Restoration of Endodontically Treated Premolars and Molars: A Review of Rationales and Techniques

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Abstract
Restorations of endodontically treated premolars and molars can be very different from restorations of anterior teeth. The complex root canal anatomies, limited interocclusal spaces and occlusal loads involved make premolar and molar restorations more challenging than those for anterior teeth. This article discusses the rationales and techniques of post/core fabrication, and a novel application of bonded ceramic restoration for posterior teeth.

Keywords: post and core, fracture strength, endodontically treated teeth, resin cement

Introduction
There are a variety of post and core related research studies in the literature discussing the effect of ferrule length, post type, length and diameter. However, the sample or study models used in those studies often had a single root and straight canal. As such, information about the curved canals or multiple canals of premolars and molars is very limited. The complex root canal anatomies of posterior teeth, as well as the intensities and directions of the occlusal loads affecting them, make it difficult to utilize the same rules as are used for anterior teeth when fabricating posts and cores for posterior teeth restorations. Nevertheless, endodontic sealers, irrigants, intracanal medications, the grease of temporary cements and fit checkers have been found to negatively affect the bond between resin cement and root dentin surface. As such, it has been recommended that clinicians pretreat root dentin surfaces before post cementation to enhance the longevity of resin-dentin bonds. This article will review the studies concerning post-core foundations for premolars and molars and the effects of root dentin treatment before post cementation.

The Complex Root Canal Anatomies of Posterior Teeth
The most common problems affecting the restoration of endodontically treated posterior teeth are as follows:

a. Multiple root canals with curvature
b. Intensity and direction of occlusal loading force
c. Limited interocclusal space
d. Accessibility
e. Difficulty in moisture control
f. Retention and resistance form
g. Tilting, supraeruption or crossbite
h. Occlusal interference

These specific factors in posterior areas can potentially negate the prognosis of the post and core. Thus, teeth with multiple root canals require a different treatment approach.

To build up an appropriate protocol for posterior teeth, there are many questions that need be answered:
1. Does root canal treatment alone weaken the fracture resistance of posterior teeth?
2. Does an endodontically treated tooth need a crown or onlay?
3. Do the post and core reinforce the tooth structure?
4. Can adhesive techniques influence fracture resistance?
5. What types of post materials make a difference?
6. What factors affect the cement-post interface?
7. Should pre-cementation surface treatment be applied to root canal dentin?
8. Should the same rules used for the post length for anterior teeth be applied for posterior teeth?
9. Should the post/core always be retrieved and the root canal retreated before remaking the crown?
10. What are the survival rates and prognoses for posterior posts and cores?

The removal of an old crown or fixed partial denture does not always validate the removal of an old post and core. There are indications for keeping the existing post and core foundation. First, the past root canal treatment must remain asymptomatic and imperviously sealed. One clinical investigation showed that a previous treatment that remained asymptomatic for more than 4 years did not require retreatment. Moreover, the previous fixed prostheses were stable without signs of loosening or marginal caries and prevented the core material from immersing in saliva. And most importantly, the post length and core morphology were appropriate and could provide retention/resistance form for fixed prostheses. However, in a case in which any of the aforementioned characteristics is uncertain, removal of the existing post/core is indicated.

On the other hand, there are risks in post and core retrieval: loss of sound tooth structure, vertical root fracture, coronal leakage of the root canal filling and breakage of the post. As such, the patient should be carefully informed of these risks before commencing the procedure.

Premolars

The root canals of the maxillary premolars are relatively small and short compared with those of maxillary anterior teeth. More than two-thirds of maxillary first premolars and approximately half of maxillary second premolars have two canals. However, there is limited information provided in the literature about post and core foundations for teeth with more than one canal. The following discussion will review the classic studies and their clinical relevance in root canal treated (RCT) premolar restorations.

