The Use of Modified Polyetheretherketone Post and Core for an Esthetic Lithium Disilicate Anterior Ceramic Restoration: A Clinical Report

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This clinical report presents the use of a modified polyetheretherketone (PEEK) post and core in order to support a lithium disilicate ceramic crown for a maxillary lateral incisor. When considering post-and-core restorations, material flexibility is essential to prevent root fractures. The low elastic modulus of PEEK (4 GPa) could result in lower root fracture rates, preserving tooth structure and favoring tooth re-restoration if the post fractures. PEEK is biocompatible, presents adequate bond strength with dentin when bonded with a resin cement, and can be used under ceramic restorations because of its white, esthetic color. PEEK posts and cores could also cost less when fabricated using common laboratory procedures. Polyetheretherketone (PEEK) posts and cores could be a viable alternative to rigid cast or zirconia posts, or even to fiber-reinforced composite posts, especially when combined with lithium disilicate crowns. Int J Prosthodont 2021;34:120–125. doi: 10.11607/ijp.6504

Endodontic treatment often results in loss of dental structure. If the remaining coronal tooth structure is inadequate for retention of the core, a post must be used in order to retain the core structure.1 Ideally, the post-and-core system should have physical properties similar to dentin, can be bonded to the tooth structure, and should be biocompatible in the oral environment.2,3 It should also act as a shock absorber by transmitting only limited stress to the residual tooth structure.4 For many years, rigid gold cast posts and cores have been the gold standard to support a crown for a tooth with substantial loss of coronal structure.5,6 Even though cast posts and cores have several advantages, they have been known to result in uneven stress distribution, microleakage, and corrosion, as well as in the reflection of their dark color under ceramic restorations.7 The high modulus of elasticity of cast posts and cores (180 to 240 GPa) compared to that of dentin (18 GPa) is considered responsible for poor stress distribution, leading to a high incidence of root fractures.8,9

The esthetic alternative to cast posts and cores are zirconia posts. Zirconia posts possess the mechanical advantages of cast post-and-core systems and are an esthetic solution, especially for placement under ceramic restorations. Zirconia posts are rigid with a modulus of elasticity higher than stainless steel and are resistant to fracture,10 radiopaque, and biocompatible.11 Their disadvantages include a lower fracture resistance than metal posts, difficult retrieval of the fractured post within the root canal, a high incidence of root fractures, and poor resin-bonding capabilities of the post to radicular dentin.12

The disadvantages of rigid metal and zirconia posts have led most practitioners to the use of fiber-reinforced composite (FRC) posts. The introduction of FRC posts helped to improve unfavorable stress distribution and decrease root fracture rates, as their elastic modulus closely matches that of dentin, as demonstrated by several
studies. Today, fiber posts are used by 72% of dentists. One of the rationales for placing a flexible post instead of a rigid post is that, if the tooth breaks, the mode of fracture is more favorable and the tooth may be re-restored.

Moreover, glass FRC posts present a lower elastic modulus than carbon fiber posts and are tooth colored, thus proving more suitable for anterior esthetic restorations.

An alternative material for the fabrication of esthetic posts due to its tooth-colored shade could be polyetheretherketone (PEEK), a new material that was introduced to dentistry during the last decade. A modified polyetheretherketone (PEEK) material containing 20% ceramic fillers (Bio HPP, Bredent) has been used in dentistry in various applications, such as endocrowns, frameworks for FDPs, implant abutments, implant frameworks and implant parts, and removable dental prostheses (RDPs).

This material presents biocompatibility, low plaque affinity, and good mechanical properties. Studies evaluating the properties of this material are limited, and reports on this material are generally in vitro. Another advantage of this modified PEEK material is the high bond strength to PMMA and to composite resin materials. Various surface treatments and bonding agents have been tested in order to achieve an adequate bonding value of 25 MPa between PEEK and composite resins or PMMA. A PMMA and composite primer (visiolink, Bredent) have been demonstrated to satisfy such a requirement. Also, current literature has proven that modified PEEK bonds well to dentin when a resin cement is used. In vitro studies that tested the fatigue resistance of a three-unit fixed partial denture demonstrated fracture load values greater than 1,200 N under fatigue stress (1.2 million cycles), but how PEEK posts and cores would behave under fatigue stress is unclear.

The most important property of PEEK when used for the fabrication of a customized post and core is the elastic modulus. This material exhibits an elastic modulus of 4 GPa, which is lower than dentin (18 GPa) and can be used for prosthesis fabrication either by injection molding or with CAD/CAM. For the fabrication of a customized PEEK post and core, the fabrication of an acrylic post-and-core pattern is necessary. This customized acrylic post-and-core assembly is used to produce the final PEEK post and core by injection molding with a similar process to the casting laboratory procedure.

