Original article

The evaluation of the carbon fiber post system on restoration of teeth defect in children

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Keywords: *carbon fiber; dental occlusion; dental prosthesis; root canal therapy; cementation; dental etching*

Background Post and post-core systems are used to restore extensively damaged teeth. Among these systems, cast alloy post and core, prefabricated threaded alloy post and prefabricated simple alloy post are most frequently applied in China nowadays. In Europe and North America a combined application of the fiber post, resin-core and crown has been applied to restore seriously destructed teeth with satisfactory results in recent years. This study was intended to evaluate the clinical effect of carbon fiber post system on restoration of child anterior tooth defect after root canal therapy, based on 3—5 years' observation.

Methods One hundred and six children with incompletely established occlusion were observed and followed for an average of 42 months (ranging from 36 to 60 months). Eighty-five upper teeth and forty-one lower teeth were restored with carbon fiber post system and composite jacket crown. Periodic check-up was conducted for periodontal condition and restoration effect.

Results One hundred and twenty-one (96.2%) restorations were successful. Four jacket crowns (3.0%) were lost. One tooth (0.8%) had slight gingival inflammation. Tooth root or post fracture and gingival stain were not observed. X-ray showed there was no obvious change in aspects including the width of periodontal membrane, the density of alveolar bone and the height of alveolar ridge crest.

Conclusions Carbon-fiber post system can satisfy the clinical requirements of young patients who have residual anterior crown and root caused by trauma or caries, and have incomplete occlusion and have completed root canal therapy. This system helps realize good esthetic result for patients and easy practice for dentists. Carbon fiber post is safe and convenient, especially for sick children.

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The metal post and core restoration system is currently widely used in China to treat patients afflicted by teeth defect. With the advance of materials and technology, and in accordance with elevated clinical requirements, new restoration systems of tooth defect, the non-metal post and core systems, including carbon fiber post system, glass fiber post system and quartz fiber post system, have been put into clinical use since early 1990s in Europe.[1,2] In recent years, these systems have been introduced into China for clinical treatments. Although the laboratory experimental tests of fiber post systems showed satisfactory physical and chemical quality, clinical data are still needed to validate its potential for successful application. In the present report, we conducted carbon fiber post system in 106 children patients with 126 decayed anterior teeth, and followed them for an average of 42 months to evaluate the system. With its excellent mechanical, biological and esthetical qualities, we found it a safe and convenient restoration system.

METHODS

Patients

During the years from September, 2000 to September, 2002 we conducted carbon fiber post, resin core and jacket crown restoration in 278 children patients aged 9—14 years, who visited the Department of Prosthodontics, Peking University School of Stomatology. Among them, 106 were periodically followed up and observed for 36—60 months.

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Therefore we included 106 patients in our study. These patients all met both conditions as below: (1) having residual anterior crown and root made by trauma or caries and having incomplete occlusion; and (2) having completed root canal therapy.

Materials

Carbon fiber posts and accessory dual cure core resin (Bisco, Schaumburg, USA); all Bond 2 dentin bond (Bisco); root canal preparation drill (Bisco); root surface preparation drill (Mani, Japan); Adhesive Resin Cement Paste Universal (3M, USA); gingival retraction cords, gingival retraction fluid and gingival retraction tools (Ultradent, USA); resin jacket crown (3M, USA).

Methods

The residual crown was removed and the root surface was roughly prepared. The carbon-fiber post of proper size were selected, and the corresponding shaping drills and finishing drills were used to prepare the root canal to conventional length. The carbon-fiber post was cut to desired length with diamond bur but not regular scissors, because the latter will cause the spread of the fibers. When prepare the fracture surface of root canal, we maintained as much tooth tissue as possible.

Cleaned and sterilized root canal and root surface were conducted. Conventional resin cement adhesive was used to fix the carbon-fiber post inside the root canal. The root surface was treated by 32% phosphorous acid (UNI-ETCH) for 15 seconds and then washed thoroughly for over 15 seconds. Subsequently the air syringe was used to dry the surface. Two drops of ALL-BOND2 Fluid A and the same amount of Fluid B were mixed evenly before applied to the root surface. Then the mixture was evenly spread on the surface of carbon-fiber post, and the surface was breezed to dry and light cured for 10 seconds.

The part of the post exposed to the oral cavity was covered by dual cured resin and then made it core shape with hand instrument, and followed by curing for 40 seconds. It was formed following the preparation requirements of full crown.

Gingival retraction cords of proper diameter and length were selected and then dipped into gingival retraction fluid. The gingival retraction cords were then pushed into the gingival groove with the help of gingival retraction tools. After 5 — 10 minutes of gingival retraction, a sodium thiosulphate impression was made and then a calcium sulfide cast was created.

The plastic jacket crown was produced in either clinics or technical center. The margin of the jacket crown should fit well, and if necessary, it should be shaped to the satisfaction of the patient. After re-shaping, surface smoothing, sterilization and drying, glass-ionomer cement was used to bond the jacket crown.