Post Length Determination

In a review, Goodacre\textsuperscript{2} listed a number of opinions from earlier studies regarding what length the post should be, although some are in conflict with each other:

a. Equal to the clinical crown (Harper et al\textsuperscript{5} 1976; Mondelli et al\textsuperscript{6} 1971; Rosenberg\textsuperscript{7} 1971)
b. Longer than the crown (Silverstein\textsuperscript{8} 1964)
c. Equal to 1 1/3 of the crown length (Doolley\textsuperscript{9} 1967)
d. 1/2 of the root length (Jacoby\textsuperscript{10} 1976; Baraban\textsuperscript{11} 1967)
e. 2/3 of the root length (Dewhirst\textsuperscript{12} 1969; Hamilton\textsuperscript{13} 1959; Larato\textsuperscript{14} 1966; Christie\textsuperscript{15} 1967; Bartlett\textsuperscript{16} 1968)
f. 4/5 of the root length (Burnell\textsuperscript{17} 1964)
g. Terminated halfway between crestal bone and apex (Perel\textsuperscript{18} 1972; Stern\textsuperscript{19} 1973)
h. 4-5 mm of gutta-percha to ensure apical seal (Goodacre\textsuperscript{2} 1995)
Potential complications are as follows:

a. Straightening/stripping of the curve canals
b. Over-enlargement
c. Loss of apical seal
d. Coronal microleakage
e. Perforation or weakening of the root canal wall
f. Debris/bacteria trapped at the end of the post
g. The edge of the core interferes with the fit of the crown margin to the tooth structure

Therefore, following the previously mentioned rules to create a long post space in these cases could jeopardize the strength and integrity of the canal system. In the worst situation, the post compromised the prognosis by causing root fracture and apical pathosis. Some clinicians try to place a very short post or screw post with active engagement force into root dentin. These approaches may lead to catastrophic failure of restorations, microleakage, caries or root/furcation damage to posterior teeth. A proper post length and the appropriate type of post/core material to use may vary from one patient to another. One must evaluate all potential risk factors in each individual.

Generally, a straight post can only extend to the start of the root canal curvature. Otherwise, it could weaken the root strength. For premolars and molars, pulp chamber space becomes important for assisting the retention of core material. The use of resin or ceramic core bonded to the residual dentin wall can further reinforce the retention.

Fracture Resistance

Various researchers have previously investigated the change of dentin strength after root canal treatment. Gutmann (1992) concluded that the three major factors identified in the past research as contributing to tooth structure weakening are as follows: (1) the loss of approximately 9% of moisture; (2) decreased dentin strength; (3) changes in collagen cross-linking.

However, there was no scientific assessment of the accuracy of these changes. At present, architectural changes and the loss of structure integrity are considered the major factors affecting the fracture resistance of endodontically treated teeth.

Reeh (1989) pointed out endodontic procedures reduced stiffness by only 5%, whereas MOD cavity preparation reduced it...
lost at a rate 6.0 times greater than those that were crowned. Scotti et al (2013) evaluated the influence of adhesive techniques on fracture resistance. In specimens with a cavity wall thickness >2 mm, direct intracuspal composite resin restorations supported by a fiber post achieved comparable fracture resistance with that of unprepared teeth. With a residual wall thickness of less than 2 mm, only cuspal coverage with or without a fiber post provided satisfactory fracture resistance.

The remaining wall thickness could be an important clinical parameter in deciding how to restore endodontically treated premolar teeth.

Post Selection

There are three major types of posts, each consisting of different materials:
- Metal posts consisting of casting alloy or stainless steel
- Fiber posts consisting of carbon fiber, glass fiber or quartz fiber reinforced with resin composite
- Ceramic posts consisting of zirconia

Metal posts, including casting or prefabricated posts, have a long history of success. Their high mechanical strength and rigidity can withstand occlusal loads and maintain retention and stability in the root canal. However, the modulus of elasticity for such posts is significantly higher than that of dentin and so this type of post transfers stress along the root and may cause vertical fractures.

In contrast, the elastic modulus and mechanical properties of fiber posts are similar to those of dentin. Some authors claim that the assembly of a fiber post and resin core bonded to remaining tooth structure can form a "monoblock." It is believed that a monoblock provides functional integrity in occlusion. The occlusal stress can be homogeneously distributed inside the restoration and RCT teeth. However, the modulus of elasticity for such posts is significantly higher than that of dentin and so this type of post transfers stress along the root and may cause vertical fractures.

There is convincing evidence that cuspal coverage increases the survival of posterior teeth (Schwartz & Robbins, 2004). Endodontically treated molar teeth should receive cuspal coverage, but in most cases, do not require a post. Unless the destruction of the coronal tooth structure is extensive, the pulp chamber and canals provide adequate retention for a core buildup.

Molars must resist primarily vertical forces. In those molars that do require a post, the post should be placed in the largest, straightest canal, which is the palatal canal in the maxillary molars and a distal canal in the mandibular molars. Rarely, if ever, is more than one post required in a molar.

