Clinical Evaluation of Teeth Restored with Quartz Fiber–Reinforced Epoxy Resin Posts

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Purpose: This prospective clinical follow-up evaluated the acceptability of quartz fiber–reinforced epoxy posts used in endodontically treated teeth over a 30-month period. **Materials and Methods:** In 132 patients, 180 endodontically treated teeth were restored using Æstheti-Plus quartz-fiber posts. The posts were luted with the All-Bond 2 adhesive system and C&B Resin Cement according to the manufacturer's recommendations. The core was made with Core-Flo or Bis-Core, and all-ceramic crowns or metal-ceramic crowns were applied as final restorations. The parameters considered as clinical failure were displacement, detachment, or fracture of posts; core or root fracture; and crown or prosthesis decementation. Patients were reevaluated at 6, 12, 24, and 30 months. **Results:** One cohesive failure involving a margin of the composite core was observed after 2 weeks, and two adhesive fractures were seen after 2 months. These failures were located between the cement and the dentin walls of the canals. All three failures occurred during removal of the temporary crown. The percentage of failures was thus 1.7% over a 30-month period, but it was possible to successfully replace the restoration in all three failed cases. **Conclusion:** Over a 30-month period, the rehabilitation of endodontically treated teeth using quartz-fiber posts showed good clinical results. No crown or prosthesis decementation was observed, and no post, core, or root fractures were recorded. *Int J Prosthodont 2003;16:39–44.*

Both researchers and manufacturers have introduced several post-and-core restorations with the aim of providing reliable systems for reconstruction of endodontically treated teeth. In spite of these efforts, it is still difficult to predict the clinical survival times of treated teeth restored with posts and cores. The prognosis is related to several factors, including the type of material used for the post and core; the shape, dimensions, and length of the post; and the kind of cement used. The major disadvantage associated with conventional cast-metal posts is vertical root fracture. Having high rigidity, metal posts appear to vibrate at high frequencies when loaded with lateral forces. The focusing of these forces in unpredictable "critical points" may determine longitudinal fractures of the root or metal corrosion[1] and consequently lead to loss of the tooth.[2–4]

In 1990, Duret et al[5] proposed carbon-fiber posts, among the many prefabricated fiber post-and-core systems, to reduce the failure rate. These relatively recent posts are made of equally aligned carbon fibers attached to an epoxy resin matrix and present an interesting property, anisotropic behavior. In other words, the material has different physical responses when loaded in different directions. This characteristic is of clinical relevance, as it may strongly reduce the possibility of root fracture and decementation.[3] The objective is to create a "cement-post-core" system with homogeneous properties and physical characteristics similar to tooth tissues. To fulfill esthetic requirements, quartz- and glass-fiber posts embedded in a filled resin matrix have been developed.

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Table 1 Distribution of Treated Teeth According to Type

Jaw	Central incisors	Lateral incisors	Canines	Premolars	Molars
Maxilla	43	17	28	24	8
Mandible	9	11	16	8	16
Both	52	28	44	32	24

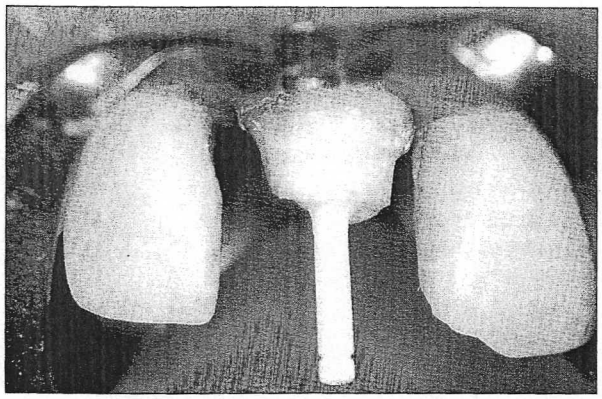

Fig 1 Æstheti-Plus quartz-fiber post cemented in a maxillary right central incisor.