All the 106 patients were followed for 3 to 5 years (average: 42 months) for evaluating the clinical effect of the restorations. X-ray was obtained before and after the root canal therapy, and during the follow-up.

Criteria of clinical evaluation and observation

The patients were required to visit the dentist every half a year. They were inspected and treated by the author. The restoration was evaluated according to 7 criteria listed below. (1) Gingival inflammation:[3,4] A. no gingival inflammation and gingival recession; B. slight gingival inflammation, slight bleeding with dental explorer, and slight gingival recession; C. apparent inflammation, bleeding, and deepened pocket and gingival recession affecting esthetics. (2) Gingival marginal color:[3,4] A. no color change and having same color as the adjacent tissues; B. color change, and observable difference in color between the gum and the adjacent tissues. (3) Whether there is a falling-off of jacket crown. (4) Whether there is a fracture/fractures of the carbon fibers post. (5) Whether there is a cleavage/cleavages or falling-off of the resin core. (6) Whether there is falling-off of the carbon fiber post. (7) Comparison of X-ray photographs of the afflicted tooth: whether there is change on the density of alveolar bone and whether there is change at the height of alveolar ridge crest.

RESULTS

In the follow up examinations, we detected no fracture of the post and the root. And the observation results of the 7 categories turned out quite positive (Table).

Among the 126 teeth treated with carbon fiber post,

Table. Evaluation of prosthesis results with 126 decayed teeth of the carbon fiber post system in 106 young patients who received restorations

Decayed teeth number	Gingival inflammation			Gingival marginal colour		Fall of the jacket crown		Fracture of the post and root		Crack or fall of the core		Fall of the post		X-ray results			
	A	B	C	A	B	Y	N	Y	N	Y	N	Y	N	A	B	C	D
Sum	125	1	0	0	126	2	124	0	126	2	124	0	126	126	0	126	0
Percentage (%)	99.2	0.8	0	0	100	1.6	98.4	0	100	1.6	98.4	0	100	100	0	100	0

Gingival inflammation: A: no gingival inflammation; B: slight gingival inflammation; C: serious gingival inflammation. Gingival marginal colour: A: no stain in gingival margin; B: stained in gingival margin. X-ray results: A: no change at the density of alveolar bone; B: changed at the density of alveolar bone; C: no change at alveolar ridge crest; D: changed at alveolar ridge crest. X-rays and pictures of a typical case: A: the density of alveolar bone has no change or increases and the low density area in the image decreases; B: the density of alveolar bone decreases or the low density area in the image increases; C: no noticeable change at alveolar ridge crest; D: alveolar ridge crest lowers. Y: yes; N: no.

resin core and jacket crown, 99.2% of the teeth developed no inflammation, 100% had no color change in gingival margin, 98.4% of the jacket crowns did not fall, 100% of the posts did not fall and fracture, 98.4% of the resin cores did not crack or fall, and 100% had no change in the density of alveolar bone and the height of alveolar ridge crest.

However, we also found inflammation occurred in one case, 2 jacket crowns fell, and 1 core cracked and another core fell.

X-ray results and pictures of one case, which is typical of all, are presented (Fig.).

DISCUSSION

At the present time, cast metal post, core and crown are applied widely with decayed tooth, and Ni-Cr alloy metal is the most often used material in China. The weakness of this traditional technique has been known along with time by more and more dentists. Although the fiber post has been testified with excellent mechanical qualities by many laboratory experiments,[5-7] many Chinese dentists are still uncertain about its clinical application, especially, does the fiber post have enough fracture strength over time?[8-10]

The present study was dedicated to evaluate the effect of the carbon fiber post system on young patients over a 3—5 year period. At it turned out, the results were quite satisfactory. The data based on 126 afflicted teeth from 106 patients showed no root or post fracture over three years' observation, which is consistent with the observation of Arturo and Robert:[11,12] the tooth with carbon fiber post + resin core restoration will end up with fracture in the post-core surface with load while the tooth itself seldom has fracture. On the other hand, Arturo's experiment also showed that the major problem with the tooth restored by metal core-post system is tooth fracture, whose ratio runs as high as 91%. Fredriksson[13,14] gained the similar results as Arturo's in a clinical retrospective study of 236 patients with teeth restored by carbon fiber posts. These suggest that carbon-fiber post has similar modulus of elasticity to dentin, and the stress can be evenly distributed around the post, which saves the post or the root from fracture, which is often caused by over concentration of stress.[1,15]

The removal of post-core systems, especially metal post and core, has been one of the toughest tasks in clinics, which, however, was solved with the application of carbon fiber post-core system. For removal, a thin diamond fissure bur should first be applied with high-speed handpiece to drill a position hole in the center of the carbon-fiber post. Then a thinner diamond fissure bur with low-speed handpiece is applied to remove the post completely. This process takes only a few minutes, which saves much more time than the removal of a metal post and core. Besides, possible root canal puncture or fracture due to the metal post removal can be avoided, which adds to the chances of successful restoration. For young patients who have not built occlusion or have built occlusion incompletely, if cast alloy post and core are used for restoration, it will become a troublesome and dangerous task to remove