Aquilino and Caplan (2002) studied factors affecting RCT teeth survival and found that, controlling for tooth type and caries, teeth which were not crowned after RCT were
Review Article

Post Cementation

Post retention is a critical factor in the prognosis of fixed prostheses. Except for mechanical retention provided by the post length and shape, the use of resin cement bonding to the post and to the root dentin has been advocated to enhance the chemical and micro-interlocking retention (Fig. 3). It seems the resin matrix of fiber posts can optimally bond to resin cement without any adhesive or pretreatment. However, some types of fiber posts have an epoxy resin matrix (e.g., RelyX post, 3M ESPE), and do not chemically bond with the methacrylic bases of most resin cements. Others have a highly polymerized and cross-linked dimethacrylate matrix which may not retain much functional double bond residue (e.g., FRC-Plus post, Ivoclar-Vivadent). There are several ways to increase the shear bond strength between resin cement and a fiber post. One of them is blasting the fiber post with a Cojet system (3M ESPE) to roughen the surface so that the embedded ceramic layer enables silane coupling with the resin composite for a true chemical bond.

Self-etching resin cements and self-adhesive cements have been advocated in post cementation recently for their excellent strength and clinical convenience. Self-adhesive cements eliminate the procedure of etching and bonding adhesive application. Phosphate monomers and silane coupling agents are added in the cement base to enhance the bond strength to the root dentin, ceramic or metal substrate. Two of the most commonly added phosphate monomers in the primer or cement base are 10-methacryloxydecyl dihydrogen phosphate (10-MDP) and 6-methacryloyloxyhexyl phosphonoacetate (6-MHPA) (Fig. 4, 5). The phosphate group bonds to metal oxide, zirconia, alumina and porcelain glass matrixes (Table 1).

It has been reported that the quality of the resin-dentin bond may not be homogeneous along all portions of the root canal. Pereira et al.29 (2013) tested the push-out bond strength of different luting agents used to cement fiber posts. The roots were sectioned to upper, middle and lower segments. Dual-polymerizing resin cements provided significantly lower mean bond strength compared to self-adhesive cements and glass ionomer cements. Dual-
Table 1: A list of commercial resin cements with phosphate groups

<table>
<thead>
<tr>
<th>Primer</th>
<th>Self-adhesive Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal / Zirconia Primer (Ivoclar Vivadent)</td>
<td>Panavia 21 (Kuraray)</td>
</tr>
<tr>
<td>Monobond Plus (Ivoclar Vivadent)</td>
<td>BisCem (Bisco)</td>
</tr>
<tr>
<td>Clearfil Ceramic Primer (Kuraray)</td>
<td>G-Cem (GC)</td>
</tr>
<tr>
<td>Signum Zirconia Bond (Heraeus)</td>
<td>Clearfil SA Cement (Kuraray)</td>
</tr>
<tr>
<td>AZ Primer (Shofu)</td>
<td>RelyX Unicem/U-100/U-200/Ultimate (3M ESPE)</td>
</tr>
<tr>
<td>ZPrime Plus (Bisco)</td>
<td>MaxCem (Kerr)</td>
</tr>
<tr>
<td>Alloy Primer (Kuraray)</td>
<td>Single Bond Universal (3M)</td>
</tr>
</tbody>
</table>
| Estenia Opaque Primer (Kuraray) | |}

Phosphate monomers

- **10 - Methacryloxydecyl Dihydrogen Phosphate (10-MDP)**

\[
\begin{align*}
&\text{O} \\
&\text{O} \\
&\text{HO-P-OH} \\
\end{align*}
\]

- **6 - Methacryloyloxyhexyhexyl Phosphonoacetate (6-MHPA)**

\[
\begin{align*}
&\text{O} \\
&\text{O} \\
&\text{O} \\
&\text{P-OH} \\
\end{align*}
\]

Fig. 4: Two of the most commonly used phosphate monomers in adhesive systems: 10-MDP and 6-MHPA.