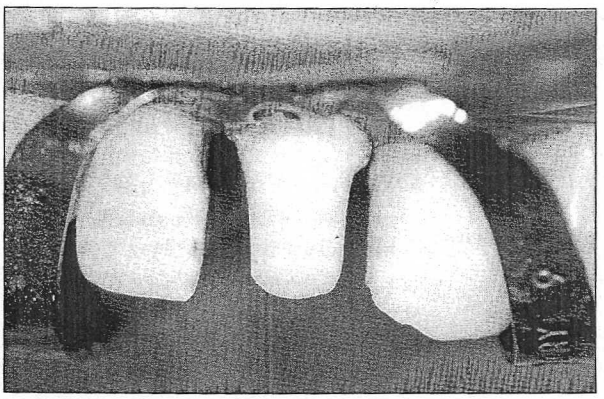

Fig 2 Completed core buildup.

According to the manufacturer, the mechanical properties of these posts are similar to those of carbon posts and provide an additional esthetic benefit. Fiber posts appear to be biocompatible, are easy to insert, and are time and cost effective. Moreover, there is no need for temporary fillings, since the post is placed using a one-stage technique. The system is conservative with regard to the remaining dental structure and offers the possibility of orthograde retreatment in cases of endodontic failure.[6]

Several in vitro studies have been conducted on carbon-fiber posts, although only a few investigations have been carried out on the esthetic quartz-fiber post system. Relatively few reports have evaluated the in vivo effectiveness of carbon- and quartz-fiber posts. A 6-year clinical study using carbon-fiber posts (Composiposts, RTD)[7] reported two failures in 575 restorations. A retrospective study[8] reported that the Composipost system performs favorably after 2 to 3 years. In fact, only 2% of treated teeth had to be extracted, and none of these failures were attributable to the fiber post system. Others[9] evidenced a 3.2% failure rate among 1,304 treated teeth restored with carbon- and quartz-fiber posts in a 6-year study. Neither of these studies reported root fractures.

The purpose of this prospective clinical follow-up was to evaluate the survival rate of 180 endodontically treated teeth restored using quartz-fiber posts and composite resin material, and finalized with metal-ceramic or all-ceramic crowns over a 30-month period.

Materials and Methods

One hundred eighty endodontically treated teeth in 132 patients (aged 18 to 65 years) were restored by 13 different operators (Table 1). Restored teeth had the following characteristics: need for prosthetic crown, root canal therapy performed at least 3 months previously with no subjective or objective symptoms, and no lesions visible upon radiography. Radiographs were taken with the long-cone technique when the restoration was performed and were examined with approximately 5× magnification.

Teeth were restored with Æstheti-Plus quartz-fiber posts (RDT) (Figs 1 and 2). This post system is composed of equally aligned quartz fibers that are longitudinally embedded in an epoxy resin matrix. Posts are available in three sizes, have a cylindric, double-section shape, and are 22 mm long. Post 1 has a diameter of 1.4 mm in the wider cylindric section and 1.0 mm at the narrow end, Post 2 has a diameter of 1.8 mm at the large end and 1.2 mm at the narrow portion, and Post 3 has diameters of 2.1 mm and 1.4 mm, respectively. This special shape is apparently better adapted to the prepared canal. The choice of three different diameters provided the possibility to find the adequate post dimension following the criteria of maximum conservation of the residual dental tissue.

In accordance with previous studies,[8,10] the following parameters were considered relevant: number of canals; remaining tooth tissue, defined as complete (C;

66% to 100% of the tooth), partial (P; 33% to 65% of the tooth), or absent (A; 0% to 32% of the tooth); shape of the canal space; and tooth antagonist. Among the 180 treated teeth, 69% presented one root canal, and 31% had two or three canals. In 14 maxillary premolars and 11 molars (four maxillary and seven mandibular ones), the restorations were done with the anchorage of two posts per tooth. Thus, among the 180 teeth restored, 205 canals were treated, and the same number of posts was used. Seventy-nine percent of the canals treated showed a round shape (R), 19% an oval one (O), and 2% a semicircular shape defined as C. Of the opposing occluding teeth, 53% were natural teeth, 19% had metal-ceramic crowns, 16% were dentures, 11% occluded with metal-resin crowns, and 1% were not in occlusion.

