# Survival Rates of Endodontically Treated Teeth Restored with Fiber-Reinforced Custom Posts and Cores: A 97-Month Study

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Purpose: This study aimed to assess the long-term survival rates of polyethylene fiber-reinforced posts and cores used in endodontically treated teeth over a 97-month period. Materials and Methods: Sixty-nine patients from a private dental office who underwent endodontic treatment with coronoradicular fiber-reinforced restorations were selected and invited for evaluation. All teeth were restored with the same high molecular weight polyethylene fiber (Ribbond, Ribbond Inc) and resin composite cement (Enforce, Dentsply) post-and-core system by a single operator and then prepared and restored with complete cast crowns or direct resin composite. Survival functions of restorations were analyzed with Kaplan-Meier and log-rank tests ($\alpha$ = .05) and displayed according to the variable tooth location and material of the final restoration. Results: Four posts fractured among the 36 anterior restorations evaluated, and 2 posts fractured among the 73 posterior restorations. The mean overall survival estimate was 90.2 (± 3.7) months (95% CI: 82.8–97.5). There were no differences between survival functions regarding tooth location or type of final restorative material as variables ($P$ > .05). Conclusions: The results suggest that polyethylene fiber-reinforced posts with composite cores may be recommended for clinical use. Restorations evaluated in this study presented high survival rates after the 97-month follow-up period. *Int J Prosthodont 2007;20:xxx–xxx.*

In recent decades, metal posts have been widely used to restore endodontically treated teeth because of their good physical properties.[1–3] However, new developments in resin technology and patient demands for tooth-colored restorations led to an increased use of esthetic materials. These new materials and techniques enable the practitioner to approach old problems with a new perspective and achieve novel solutions.[4]

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Motivated by the desire to conserve the remaining sound tooth structure, fiber-reinforced post systems have become popular, especially because enlargement of the root canal space is not required and the risk of root perforation is eliminated.[5,6] Further, biomechanical properties similar to those of dentin are an alluring advantage of fiber-reinforced posts. Fiber posts are the only available material with this property.[7] The advantages of using intracanal fiber reinforcement include resin composite crown reinforcement, translucency, and relative manipulation facility. In addition, indirect resin composite crowns provide good shape and esthetics as well as reduced operative time.[8]

The use of endodontic posts that can be bonded to both dentin and core material may improve the distribution of forces along tooth roots, thereby contributing to the tooth-restoration reinforcement.[9] Moreover, because light transmission is impeded by metallic posts, the use of tooth-colored post-and-core systems is advocated to allow light transmission through the post structure.[10,11]

Two different types of fiber-reinforced composites are advocated for use as post-and-core systems: prefabricated posts and customized posts.[9] Customized post-and-core buildups commonly involve the use of glass or polyethylene fibers, which are luted directly into the root canal.[9,12]

Many abutment teeth planned for fixed prosthodontic treatment in dental practice require post-and-core buildups because of extensive structural defects resulting from caries, trauma, or prior restoration.[13,14] In most situations, severely compromised teeth are permanently restored with complete-coverage crowns to restore function and esthetics. The amount of remaining tooth structure dictates the type of core buildup that can be used in pulpless teeth. However, their ability to resist masticatory forces and remain seated in the tooth is critical to the survival of a restoration,[15] since endodontically treated teeth are known to present a higher risk of biomechanical failure than vital teeth,[1,16] mainly because of the lack of tooth structure.

Fiber-reinforced resin composite is an alternative option if esthetic qualities are required for the post system, with single-appointment direct build-up cores being the most popular.[17]

Therefore, this study was conducted with the aim of evaluating the survival rate of endodontically treated teeth restored with adhesively bonded polyethylene fiber-reinforced composite posts and direct composite restorative materials.

## Materials and Methods

### *Patient Selection*

For this study, the case reports of 69 adult patients from a private dental office were studied. Patients were selected and invited for evaluation via phone calls and letters based on the following inclusion criteria: *(1)* complete dentition and normal occlusion, verified by clinical and radiographic evaluations in continuous clinical follow-up visits (at least 1 annual recall); and *(2)* at least 1 endodontically treated tooth restored with a fiber-reinforced post and core between 1994 and 2000 using a resin composite core buildup (Z-250, 3M ESPE) and either direct restoration with compact-filled ultrafine resin composite (Z250 or P60, 3M ESPE) or ceramic-fused-to-metal or all-ceramic crowns as the final restorations.

