures appeared to have prevented further discoloration or color mismatch problems. Undoubtedly, the resin composite employed is inferior in terms of wear resistance[39] in comparison to full ceramic or metal-ceramic crowns.[40] However, porcelain is susceptible to brittle failure, while ductile materials utilize their plasticity to reduce stress concentrations along the crack tip.[40] The use of a direct resin composite restoration is also more economical from the patient's point of view, because these restorations are much cheaper than any other indirect restorations. The use of direct resin composite restorations also minimizes the amount of residual tooth structure that has to be sacrificed for full crown coverage. They are also less time consuming to fabricate, and no additional laboratory costs are required. The ability to refurbish these fiber post/direct resin composite restorations is thus an important alternative, with the potential to save tooth structure and increase the longevity of restorations at a lower cost.[41,42] In cases with questionable prognosis, it is also desirable to wait for some time before making definitive indirect restorations.

It has recently been shown in a laboratory study[43] that fiber posts with good mechanical properties can resist up to 2 million cycles in fatigue testing. This observation appears to support our clinical findings after 30 months of clinical service, thereby confirming pre-

vious observations.[4–6] Longer clinical trials should be performed to validate the use of fiber posts and direct resin composites as a simplified conservative approach to the rehabilitation of endodontically treated teeth.

Conclusions

After 30 months of clinical service, 100 root canal–treated teeth restored with fiber posts and direct resin composite restorations exhibited favorable clinical results.