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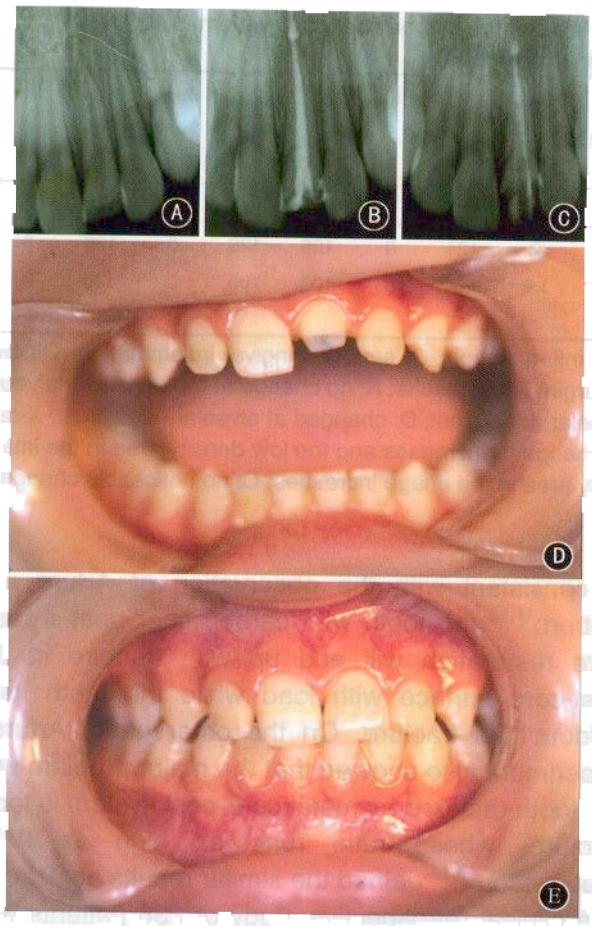

Fig. A: There is only a residual crown in this X-ray film. We have to restore it although he is a nine years old boy. **B:** Root canal treatment was made with this tooth before restoration. **C:** X-ray shows no obvious change in aspects including the width of periodontal membrane, the density of alveolar bone and the high of alveolar ridge crest after using the carbon fiber post system to restore this tooth three years later. **D:** The picture shows this boy needs an aesthetical restoration after having been restored with carbon fiber post and resin core. **E:** In spite of a resin jacket crown, the effect of restoration is satisfactory. Three years later the restoration of the young patient with the carbon fiber post system showed very well, but a certain extent wear and tear in lingual of the jacket crown appeared.

the core when these patients grow up, and further cause difficulty in re-restoration. Thus, it would be better to use carbon-fiber post system for restoration at young ages and then switch to permanent restoration at maturation. The selection of indications in this clinical test is based on the above considerations.

The effect of dental materials on radiodiagnosis is not negligible. MRI cannot be applied to patients with metal restoration, because the conductivity of metal will distort the magnetic field and thus cause significant distortion of the image.[16] However, patients treated with carbon-fiber post can be examined with MRI safely.[17]

The conventional restoration using cast Ni-Cr alloy post, core and porcelain fused to metal crown usually causes a grey band of pigmentation, which not only has negative effect on the esthetics, but also occasionally causes tissue hypersensitive and bio-toxicity due to the released metal Ni ions. The ion of Ni released from Ni-Cr alloy will inhibit the proliferation of fibroblast cells[18] and be toxic to the gingival epithelial cells.[19-21] In our clinical test with carbon-fiber post system, color pigmentation was not seen, and we attribute this to the system's good compatibility and low toxicity. In addition, the choice enables more flexibility for further aesthetic restoration. For example, full ceramic crown, which is not feasible for tooth treated with conventional cast metal post and core, becomes feasible for tooth treated with carbon fiber post and resin core, and it helps improve the aesthetic quality of restoration.

Children at mixed dentition stage usually have improper relationship of occlusion. The over bite occlusion of child's anterior teeth is especially common and difficult to restore. To avoid the inference of improper occlusion, dentists usually shape the post-core for maxillary decayed tooth to incline to the labium, or shape the post-core for mandibular decayed tooth to incline to the lingua. But, these measures will bring extreme difficulty in later restoration. However, much to our relief, carbon fiber post can be readily adjusted in shape to satisfy the needs of both esthetics and function, and facilitates decent conditions for orthodontic treatment.

Nevertheless, the carbon fiber post system is not applicable in certain conditions when the root canal is crooked or the occlusion is seriously disordered, as the post is straight. Under such circumstances, compromise has to be made according to the real situation.

Carbon-fiber post system can satisfy the clinical requirements of young patients who have residual anterior crown and root caused by trauma or caries, and having incomplete occlusion and have

completed root canal therapy. It helps realize better aesthetic result for patients and easier practice for dentists.

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