Of the 78 patients selected, 69 patients agreed to participate and signed written informed consent prior to commencement of the clinical evaluation. Nine patients fulfilled the inclusion criteria but could not be evaluated (4 patients declined the invitation without further explanation and 5 patients could not be found at the time of evaluation). The present study was approved by the local ethics committee.

### *Restorative Procedures*

One operator placed all 109 post-and-core restorations. Before starting the endodontic procedures, the tooth was isolated via rubber dam. After selection of appropriate drill size (Peeso, Dentsply Maillefer), post spaces were prepared for a length of 7 to 10 mm depending on the tooth. At least 5 mm of gutta-percha was left apically to seal the root apex. After conventional etching with 35% phosphoric acid (3M ESPE), rinsing, and drying, the root canal spaces were treated with a primer and coated with a dual-cure bonding agent (Scotchbond Multipurpose Plus, 3M ESPE). A 2-mm-wide ultrahigh molecular weight polyethylene (UHMWPE) fiber (Ribbond, Ribbond Inc) was chosen, and the fiber lengths were determined as follows: the depth of each post space (8 mm) was doubled, and 16 to 20 mm was then added to the measured length. After coating the ribbon pieces with bonding agent and blotting the excess, the ribbons were folded in a V-shape and the inside of V's were coated with a dual-cure resin (Enforce, Caulk/Dentsply). The first piece of ribbon was placed in the post space in a facial-lingual orientation. A second V of ribbon was then placed into the first V at a right angle. The ribbons were condensed and a small drop of dual-cure resin injected from a Centrix syringe and needle tube (Shelton) was then placed between the ribbon ears, protruding from the root. This was then shaped into a post and polymerized for 40 seconds with a light-curing unit operating at 600 mW $cm^{-2}$ (Demetron LC, Kerr). Finally, to finish the core buildup, a resin composite (Z-250, 3M ESPE) was used. Finishing and polishing of the cores were carried out immediately after restoration with nos. 2135 and 4138 fine diamond burs (KG Sorensen) and multilaminated carbide burs (no. H375R-023, Komet).

The abutments were provisionalized with acrylic resin crowns cemented with eugenol-free cement (TempBond NE, Dentsply). All teeth received ceramic-fused-to-metal crowns, all-ceramic crowns, or direct restoration with resin composite as the final restorations. For the direct restorations, all enamel and cavosurface margins were acid-etched and coated with a bonding agent (Single-Bond, 3M ESPE). Bonding agent was placed according to the manufacturer's instructions. The composites Filtek Z-250 (to replace dentin; Cosmedent) and Renamel Micro (to replace enamel in anterior teeth; Cosmedent) were placed and light cured using an incremental technique. Cervical overhangs were removed with a no. 12 scalpel blade and plastic finishing strips (3M ESPE). Proximal margins were finished with Sof-Lex XT disks (3M ESPE). The occlusal surfaces were finished with fine diamond finishing burs (KG Sorensen) and multilaminated carbide burs (Jet Burs), and polished with aluminum oxide points

**Table 1** Summary of Data Processing and Cases Included in the Study for Anterior Teeth

| Tooth group | No. | No. of failures | Time of failure (mo) | Cause of failure | Censored | |
|---|---|---|---|---|---|---|
| | | | | | No. | % |
| Mandibular incisors | 1 | 0 | – | – | 1 | 100.0 |
| Maxillary incisors | 25 | 3 | 15, 16, 37 | Post fracture | 22 | 88.0 |
| All incisors | 26 | 3 | – | – | 23 | 88.5 |
| Mandibular canines | 1 | 0 | – | – | 1 | 100.0 |
| Maxillary canines | 9 | 1 | 43 | Post fracture | 8 | 88.9 |
| All canines | 10 | 1 | – | – | 9 | 90 |
| Overall | 36 | 4 | – | – | 32 | 88.9 |