Clinical Procedures

Prior to cavity preparation, a rubber dam was placed, and provisional restorations were removed with 80-μm diamond burs (205, Intensiv) in a medium-speed handpiece under water cooling. Following direct clinical observation and radiographic examination, the operator selected the most suitably sized fiber post. Root preparation was done with a Pre-Forma Drill and a Forma Drill in a slow-speed handpiece with water spray. These calibrated burs provided a uniform preparation and a thin and equally distributed layer of resin surrounding the post after its cementation. The post was then reduced to the proper length using an 80-μm diamond bur (206, Intensiv) in a high-speed handpiece with water spray; the bur was kept perpendicular to the long axis of the post to avoid damaging the fiber structure and its mechanical characteristics. The length of the post was at least equal to the length of the clinical crown, always respecting the apical gutta percha seal of 4 mm.

The root canal was treated with 32% phosphoric acid (Bisco) for 15 seconds, rinsed with deionized water, and gently dried with air and a paper cone to verify that no traces of acid remained in the root preparation. Equally mixed primers A and B (Bisco) were applied with a Superfine Microbrush (Microbrush) in the canal and on the post surface and then gently dried to permit the evaporation of the acetone. Pre-Bond (Bisco) was applied inside the canal with a paper cone. Next, the two components of the self-curing C&B Resin Cement (Bisco) were mixed and applied at the edge of the root and on the post, which was immediately placed into the prepared canal. The excess cement was trimmed and given an adequate setting time (Fig 3). Core buildup was then performed using Core-Flo (Bisco) or Bis-Core (Bisco) self-curing resin composite.

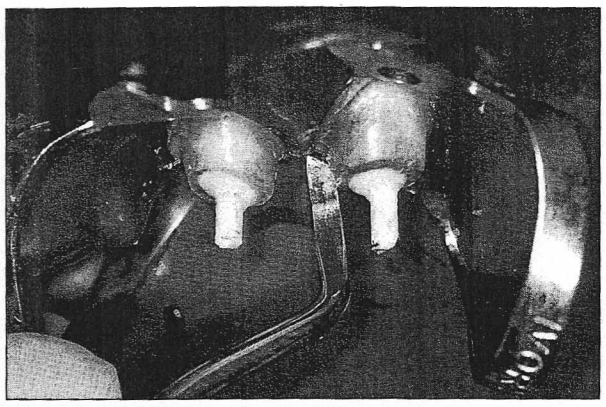

Fig 3 Trimming of the cement after insertion of posts in maxillary central incisors.

Clinical recalls were performed at 6, 12, 24, and 30 months. At the last recall, all teeth were crowned.

Three dentists evaluated the clinical performance of the restored teeth. The observers were not blinded. Outcome was considered successful if the post and core were in situ with no displacement or detachment of the post, no crown or prosthesis decementation, and no post, core, or root fracture. Subjective symptoms reported by the patients were considered potential signs of failure.

Results

After a period of 30 months, three failures were recorded; all took place during the temporary phases during removal of the resin temporary restoration. The first failure, recorded after 2 weeks in a maxillary left first premolar, was a cohesive fracture at the edge of the composite resin of the core and did not involve the post structure. The remaining dental structure was classified as P (33% to 65%), the canal shape was O, the post used had a diameter of 1.4 mm (Post 1), the length of the post was 8 mm (slightly longer than the clinical crown), and the antagonist was a natural tooth. After the fracture, the restoration was immediately replaced and the case was finalized; the post was still working successfully after 30 months.

The second and the third failures were adhesive fractures involving the cement-post-core detaching from the dentinal walls of the root canal. The failures involved two canines (one maxillary and one mandibular). Both teeth presented a rather low remaining tooth structure (A; 0% to 32%) and a very large canal diameter, probably because of excessive preparation during the endodontic therapy. Number 2 posts, which have a diameter of 1.8 mm in the upper portion, had been used; in spite of this, a thick layer of cement was around the posts. The lengths of the posts were 11 mm