Phosphate monomers

- The phosphate group bonds to metal oxides
  - ZrO, Al₂O₃, Ni-Cr alloy

\[
\begin{align*}
&\text{H₂C} \\
&\text{O} \\
&\text{O} \\
&\text{O-\text{(CH₂)}ₙ-\text{O-P-OH}} \\
&\text{O-\text{(CH₂)}₂-\text{O-H-\text{O-M}}-\text{-\text{O-M}}} \\
&\text{R-\text{(CH₂)}ₙ-O-P-O-M} \\
&\text{CH₂} \\
&\text{CH₂} \\
&\text{R-\text{(CH₂)}ₙ-O-P-O-M} \\
\end{align*}
\]

Fig. 5: Phosphate group bonds to metal oxide or ceramic oxide.
Sikko Tim (16.5 ± 1.7) was the most effective surface treatment agent compared with EDTA (4.1 ± 0.8), orthophosphoric acid (12.2 ± 1.8), citric acid (12.1 ± 2.4), and a control (3.9 ± 1.7); however, it could not remove the smear layer and sealer remnants effectively on radicular dentin surfaces (Fig. 6). The researchers concluded that removal of the smear layer and opening of dentinal tubules are not recommended when a self-etching/self-priming adhesive system is used. For a self-etching system, the additional application of phosphate or citric acid on root dentin was found to decrease the bond strength in this study.

Another study evaluated the effect of traditional irrigants on the bond strength of self-adhesive cement. Snowlight glass fiber posts were luted with self-adhesive resin cement (Clearfil SA Cement, Kuraray Medical Inc., Japan). The push-out bond strengths of pretreatment with phosphate (6.96 ± 2.44 MPa) and diode laser (8.93 ± 1.81 MPa) were significantly higher than those of pretreatment with sodium hypochlorite (3.00 ± 1.53 MPa) or EDTA (4.45 ± 0.92 MPa). Di Hipolito et al (2012) pointed out that the microtensile bond strengths of self-adhesive luting cements (RelyX U100, 3M ESPE; Multilink Sprint, Ivoclar Vivadent) to dentin pre-treated with 2.0% and 0.2% concentrations of chlorhexidine (CHX) solutions were significantly lower than those found for both of the control groups in their study. Pre-treatment of dentin with 0.2% or 2.0% CHX adversely

The dentin surface in the root canal is often smeared by canal sealer, gutta-percha, temporary cement, and the grease of an impression material or fit checker. It seems reasonable that phosphate etching and sodium hypochloride or chlorhexidine irrigation can be helpful to remove contamination and any smear layer before post cementation. However, some investigations have demonstrated that pretreatment with etching or irrigation may negatively influence the resin cement bond efficacy.

Demiryürek et al (2009) evaluated the push-out bond strength (MPa) of fiber posts to root dentin after four surface treatments. Sikko Tim (16.5 ± 1.7) was the most effective surface treatment agent compared with EDTA (4.1 ± 0.8), orthophosphoric acid (12.2 ± 1.8), citric acid (12.1 ± 2.4), and a control (3.9 ± 1.7); however, it could not remove the smear layer and sealer remnants effectively on radicular dentin surfaces (Fig. 6). The researchers concluded that removal of the smear layer and opening of dentinal tubules are not recommended when a self-etching/self-priming adhesive system is used. For a self-etching system, the additional application of phosphate or citric acid on root dentin was found to decrease the bond strength in this study.

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Erdemir et al (2004) treated root canal dentin walls of the extracted single-rooted teeth with 5% sodium hypochlorite (NaOCl), 3% hydrogen peroxide (H₂O₂), a combination of H₂O₂ and NaOCl, or 0.2% chlorhexidine gluconate for 60 seconds. The root canals were obturated using C&B Metabond (Parkell), a conventional etch/priming adhesive cement. The results indicated that NaOCl, H₂O₂, or a combination of NaOCl and H₂O₂ treatment decreased the microtensile bond strength to root canal dentin significantly. The teeth treated with chlorhexidine solution showed the highest bond efficacy. It was concluded that chlorhexidine is an appropriate irrigant to maintain the bonding effectiveness of etch-and-rinse resin adhesives.

The clinical implications extracted from these previous studies are as follows:

• For conventional three-step adhesive resin cements, sodium hypochlorite (NaOCl) irrigation negatively influenced the bond strength, while chlorhexidine (CHX) rinsing was considered to be an appropriate irrigant.
• For self-etching or self-adhesive cement:

De Munck et al (2004) found that acid etching prior to the application of RelyX Unicem raised the enamel microtensile bond strength to the same level as that of the control, but was detrimental for the dentin bonding effectiveness (Fig. 7). The latter must be attributed to inadequate infiltration of the collagen mesh as revealed by field-emission scanning and transmission electron microscopy. Morphological evaluation additionally revealed that RelyX Unicem only superficially interacted with enamel and dentin, and that application using some pressure is required to ensure close adaptation of the cement to the cavity wall.