**Table 2** Summary of Data Processing and Cases Included in the Study for Posterior Teeth

| Tooth group | No. | No. of failures | Time of failure (mo) | Cause of failure | Censored | |
|---|---|---|---|---|---|---|
| | | | | | No. | % |
| Mandibular molars | 24 | 0 | – | – | 24 | 100.0 |
| Maxillary molars | 18 | 1 | 63 | Post fracture | 17 | 94.4 |
| All molars | 43 | 1 | – | – | 42 | 97.7 |
| Mandibular premolars | 15 | 1 | 5 | Post dislodgement | 14 | 93.3 |
| Maxillary premolars | 16 | 0 | – | – | 16 | 100.0 |
| All premolars | 30 | 1 | – | – | 29 | 96.7 |
| Overall | 73 | 2 | – | – | 71 | 97.3 |

(Flexicups, Cosmedent) and a silicone brush (Jiffy Composite Polishing Brush, Ultradent) with a polishing paste (SS White). If necessary, abrasive finishing strips (3M ESPE) were used in the interproximal surfaces.

The teeth that received crowns were prepared to create a standardized angle of convergence of 20 degrees. This degree of convergence was selected because it has been a common clinical finding[18] and a lower angle of draw may increase the retention resistance to crown removal regardless of the type of cement,[19,20] since it has been shown that retention increases exponentially as the taper decreases from 10 degrees.[19] Additionally, regarding the amount of remaining tooth structure, teeth with at least 2 mm or more of remaining coronal dentin were included in this study. The ferrule design in this study was a minimum of a 1.5-mm-wide ferrule preparation and parallel dentin walls, totally encircling the tooth. Resin composite cement (Enforce, Caulk/Dentsply) was used for crown cementation following the manufacturer's recommendations.

### *Assessment and Statistical Procedures*

Patients were annually recalled for control examinations at which clinical aspects were evaluated and radiographs were taken when necessary. At the last patient recall, the status of the post-and-core restoration was recorded with the respective longevity in months. If failures occurred, they were also recorded with the respective time of failure. The possible failure causes were post and/or core fracture, post and/or core partial or total debonding, restoration mobility, and any clinical adverse symptom (ie, pain, abscess, mobility). If failures occurred, immediate replacement or repair was offered to the patients. The survival data from the post-and-core restorations, grouped on the basis of the variable tooth location (anterior vs posterior) or type of final restorative material (ceramic crown, ceramic-fused-to-metal crown, or direct resin composite restoration) were displayed as survival functions and analyzed using the Kaplan-Meier method.[21,22] Comparison between survival curves was determined with the log-rank test.

## Results

Sixty-nine patients agreed to participate in the study (78.3% female and 21.7% male). The distribution of post-and-core restorations evaluated and the number of failures recorded is shown grouped by tooth location in Tables 1 and 2 and grouped by type of final restoration in Table 3. From a total of 36 anterior restorations evaluated, 3 failures were recorded at maxillary incisors and 1 failure at a maxillary canine. In the 76 posterior teeth, 1 maxillary molar and 1 mandibular premolar failed during the observation period. Dental caries were not detected any teeth treated with posts.

**Table 3** Summary of Data Processing and Cases Included in the Study According to Material for Final Restoration

| Material | No. | No. of failures | Time of failure (mo) | Cause of failure | Censored No. | Censored % |
|---|---|---|---|---|---|---|
| Anterior teeth | | | | | | |
| Metal-ceramic | 11 | 2 | 37, 43 | Post fracture | 9 | 81.8 |
| All-Ceramic | 9 | 1 | 16 | Post fracture | 8 | 88.9 |
| Resin composite | 16 | 1 | 15 | Post fracture | 15 | 93.8 |
| Overall anterior | 36 | 4 | – | – | 32 | 88.9 |
| Posterior teeth | | | | | | |
| Metal-ceramic | 18 | 0 | – | – | 18 | 100.0 |
| All-Ceramic | 30 | 2 | 5, 63 | Post dislodgement; Post fracture | 28 | 93.3 |
| Resin composite | 26 | 0 | – | – | 26 | 100.0 |
| Overall posterior | 74 | 2 | – | – | 72 | 97.3 |
| Overall | 109 | 6 | | | 103 | 94.5 |

**Table 4** Survival Probability Estimated at 97 Months for Custom Post-and-core Restorations According to Tooth Type

| Tooth group | Estimate | Mean* SE | 95% CI |
|---|---|---|---|
| Incisors | 87.54 | 4.64 | 78.44–96.64 |
| Canines | 92.50 | 5.22 | 82.27–102.73 |
| Premolars | 94.90 | 3.03 | 88.93–100.87 |
| Molars | 97.03 | 0.96 | 95.15–98.91 |
| Overall | 90.19 | 3.74 | 82.86–97.53 |

*Estimation is limited to the largest survival time if censored (ie, no failure recording for the group).