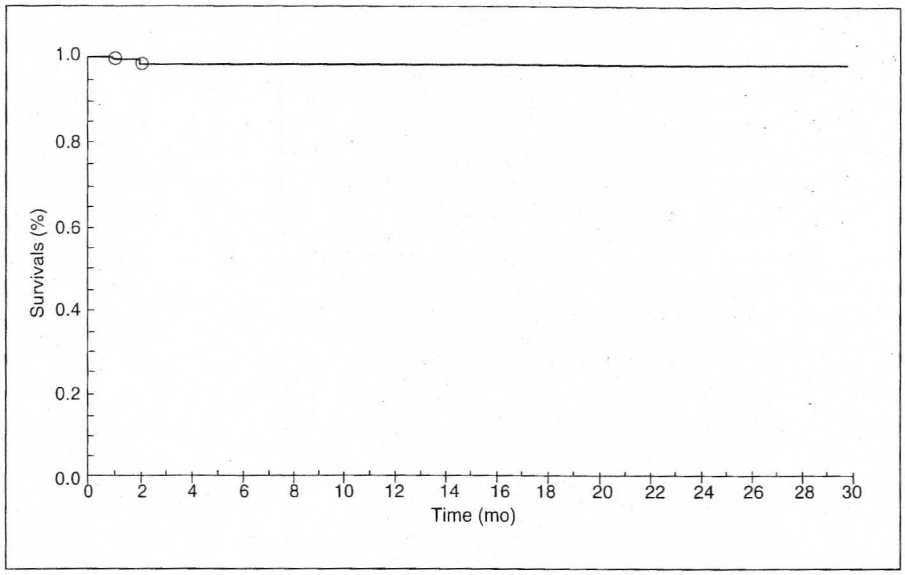

Fig 4 Kaplan-Meier survival curve for all cases.

and 9 mm, respectively. The 9-mm post was somewhat shorter than the clinical crown. Its length had been imposed by the short root and the necessity to leave an adequate seal of the apex. The antagonist was a natural tooth in one case and a ceramic crown in the other. In both cases, the post and core were replaced immediately. The cases were finalized and were still successful as of this writing.

No crown or prosthesis decementations or post, core, or root fractures were recorded. No significant variations in terms of health of periodontal tissues were observed. No caries were detected, and no subjective symptoms were reported. The three failures represented 1.7% of all treated teeth, giving a cumulative survival rate of 98.3% in a Kaplan-Meier survival curve (95% confidence interval; Fig 4).

Discussion

The implementation of a new, homogeneous post-and-core system is a good starting point for the creation of a reliable substructure for prosthetic rehabilitation. In combination with resin adhesive systems, resin cements, and composite resins, fiber posts present biomechanical characteristics similar to those of the dentin. To date, the favorable clinical outcomes observed encourage more widespread use.

In combination with the resin cement and composite resin restoration, the clinical performance of the Æstheti-Plus fiber posts was good over a 30-month period. The causes underlying the three precocious failures of the three restorations were examined in detail. In the first case, a cohesive fracture, a bubble embedded in the composite resin, was found. The defect may have been due to insufficient polymerization, possibly because of operator error. In the second and third cases, adhesive fractures between the cement and the dental tissue were found. These failures might also have been related to a procedural error by the operators or to the excess layer of cement around the post, which may have provoked a change in the mechanical behavior of the cement-post–composite resin complex (Chu MQ, personal communication, 1999). The resin cements that are supposed to provide the best adhesion[11,12] may represent a weak point in the system, mostly when a very thick and nonuniform cement layer surrounds the post. It is reasonable to further detail the mechanical procedures that the operator may perform during the temporary phases and relate these to possible failures. It should be underlined that the cases showing the adhesive failures did not have the 2-mm ferrule of dentin considered to be important to obtain a high success rate.[13]

In accordance with other clinical studies, the observed success rate of 98.3% was high and no root fractures occurred. Therefore, it was possible to replace the failing restorations.[7–9] Other desirable properties of these posts are their biocompatibility and resistance to corrosion.[14,15] Fredrikson et al[8] reported no differences in the periodontal conditions between carbon fiber–treated teeth and controls. Radiographic examination of bone height measured from the apex to the bone margin mesially and distally showed differences on the mesial side, but not on the distal surface, between the treated and control teeth.

Other in vitro studies have compared fiber posts with traditional metal posts to determine which system offers the best mechanical properties. Purton and Payne[16] compared fiber posts and stainless steel root posts by three-point bending tests to derive the transverse modulus of elasticity of the posts. The carbon-fiber material was stiffer under transverse loading than stainless steel and thus appears to have adequate rigidity for its designed purpose. This higher rigidity allows smaller diameters to be used with equivalent strength, in accordance with the conservative principles. One weak point of the system is the bond between the post and the composite core material. The authors therefore suggested that a surface treatment or modification in configuration should be introduced. Drummond[17] evaluated the pullout (shear) strength of stainless steel posts and three different fiber posts and found no significant differences. With respect to flexure strength, all fiber post systems showed a significant decrease following thermocycling, probably because of the degradation of the polymer holding the fibers together and/or the fibers themselves. The clinical relevance of this data still needs to be investigated.