Fig. 7: Surface treatment with phosphoric acid significantly reduced the dentin bond strength of self-adhesive cement. Although acid etching increased enamel bond, there is little benefit to post cementation in the root canals. Quoted from De Munck et al, 2004.

Fig. 8: Indirect technique for multiple cast posts fabrication on maxillary premolars: After tooth preparation A, B, plastic posts (C) were used for canal impression with light-body PVS or Fit Checker (GC), (D-F).
- CHX irrigation decreased the microtensile bond strength.
- Acid etching to remove the smear layer and open the dentinal tubules did not improve the bond efficacy and must be performed with caution.

Figures 8A-F and 9A-H illustrate the fabrication of multiple cast posts with indirect methods including impression with PVS or fit checker with pins or plastic posts, patterns made on a master cast and cast post cementation.

In summary, the strategy to restore premolars with two canals generally follows the principles described in the post and core studies. A post should never be placed over the curvature of a canal. The optimal length is approximately 8-9 mm counting from the 2-mm ferrule. A post and core does not reinforce the RCT teeth and a crown or onlay is suggested in RCT premolars. Pretreatment of the root canal before post cementation significantly affects the bond strength of resin cement.

**Molars**

Anterior teeth and premolars with coronal destruction generally require a dowel. However, RCT molars normally have three or more root canals. These narrow and curved canals make it difficult to place a dowel into an optimal length. On the other hand, there is usually sufficient depth and width of the pulp chamber to provide adequate retention and resistance of the core foundation without a post (Nayyar et al. 1980; Kane et al. 1990; Hunter et al. 1988, 1989; Goodacre et al. 1994; Schwartz et al. 2004). The root canals of molars are anatomically more complex and narrow than those of anterior teeth and premolars. So, the insertion of a post with an appropriate length is likely to strip or weaken molar root canals during the insertion. In situations in which post insertion is attempted to improve core retention, only maxillary palatal canals or mandibular distal canals are suitable for post cementation. In most RCT molars, direct core material buildup with the use of the pulp chamber works well without posts.

A maxillary first molar with endodontic access and one to four axial wall defects is shown in Fig.10-16 as a visual reference for discussing treatment strategies for molar posts and cores:

- **3-wall:**
  - Direct core buildup (Fig.10A-F)
  - Even with one wall missing, the 2-3 mm pulp chamber depth can provide good retention and resistance form (Fig.11).

- **2-wall:**
  - With 2 opposing walls: Direct core buildup (Fig.12)
  - Without 2 opposing walls: Direct core buildup or a post cementation in the largest canal (Fig.13)

- **1-wall:**
  - Direct core buildup with a post cement-
0-wall RCT molars with relatively short clinical crown heights, direct core buildup with or without a prefabricated post is recommended. If all four axial walls of RCT molars have been destroyed and there is no sufficient chamber space, a cast post and core assisted with a post can provide adequate retention and stability (Fig. 16A-G).

For adequate crown retention, the height of a prepared molar generally ranges from 3-6 mm. The 2-3 mm depth for a pulp chamber can usually assist another 2-3 mm buildup from the top of residual axial walls.
Fig. 12: Two-wall defect with the remaining two walls opposing to each other: amalgam or resin dowel and core is indicated. No post is needed.

Fig. 13: Two-wall defect without opposing walls: a prefabricated post cemented in the largest canal can be considered.

Fig. 14: One-wall defect: A post placement in the canal against the remaining wall.

Fig. 15: 0-wall defect: To assist the retention of core material, a post is placed in the largest palatal canal. For the other two canals, approximately 2-4 mm gutta percha should be removed from the canal orifice.

Fig. 16: Demonstration of procedures to make a cast post and core pattern with a pin or prefabricated post.
Core Materials for Molars

Traditionally, there are three major types of direct core materials:

- **Amalgam**: Adequate strength, good sealing, delayed preparation. Appropriate for use in high stress areas and areas with minimal remaining tooth structure.
- **Composite resin**: Adequate strength, rapid set, immediate preparation, bond to dentin, polymerization shrinkage, hydrophilic, requires strict isolation. Appropriate for use in esthetic areas and areas in which substantial coronal tooth structure remains.
- **Glass ionomer**: Poor strength and high rate of defects.

