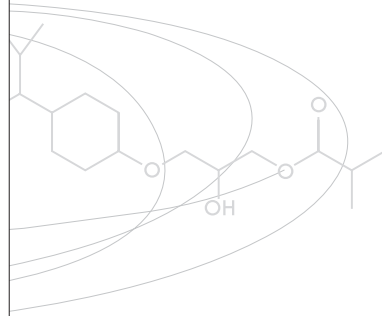


**3M** ESPE

Glass Fiber Post

*Technical Product Profile*

**RelyX<sup>TM</sup> Fiber Post**



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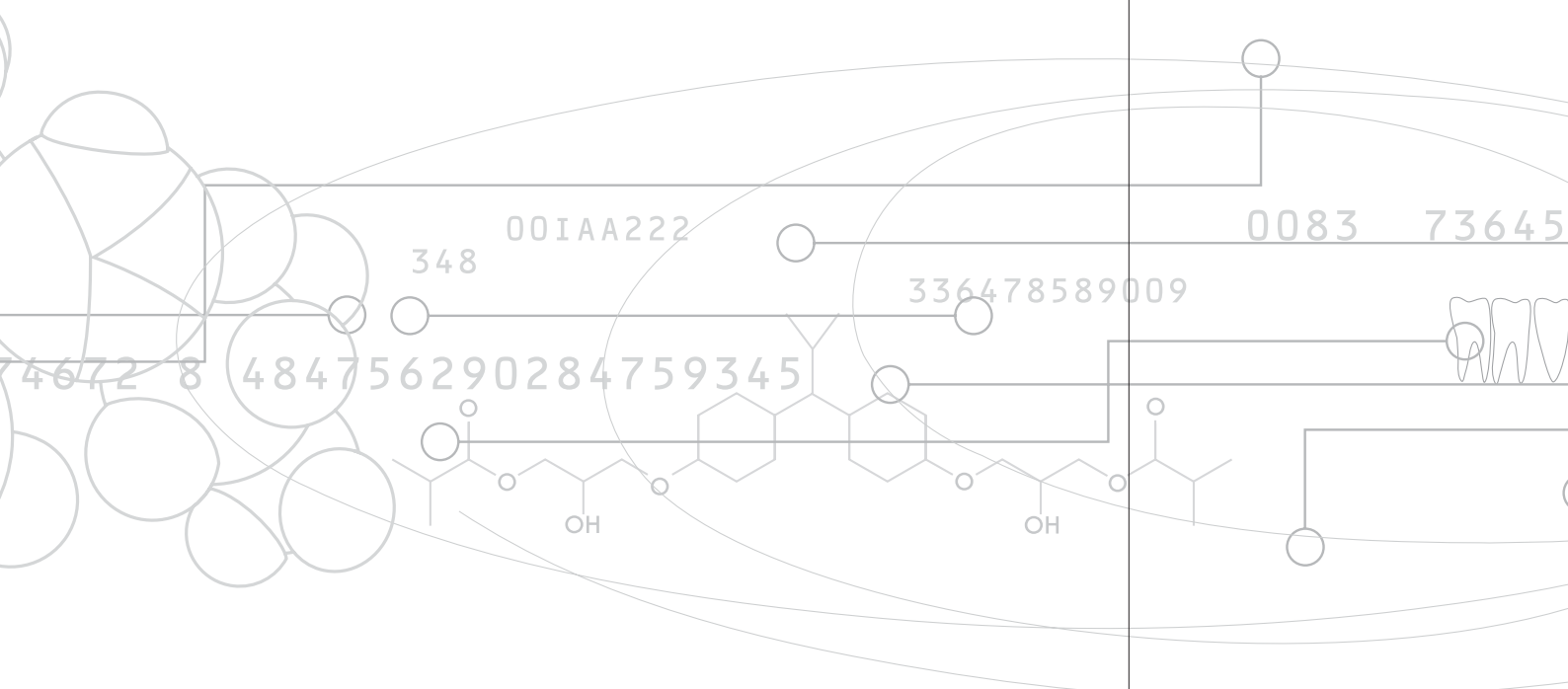
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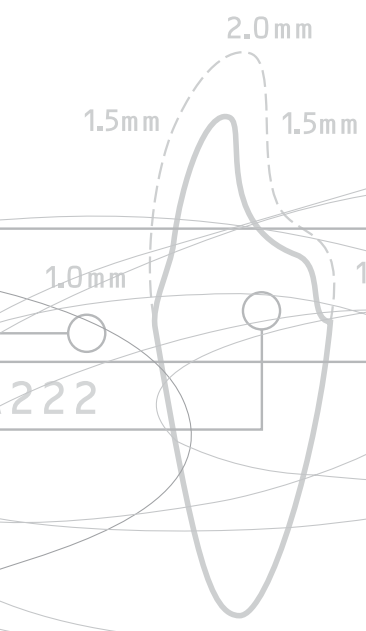
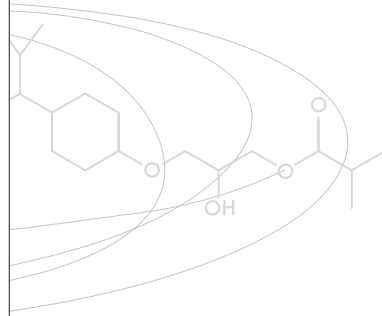
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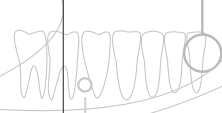