Relatively few clinical studies examining the success and failure of metallic posts have been reported. Sorensen and Martinoff[18] reported an 8.6% failure rate resulting from post dislodgments, root fractures, or post perforations. Others reported a 6.5% failure rate after 10 years or more[19] and an 8.3% frequency of failure after 2 to 3 years.[20] Lewis and Smith[21] stated that failures of the post and core are more likely to occur within the first 3 years of cementation.

A retrospective study[22] evaluated the outcome of cast posts and cores and carbon-fiber posts after 4 years of clinical service. Ninety-five percent of the teeth restored with fiber posts showed clinical success, 3% were excluded, and 2% showed endodontic failure. Among the teeth restored with cast posts, 84% showed clinical success, 9% showed root fracture, 3% showed endodontic failure, 2% had dislodgment of the post or crown, and 2% were excluded. Statistical evaluation has thus indicated that carbon-fiber posts are superior to conventional cast posts. In accordance with this study, the failures recorded with fiber posts were more benign. When a vertical fracture occurs, the entire element must be extracted.

When finalized with all-ceramic crowns, the strong demand for a post-and-core complex with good esthetic results has guided both researchers and manufacturers toward the introduction of restoring systems that meet these requirements. According to a previous study, the clinical behavior of carbon-fiber posts and quartz-fiber posts is equivalent.[10]

To determine how much the post aspect will influence light transmission under the thickness of the ceramic, the following guidelines can be used.[23] With a 2-mm ceramic thickness, color differences are clinically irrelevant, while with a ceramic thickness of 1.5 mm, the color differences are clinically visible in some cases and detectable only with a spectrophotometer in others. With a ceramic thickness of less than 1.5 mm, the aspect of the post-and-core restoration influences the all-ceramic crown in a manner that may be clinically unacceptable.

The fiber post system offers a time savings, simple clinical procedures, and reliable results. Moreover, the technique is less invasive than other post systems because of the shorter length required, and thus the apical seal can be left at around 4 mm.[24,25] In cases of endodontic failures, it is possible to remove the post with the specific bur.[26]

It is obvious that the clinician must follow the manufacturer's instructions while treating the remaining dental tissues. The use of a rubber dam is imperative while performing the restoration. The combination of good mechanical performance with satisfactory esthetics may be a good starting point toward the improvement of routine dentistry and toward predicting success. We are awaiting future evaluations of these encouraging data.

Conclusions

1. Within a 30-month period, 205 Æstheti-Plus quartz-fiber posts were used to restore 180 teeth with clinical success. The three failures recorded represented 1.7% of treated teeth.
2. All three failures occurred during the temporary phases. The cohesive fracture and two adhesive fractures involved only the post-and-core restoration. No root or post fractures occurred.
3. In the case of failure, it was possible to replace the restoration.

References

1. Goodacre CJ, Spolnik KJ. The prosthodontic management of endodontically treated teeth: A literature review. Part 1: Success and failure data, treatment concepts. J Prosthodont 1994;3:243–250.
2. Trabert KC, Cooney JP. The endodontically treated tooth. Restorative concepts and techniques. Dent Clin North Am 1984;28: 923–951.
3. Morgano SM, Milot P. Clinical success of cast metal posts and cores. J Prosthet Dent 1993;70:11–16.
4. Duret B, Reynaud M, Duret F. Un nouveau concept de reconstitution corono-radiculaire: Le Composipost (1). Chir Dent France 1990;540:131–141.
5. Duret B, Reynaud M, Duret F. Un nouveau concept de reconstitution corono-radiculaire: Le Composipost (2). Chir Dent France 1990;542:69–77.
6. de Rijk WG. Removal of fiber posts from endodontically treated teeth. Am J Dent 2000;13:19b–21b.