Amalgam is a core material with long history of success. Although some clinicians have questioned the safety of mercury, there has been no sufficient evidence or report of its toxicity in dental use. Nayyar et al.\(^35\) (1980) advocated an amalgam coronal-radicular dowel and core technique. They recommended that two criteria be met:

1) The size of the remaining pulp chamber should be of sufficient width and depth to provide for adequate bulk of amalgam and for retention.
2) Adequate dentin thickness in the area of the pulp chamber is required for rigidity and strength.

The amalgam dowel and core can be completed at the end of the obturation appointment. All gutta-percha should be removed from the pulp chamber and to a depth of 2-4 mm into each canal. If needed, a matrix band or copper band should be placed. Amalgam is condensed into the canals with a periodontal probe or root canal plugger and into the pulp chamber and remaining cavity by conventional methods. The procedures should be performed under rubber dam isolation or strict isolation from saliva and bacteria. If fast-setting amalgam is used, the tooth may be prepared for a cast restoration immediately after hardening, and a final impression can be made at the same appointment.

Over a four-year period, approximately 400 restorations of this type had been placed by Nayyar et al without any failures attributable to the amalgam dowel and core reported.\(^35\)

Resin composite cores have gained in popularity over the last decade for their relative safety and ease of buildup. The bonding procedures of a composite core are similar to those for a cavity filling. The residual sealer, gutta-percha or temporary restorative materials should be removed with diamond burs and EDTA. The dentin of the pulp chamber and root canal is then etched and primed carefully. Adhesive application, incremental buildup and sufficient light polymerization are critical.

A sonic-activated bulk fill composite resin (SonicFill, Kerr) has been introduced that enables cavities to filled up to 5 mm. The change in viscosity under ultrasonic vibration and the component of shrinkage stress reliever were claimed to improve the marginal adaptation and reduce polymerization stress. Figure 10A-F demonstrates the clinical procedure of resin core buildup with SonicFill.

Resin-Bonded Ceramic Post Crown

It is not uncommon to see RCT molars with a very short crown height (<3mm) and limited restorative space, e.g., second molars with thick and dense periodontal soft tissue or a severely worn dentition. After tooth preparation, the remaining axial wall is too short to provide crown retention. Except for clinical crown lengthening procedures, a post and core crown integrating the post, core and crown as one unit is another treatment option. By expanding the crown into the pulp chamber and root canal, the retention, stability and bulk strength are improved. However, a previous investigation raised concerns about poor adaptation and long-term survival rates. The major problem of a post-core crown restoration is the casting inaccuracy. A full-coverage crown is generally made to have some expansion to compensate for alloy shrinkage and ease of insertion. This expansion also made the post portion of a post crown difficult to fit into the pulp chamber.

The author of the present review has demonstrated a novel technique of a resin-bonded lithium disilicate post-core crown. With the use of heat-pressing (Fig.17A-I) and CAD/CAM (Fig.18A-I) techniques, the volumetric change of restorative materials was decreased. The coefficient of thermal expansion (CTE) of lithium disilicate (Emax, Ivoclar Vivadent) is 10.2 × 10\(^{-6}\), compared with a CTE of 13.8-15.2 × 10\(^{-6}\) for high gold alloy. The pressing temperature of emax is 920 °C, which is also lower than the casting temperature of ceramic alloy (1450 °C). With a decreased temperature gradient and controlled cooling contraction, the internal adaptation and marginal integrity were
adhesive (3M ESPE) was applied on the teeth and the internal surfaces of post-core crowns. The silane coupling agent and phosphate monomer in this adhesive can enhance the bond between emax and resin cement. The final restorations were finished, cemented and adjusted for occlusion.

Conclusions

- The optimal post length of two-canal premolars generally ranged from 8 to 9 mm, including 2 mm ferrule and the root canal space deducting 4-5mm of apical gutta-percha.
- Root canal pretreatment with acid etching, sodium hypochlorite or chlorhexidine irrigation may negatively affect the resin cement bond strength.
- In RCT molars, there is usually sufficient depth and width of the pulp chamber to
provide adequate retention and resistance of the core foundation without a post.
- Resin-bonded lithium disilicate post and core crowns were demonstrated as an alternative technique to restore RCT molars with limited clinical crown height.

Fig. 18: (A–C) Presented a RCT maxillary first molar with limited interocclusal space. The pulp chamber was prepared and final impression was taken. (D–E) The core-crown was fabricated with Cerec 3D system (Sirona). (F–I) Final restoration was pretreated and cemented with self-adhesive resin cement.

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