All failures recorded (post fractures or dislodgement of the crown/post) were considered as complete failures and replaced immediately. None of the teeth evaluated exhibited failure related to the final restorative material (crowns or direct restorations). Kaplan-Meier overall mean estimated survival probability at 97 months was 90.2% (Table 4). The log-rank test showed no differences between survival functions regarding tooth group, tooth location, or type of final restorative material as variables ($P > .05$) (Figs 1 to 6).

## Discussion

The present longitudinal clinical study was designed to evaluate the performance of polyethylene fiber-reinforced posts used in endodontically treated teeth. The study design allowed the assessment of clinical outcomes of these restorations placed in general practice. If a large amount of tooth structure has been removed as a result of endodontic therapy, decay, and resulting preparation for restorative procedures, the teeth are structurally compromised. Under these circumstances, buildup with a post and core in combination with a crown becomes necessary.

In the present study, 3 types of final complete-crown coverage were evaluated. No differences were observed among resin composite, all-ceramic, and ceramic-fused-to-metal reconstructions. These data are in agreement with those of Fredriksson et al[23] and Mannocci et al,[24] who also found no differences between composite and metal-ceramic restored teeth. However, long-term evaluations are necessary to further assess the efficiency of direct composite restorations compared to full-coverage crowns.

Even though single crowns in posterior teeth have shown a relatively high survival rate compared with other tooth types and locations,[25] in the present study no differences between tooth groups (anterior and posterior) were found, which corroborates the 5-year results of Creugers et al.[7]

Clinical trials evaluating post-and-core systems report survival rates varying from 98.6% after a 10-year follow-up to 77.6% after a 5.2-year follow-up.[25,26] A retrospective study in which 516 teeth restored with a cast post-and-core buildup were followed from 1970 to 1990 found survival rates of 82% after 10 years for posts and cores in the anterior region.[25] Similarly, in the present study, the mean survival was 90.2% after the follow-up period for teeth restored with fiber-reinforced post-and-core buildups.

Torbjorner et al[27] studied the survival rates and failure characteristics of 2 prefabricated post designs and reported a cumulative failure rate of 15% for tapered posts and 8% for 332 parallel-sided posts, with a significantly higher success rate for parallel-sided posts. Loss of retention was the most frequent reason for failure for both types of posts, whereas root fractures had the most serious consequences, and all resulted in extraction. Kern et al[28] followed 80 endodontically treated teeth restored with zirconia posts over an average period of 16 months and reported a 100% survival rate. In a retrospective study with teeth restored by carbon

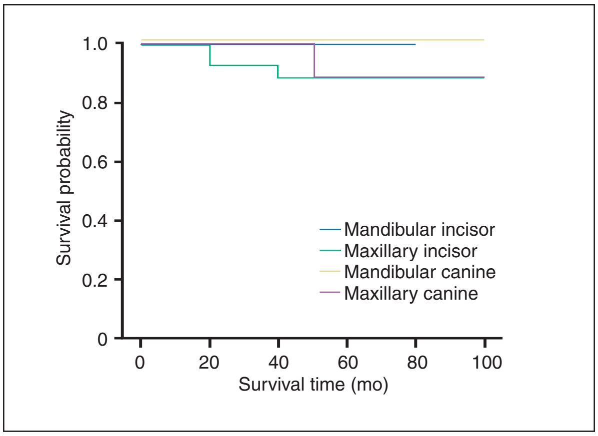


Fig 1 Survival functions for anterior teeth restored with fiber-reinforced post and core. Differences among curves were not statistically significant (log-rank test; $P = .967$).