7. Dallari A, Rovatti L. Six years of in vitro/in vivo experience with Composipost. Compendium 1996;17:57–63.
8. Fredrikson M, Astback J, Pameius M, Arvidson K. A retrospective study of 236 patients with teeth restored by carbon fiber reinforced epoxy resin posts. J Prosthet Dent 1998;80:151–157.
9. Ferrari M, Vichi A, Mannocci F, Mason PN. Retrospective study of the clinical performance of fiber posts. Am J Dent 2000;13:9b–13b.
10. Chalifoux PR. Esthetic restoration of endodontically treated teeth: Factors that affect prognosis. J Esthet Dent 1998;10:75–83.
11. Ross RS, Nicholls JI, Harrington GW. A comparison of strains generated during placement of five endodontic posts. J Endod 1991; 17:450–456.
12. Goldstein GR, Hudis SI, Weintraub DE. Comparison of four techniques for the cementation of posts. J Prosthet Dent 1986;55: 209–211.
13. Assif D, Pilo R, Marshak B. Restoring teeth following crown lengthening procedures. J Prosthet Dent 1991;65:62–64.
14. Torbjörner A, Karlsson S, Syverud M, Hensten-Pettersen A. Carbon fiber reinforced root canal posts. Mechanical and cytotoxic properties. Eur J Oral Sci 1996;104:605–611.
15. Jockisch KA, Brown SA, Bauer TW, Merritt K. Biological response to chopped-carbon-fiber-reinforced peek. J Biomed Mater Res 1992;26:133–146.
16. Purton DG, Payne JA. Comparison of carbon fiber and stainless steel root canal posts. Quintessence Int 1996;27:93–97.
17. Drummond JL. In vitro evaluation of endodontic posts. Am J Dent 2000;13:5b–8b.
18. Sorensen JA, Martinoff JF. Clinically significant factors in dowel design. J Prosthet Dent 1984;52:28–35.
19. Weine FS, Wax AH, Wenckus CS. Retrospective study of tapered, smooth post system in place for 10 years or more. J Endod 1991;17: 293–297.
20. Torbjörner A, Karlsson S, Ödman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent 1995;73:439–444.
21. Lewis R, Smith BG. A clinical survey of failed post retained crowns. Br Dent J 1988;165:95–97.
22. Ferrari M, Vichi A, García-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. Am J Dent 2000;13:15b–18b.
23. 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.
24. Goerig AC, Mueninghoff LA. Management of the endodontically treated tooth. Part I: Concept for restorative designs. J Prosthet Dent 1983;49:340–345.
25. Goerig AC, Mueninghoff LA. Management of the endodontically treated tooth. Part II: Technique. J Prosthet Dent 1983;49:491–497.
26. Sakkal S. Carbon-fiber post removal technique. Compend Contin Educ Dent Suppl 1996;(20):86S.

Literature Abstract

Evaluation of design parameters of osseointegrated dental implants using finite element analysis.

This study determined through two-dimensional finite element analysis which implant thread shape effectively distributes stress in bone as a function of different parameters, including width of the thread end, height of the thread, length of the implant, and various load directions. Five thread designs were used: plateau type, plateau with a small radius of curvature, triangular-thread screw type with 0.7 mm in screw pitch, square-thread screw with 0.9 mm in screw pitch, and square-thread screw filleted with a small radius. Implant diameter was standardized at 4 mm, and length varied between 8, 10, 12, and 15 mm. An oblique load of 15 degrees, as well as a vertical load, was applied. The jawbone used was modeled after a homogenous compact bone 20 mm in height and 16 mm in diameter. The implants were modeled on the properties of pure titanium. The highest stress concentration occurred at the region of the jawbone adjacent to the first thread of the implant for all models. The load applied at a 15-degree oblique angle produced twice as much stress with the same magnitude as the 0-degree load. Stress was best distributed with the use of a square-thread screw filleted with a small radius and when the width of the thread end and height of the thread were p/2 and 0.46p (with p being the pitch). The variations of implant length studied did not have any substantial effect on stress reduction, as the reduction plateaued after reaching a certain length. Decreasing the screw pitch gradually more effectively reduced stress.

Chun HJ, Cheong SY, Han JH, et al. *J Oral Rehabil* 2002;29:565–574. **References:** 14. **Reprints:** H. J. Chun, School of Electrical and Mechanical Engineering, Yonsei University 134, Shinchon-Dong, Seodaemun-Ku, Seoul 120-749, Korea. e-mail: hjchun@yonsie.ac.kr—*Josephine Esquivel-Upshaw, San Antonio, Texas*