The present clinical case presents the use of a modified PEEK as an alternative esthetic post-and-core material for a maxillary lateral incisor that was to be restored with a ceramic crown (IPS e.max, Ivoclar Vivadent) in order to utilize the excellent esthetic and adhesion properties of lithium disilicate to tooth structures.

Case Presentation
A 62-year-old male patient presented for a full-mouth restoration. The patient was a smoker at the time of initial screening, but gave up smoking at the beginning of phase two of his dental treatment. Phase one treatment included periodontal therapy, multiple endodontic treatments, post-and-core fabrication, and a long-term temporary restoration. Phase two included endodontic and periodontal posttreatment evaluation and the delivery of definitive restorations. The definitive maxillary treatment plan included a single-unit PFM crown for the right second molar, a four-unit PFM fixed dental prosthesis (FDP) from the right first molar to the right canine, a single-unit lithium disilicate FDP for the right lateral incisor, and a three-unit PFM FDP from the left canine to the left first molar. The maxillary right lateral incisor had undergone endodontic therapy in the beginning of phase one treatment, and a temporary filling material (Cavit, 3M ESPE) was placed in the access hole (Fig 1a).
The patient had to discontinue his dental treatment due to personal issues and returned for completion (phase two) 2 years later. The lateral incisor was discolored due to microleakage and carious lesions (Fig 1b), and the endodontic treatment had to be repeated. No core remained to retain a crown after caries removal (Fig 2). The fabrication of an esthetic PEEK post and core in order to retain a lithium disilicate crown was followed as a treatment option. Gutta percha was removed using Gates Glinden #3 (Kerr), leaving 4 mm of apical seal, and a conventional acrylic resin (GC pattern resin, GC America) post-and-core pattern was fabricated. This pattern was invested with a special investment (Brevest, Bredent) material, followed by conventional burnout procedures and the injection molding technique using a vacuum press device (2 press, Bredent) designed for this material. The resulting post and core were adjusted and passively fitted intraorally using a carbide bur (Brasseler), airborne-particle abraded with 110 µm aluminum oxide, coated with bonding agent (visio.link), and light polymerized before cementation. A dual-polymerizing resin cement was used for definitive cementation according to the cement manufacturer’s instructions (Variolink Esthetic, Ivoclar Vivadent) (Fig 3). The minimum 2-mm amount of ferrule was present; therefore, no crown lengthening procedures were performed for this restoration. The tooth was prepared using the same carbide bur under a copious amount of water in order to facilitate preparation of the PEEK core and to prevent overheating. A definitive impression was made with polyvinyl siloxane impression material (Elite HD, Zhermack), and the definitive cast was poured with type IV dental stone (Prima-Rock, Whip Mix). Intraoral fit verification of the lithium disilicate core (IPS e.max press, Ivoclar Vivadent) was performed together with the full-mouth metal try-in (Fig 4). The definitive lithium disilicate layered ceramic restoration was adjusted, pretreated with hydrofluoric acid 5% for 20 seconds, rinsed, and cemented using the same dual-polymerizing resin cement and according to the manufacturer’s instructions (Fig 5a). A postcementation periapical radiograph was performed (Fig 5b).

The patient consented to the publication of all intraoral pictures concerning his dental treatment, agreeing on data protection principles.

**DISCUSSION**

The fabrication of a PEEK esthetic post and core was performed in order to support a lithium disilicate ceramic crown for the restoration of a maxillary lateral incisor. Posts and cores should demonstrate esthetics, elasticity close to dentin, high retention properties, biocompatibility, good mechanical properties, and retrievability.3

PEEK’s light color matches that of glass fiber posts, so that PEEK posts and cores can be used under ceramic crowns without jeopardizing the definitive esthetic result. A tooth-colored shade (A3) (BioHPP, Bredent) was lately introduced that could facilitate the use of this material as a post and core for darker-shade ceramic transparent cores.

The elastic modulus of PEEK (4 GPa) is lower than that of carbon or glass fiber posts (20 GPa), and it is therefore expected to result in even less stress concentration and

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Fig 2 The sound tooth structure remaining after endodontic treatment was inadequate to retain a crown.

Fig 3 PEEK post-and-core restoration.