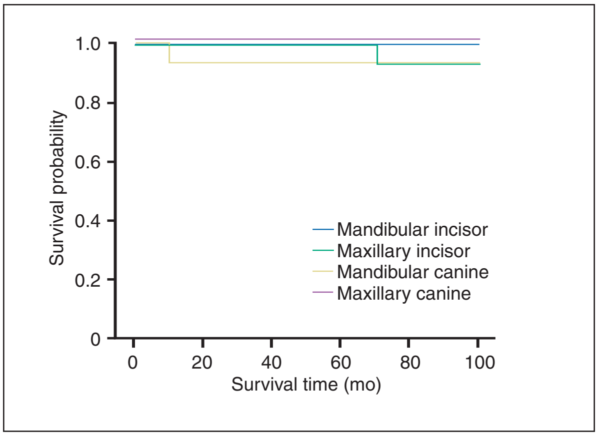


Fig 2 Survival functions for posterior teeth restored with fiber-reinforced post and core. Differences among curves were not statistically significant (log-rank test; $P = .504$).

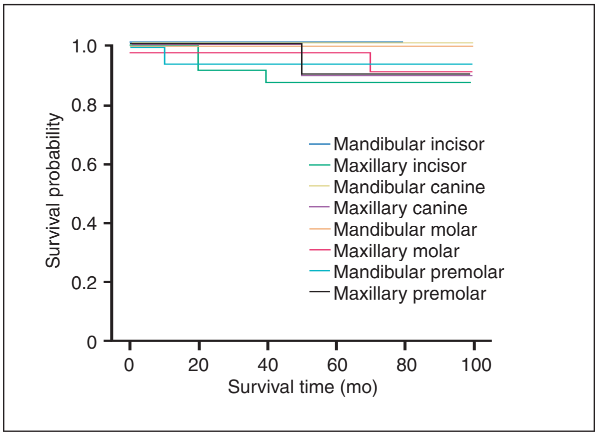


Fig 3 Survival functions for grouped teeth restored with fiber-reinforced post and core. Differences among curves were not statistically significant (log-rank test; $P = .680$).

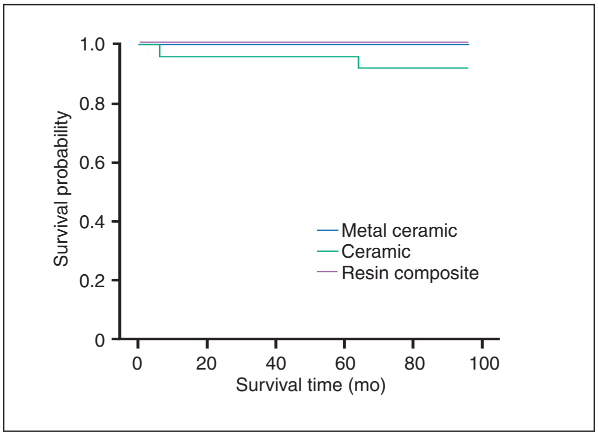


Fig 4 Survival functions of posterior teeth restored with fiber-reinforced post and core according to the final restorative material. Differences among curves were not statistically significant (log-rank test; $P = .208$).

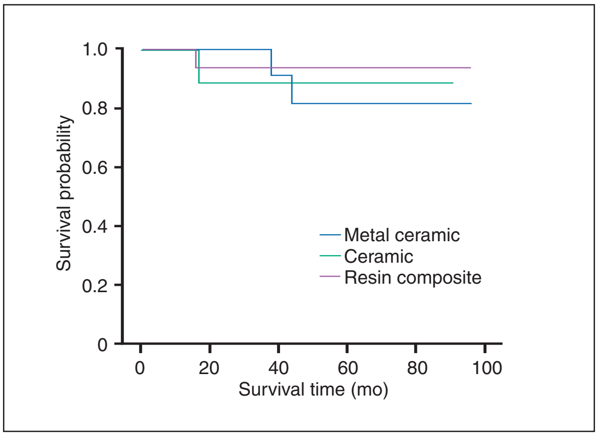


Fig 5 Survival functions of anterior teeth restored with fiber-reinforced post and core according to the final restorative material. Differences among curves were not statistically significant (log-rank test; $P = .674$).