References

1. Bradley JS, Hastings GW, Johnson-Nurse C. Carbon fibre–reinforced epoxy as a high strength, low modulus material for internal fixation plates. Biomaterials 1980;1:38–40.
2. Duret B, Reynaud M, Duret F. Un nouveau concept de reconstitution corono-radiculaire: Le composiposte (1). Chir Dent France 1990;540:131–141.
3. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275–278.
4. Fredriksson M, Astback J, Pamenius M, et al. A retrospective study on 236 patients with teeth restored by carbon fiber–reinforced epoxy resin posts. J Prosthet Dent 1998;80:151–157.
5. Ferrari M, Vichi A, Mannocci F, Mason PN. Retrospective study of clinical performance of fiber posts. Am J Dent 2000;13:9B–14B.
6. Ferrari M, Vichi A, García-Godoy F. A retrospective study of fiber-reinforced epoxy resin posts vs. cast posts and cores: A four-year recall. Am J Dent 2000;13:B9–B14.
7. Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent. 2000;83:412–417.
8. Drummond JL, Toepke RS, King TJ. Thermal and cycling loading of endodontic posts. Eur J Oral Sci 1999;107:220–224.
9. Nakabayashi N, Pashley DH. Hybridization of Dental Hard Tissue. Berlin: Quintessence, 1998.
10. Chappel RP, Cobb CM, Spencer P. Dentinal tubule anastomosis: A potential factor in adhesive bonding? J Prosthet Dent 1994;72:183–188.
11. Mjör IA, Nordhal I. The density and branching of dentinal tubules in human teeth. Arch Oral Biol 1996;41:401–412.
12. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, Mjör IA. Bonding to root canal: Structural characteristics of the substrate. Am J Dent 2000;13:380–386.
13. Vichi A Grandini S, Ferrari M. Comparison between two clinical procedures for bonding fiber posts into a root canal: A microscopic investigation. J Endod 2002;28:355–360.
14. Gateau P, Sabek M, Dailey B. Fatigue testing and microscopic evaluation of post and core restorations under artificial crowns. J Prosthet Dent 1999;82:341–347.
15. Cohen BI, Pagnillo MK, Condos S, Deutsch AS. Four different core materials measured for fracture strength in combination with five different designs of endodontic posts. J Prosthet Dent 1996;76:487–495.
16. Freedman GA. Esthetic post and core treatment. Dent Clin North Am 2001;45:103–116.
17. Dietschi D, Romelli M, Goretti A. Adaptation of adhesive posts and cores to dentin after fatigue testing. Int J Prosthodont 1997;10:498–507.
18. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: A 2-year prospective study. Int J Prosthodont 2003;16:593–596.
19. Creugers NH, Mentink AG, Fokkinga WA, Kreulen CM. A 5-year follow-up of a prospective clinical study on various types of core restorations. Int J Prosthodont 2005;18:34–39.
20. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: A study of endodontically treated teeth. J Prosthet Dent 1984;51:780–784.
21. Paul S, Scharer P. Post and core reconstruction for fixed prosthodontic restoration. Pract Periodontics Aesthet Dent 1998;5:513–520.
22. Fuss Z, Lustig J, Katz A, Tamse A. An evaluation of endodontically treated vertical root fractured teeth: Impact of operative procedures. J Endod 2001;27:46–48.
23. Aquilino SA, Caplan DJ. Relationship between crown placement and the survival of endodontically treated teeth. J Prosthet Dent 2002r;87:256–263.
24. Newman MP, Yaman P, Dennison J, Rafter M, Billy E. Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent 2003;89:360–367.
25. Hassan K, Mante F, List G, Dhuru V. A modified incremental filling technique for Class II composite restorations. J Prosthet Dent 1987;58:153–156.
26. Bichacho N. The centripetal build-up for composite resin posterior restorations. Pract Periodontics Aesthet Dent 1994;6:17–23; quiz 24.
27. Ausiello P, De Gee AJ, Rengo S, Davidson CL. Fracture resistance of endodontically treated premolars adhesively restored. Am J Dent 1997;10:237–241.
28. Yamada Y, Tsubota Y, Fukushima S. Effect of restoration method on fracture resistance of endodontically treated maxillary premolars. Int J Prosthodont 2004;17:94–98.
29. Ferrari M, Vichi A, Grandini S, Goracci C. Efficacy of a self-curing adhesive/resin cement system on luting glass-fibre posts into root canals: An SEM investigation. Int J Prosthodont 2001;14:543–549.
30. Tay FR, Gwinnett AJ, Pang KM, Wei SHY. Micromorphologic relationship of the resin-dentine interface following a total-etch technique in vivo using a dentinal bonding system. Quintessence Int 1995;26:63–70.
31. Baran G, Boberick K, McCool J. Fatigue of restorative materials. Crit Rev Oral Biol Med 2001;12:350–360.
32. Ferrari M, Vichi A, Grandini S. Influence of adhesive application technique on efficacy of bonding to root canal walls: An SEM investigation. Dent Mater 2001;17:422–429.
33. Lovdahl PE, Nicholls JI. Pin-retained amalgam cores vs. cast-gold dowel-cores. J Prosthet Dent 1977;38:507–514.
34. Trabert KC, Caputo AA, Abou Rass M. Tooth fracture: A comparison of endodontic and restorative treatments. J Endod 1978;4:341–345.
35. Sorensen JA. Preservation of tooth structure. J Calif Dent Assoc 1988;16:15–22.
36. Gesi A, Magnolfi S, Goracci C, Ferrari M. Comparison of two techniques for removing fiber posts. J Endod 2003;29:580–582.
37. Frankenberger R, Kramer N, Ebert J, et al. Fatigue behavior of the resin-resin bond of partially replaced resin-based composite restoration. Am J Dent 2003;16:17–22.
38. Saunders WP. Effect of fatigue upon the interfacial bond strength of repaired composite resin. J Dent 1990;18:158–162.
39. Yip KH, Smales RJ, Kaidonis JA. Differential wear of teeth and restorative materials: Clinical implications. Int J Prosthodont 2004;17:350–356.
40. Derand P, Vereby P. Wear of low-fusing dental porcelains. J Prosthet Dent 1999;81:460–463.
41. Hickel R, Heidemann D, Staehle HJ, Minnig P, Wilson NH. Direct composite restorations: Extended use in anterior and posterior situations. Clin Oral Investig 2004;8:43–44.
42. Mjör IA, Gordan VV. Failure, repair, refurbishing and longevity of restorations. Oper Dent 2002;27:528–534.
43. Grandini S, Goracci C, Monticeli F, Tay FR, Ferrari M. Fatigue resistance and structural characteristics of fiber posts: Three-point bending test and SEM evaluation. Dent Mater 2005;Feb;21:75–82.