Fig 4 Lithium disilicate core try-in.
lower root fracture rates.\textsuperscript{16} The literature reports that the more flexible the post, the more stress concentration at the cervical margin, which may result in microleakage at the restoration margin.\textsuperscript{20} Since it is more elastic than fiber posts and dentin, PEEK posts and cores could potentially produce more stress concentration under function and microleakage than carbon and glass fiber posts at the cervical margin. The above statement has been partially supported by Lee et al,\textsuperscript{39} suggesting that polyetherketoneketone (PEKK) posts and cores present a higher probability of debonding and crown failure under long-term cyclic loading. PEKK composition differs from the modified PEEK used in the present study, since no ceramic fillers are incorporated in its material matrix. In Lee et al,\textsuperscript{39} no post-and-core surface treatment was performed nor bonding agents used prior to cementation. Additionally, the type of cement was not specified. The bond between the resin cement and the PEEK post and core is one of the factors that can affect the post-and-core retention. This bond can be enhanced by two critical factors: surface treatment with airborne-particle abrasion (110 µm aluminum oxide powder under

\textbf{Fig 5} (a) Insertion of definitive lithium disilicate crown. (b) PEEK postcementation radiographic image. (c) Close-up of definitive crown and (d) esthetic zone 3 years posttreatment.
200 to 300 kPa pressure at a minimum distance of 3 mm), and the use of a surface bonding agent that reacts and bonds well with the ceramic fillers incorporated into the PEEK matrix. Both of the above factors contribute to an adequate bond strength value of 25 MPa,\(^{33,34}\) and it is therefore anticipated that the retention of these injection-molded PEEK posts and cores is satisfactory. This, in combination with the use of a lithium disilicate ceramic crown that bonds excellently to dentin when using a resin cement, could potentially reduce such stress concentration and compensate for such marginal microleakage.\(^{38}\) Further research is required to confirm this assertion.

Fatigue resistance tests have proven that PEEK can be used for a three-unit partial denture,\(^{35}\) but it is uncertain how a post and core would behave under compressive stress since research studies on that matter are scarce. The failure mode of PEEK post-and-core assemblies should follow a certain pattern that includes post fracture and loss of retention,\(^{20}\) with a fracture mode that favors the re-restoration of the tooth.\(^{18,19}\)

PEEK is radiolucent, which may facilitate recurrent caries detection but could make post retrieval more difficult for the general dentist, since any remaining post material could not be easily detected radiographically.

Retrievability should not be a matter of concern since endodontic microscopy together with the use of current endodontic instrumentation could ensure for easy post removal. Since PEEK is a thermoplastic material that is softer than metal, zirconia, or even fiber posts, it could be more easily removed with the available special endodontic warm instruments and techniques. Clinical trials are needed in order to ensure the retrievability potential of these post-and-core assemblies.

To summarize, the use of PEEK for the indirect fabrication of posts and cores is clinically significant because this material combines the advantages of cast posts and cores (conservative, less dentin removal) with the advantages of more flexible esthetic posts. PEEK is biocompatible, bonds well to dentin when combined with a resin cement, and can be used under ceramic restorations because of its white, esthetic color. When compared to gold and zirconia cast posts and cores (same fabrication technique), PEEK posts and cores cost less because peek pellets are less expensive than the gold metal or zirconia ingots. When compared to fiber posts, the technique is more time consuming (indirect laboratory technique) and probably more expensive (due to laboratory cost), but more conservative due to limited or no instrumentation of the canal space (customized technique) with the drills of the prefabricated fiber post systems. At the time of writing this report, the present post-and-core restoration has been in use for 3 years without retention loss or any signs or symptoms (Figs 5c and 5d).

**CONCLUSIONS**

The use of a PEEK post and core in combination with a lithium disilicate ceramic crown were used to restore a maxillary lateral incisor. Further research studies are indicated in order to establish this material as an alternative to flexible FRC post systems.

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**REFERENCES**

Adhesion to Zirconia: A Systematic Review of Current Conditioning Methods and Bonding Materials

Reliable bonding between composite resin cements and high-strength ceramics is difficult to achieve because of chemical inertness and lack of silica content, which makes etching impossible. The purpose of this review was to classify and analyze the existing methods and materials suggested to improve the adhesion of zirconia to dental substrates using composite resins in order to explore current trends in surface-conditioning methods with predictable results. The current literature examining the bond strength of zirconia ceramics was analyzed. The search for the literature was carried out using PubMed and the Cochrane Library databases for papers in English published online from 2013 to 2018. The following keywords and their combinations were used: zirconia; 3Y-TZP; adhesion; adhesive cementation; bonding; resin; composite resin; composite material; dentin; and enamel. The literature search provided 390 titles with abstracts. From these, a total of 93 publications were chosen for analysis. After a full-text evaluation, 7 articles were discarded. Therefore, the final sample was 86, including in vitro studies, clinical studies, and one systematic review. Various adhesive techniques with different testing methods were examined. Airborne-particle abrasion and tribochemical silica coating are the pre-treatment methods with the most evidence in the literature. Increased adhesion could be expected after physicochemical conditioning of zirconia. Surface contamination has a negative effect on adhesion. There is no evidence to support a universal adhesion protocol.