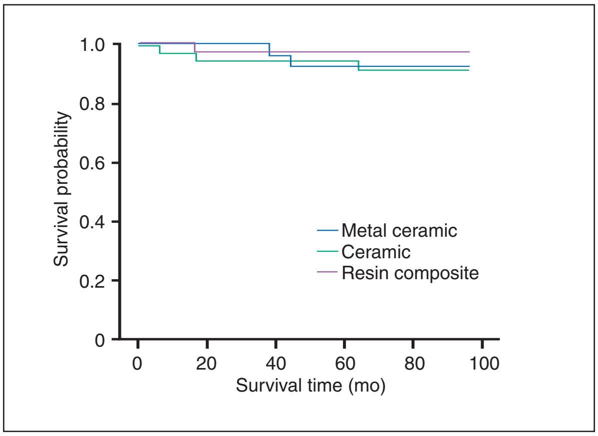


Fig 6 Survival functions for grouped teeth restored with fiber-reinforced post and core according to the final restorative material. Differences among curves were not statistically significant (log-rank test; $P = .512$).

fiber-reinforced epoxy resin posts with ceramic restorations (80%), ceramic crowns (10%), and resin omposite restorations (10%) as the final restorations, Fredriksson et al[23] reported that 98% of the teeth survived after a period of 2.3 to 3.4 years. The same trend was reported by Malferrari et al,[29] with a 98.3% cumulative survival rate after 2.5 years and failures related to cohesive fractures. Naumann et al,[30] however, showed a rising failure of glass fiber–reinforced post restorations from 3.8% after 12 months to 12.8% after 24 months. Possible reasons for this result include the absence of standardized assessments, limitations of the clinical studies, and variations in materials and techniques.[31]

Ferrari et al[32] reported a 3.2% failure rate in a retrospective study of the clinical performance of 3 fiber posts after a period clinical service ranging from 1 to 6 years. Failures were the result of post debonding or periapical lesions. These findings partially corroborate the results found in the present study, with a high survival rate and the reason for failure mainly related to debonding of the post.

Reasons for root canal–treated tooth extractions include periodontal disease, caries, coronal and root fractures, prosthetic complications, and endodontic failures.[33] The failure cause present in this study was post and/or core fractures or dislodgement, and the failures did not compromise the remaining dental structure, allowing retreatment with a new post-and-core construction with the same material and technique. These failures could be associated to some adhesion/cohesion defect inserted within the composite-reinforced structure during clinical sessions, but further reasons for failure could not be studied in general clinical settings.

Even though the idea of strengthening weakened teeth with post-and-core restorations was already under doubt in the 1980s,[34] these restorations are still carried out to increase the strength of a tooth. However, in vitro studies have shown that the space prepared to receive the post weakens the tooth and does not reinforce it.[35–39] Still, Sorensen and Martinoff[1] showed that posts do not strengthen teeth, and post-and-core restorations may result in root fractures or perforations, post fractures, and post dislodgement. This led to the opinion that a post is not always necessary to support its core.[7] Furthermore, preservation of tooth structure protects against fractures under occlusal loads, which improves clinical survival. Indeed, dentin provides the solid base required for the retention and support of tooth restorations.[40–43] The use of fiber reinforcement not only offers suitable properties, it also preserves tooth structure, ultimately preserving the teeth.

Restoration with adhesive techniques allows preservation of the maximum amount of sound tooth structure.[24] Some studies show that bonded composite restorations strengthen a tooth compared to amalgam,[36,44,45] and that restorations with fiber posts and composite were more effective than amalgam in preventing root fractures.[46] The advantages of bonding agents are the absence of wedging effects and less dentin removal because posts can be shorter and thinner, thus showing lower fracture susceptibility.[47]

The addition of a leno-woven ultrahigh molecular weight polyethylene fiber in a composite structure may provide an increase in fracture strength, based on the concept that the presence of glass or polyethylene network creates a change in the stress dynamics at the restoration/adhesive resin interface.[4] Further, fracture propagation within composite structures may be impaired by fiber reinforcement. The modulus of elasticity and flexural modulus of the polyethylene fiber may have a modifying effect on how the interfacial stresses are developed along the restoration-tooth interface.[48]

## Conclusions

Fiber-reinforced posts with composite cores offer several advantages: *(1)* reduction in the removal of sound dental structure, *(2)* bonding capacity (preventing microleakage), *(3)* good esthetics, *(4)* low cost in relation to indirect restorations, and *(5)* good performance in clinical trials. The results of this study concur with previous findings, showing good clinical results of coronoradicular polyethylene fiber-reinforced restorations; therefore, these restorations may be recommended for clinical use.

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