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# 1. Introduction

Over the past decade fiber reinforced composite (FRC) posts have gained popularity in the dental market because of their benefits regarding mechanical properties, aesthetics and removability, offering predictable clinical performance in several ways.

- a) The risk of root fractures is significantly reduced with fiber posts. Stiff and hard metal posts exert a “wedge effect” that can be compared to that of a metal wedge in a piece of wood. Fiber posts avoid this effect because of the dentin-like elastic properties.
- b) Aesthetic demands of full-ceramic restorations are met by fiber posts due to their natural translucency.
- c) In case the endodontic treatment has to be redone fiber posts can be easily removed with drills.

Despite these clear advantages and the paradigm shift from metal to fiber posts that is also reflected in the scientific community, there is one drawback: fiber posts have to be adhesively cemented into the root canal which is difficult for multi-step, moisture sensitive adhesive protocols. Market research has shown that many dentists expect difficulties with the complex cementation procedure of fiber posts in the root canal and as a consequence do not use them.

RelyX™ Fiber Post and RelyX™ Unicem™ Aplicap™ Self-Adhesive Universal resin cement with the RelyX Unicem Elongation Tip offer the solution:

RelyX Unicem cement offers safe and reliable adhesion without any pre-treatment neither of the root canal dentin (i.e. etching, priming, and bonding) nor the RelyX Fiber Post (e.g. silanating and roughening). The RelyX Unicem Elongation Tip allows the application of RelyX Unicem cement into the root canal in one single step. The Elongation Tip locks securely onto the RelyX Unicem Aplicap nozzle via a simple hook mechanism. The system allows an easy, time-saving, and virtually void-free cementation of RelyX Fiber Post.

## Advantages

- RelyX Fiber Post is a radiopaque, translucent, glass-fiber reinforced composite root post
- RelyX Fiber Post is an esthetic, conservative, and reliable restoration for severely destroyed teeth
- RelyX Unicem Aplicap self-adhesive resin cement used for a safe and reliable bond between the root post and the root canal dentin without any pretreatment
- RelyX Unicem Aplicap Elongation Tips provides an easy, time-saving, and virtually void-free cementation of root posts with RelyX Unicem cement

## 2. Indications

In case of insufficient residual tooth structure (<4 mm) the post is needed to support and secure the coronal restoration.

RelyX™ Fiber Posts and drills are available in three sizes and are color-coded to ensure an accurate match and prevent errors.



The RelyX™ Fiber Post system comes with a universal pre-drill and RelyX Unicem Aplicap Elongation Tips to dispense the cement into the root canal for virtually void free cement application.



## 3. Clinically Relevant Product Properties

### 3.1. Material Properties

#### 3.1.1. Sizes

RelyX™ Fiber Posts and drills are available in three sizes and are color-coded to ensure an accurate match.

| Post color code                   | Yellow     | Red        | Blue        |
|-----------------------------------|------------|------------|-------------|
| Diameter of apical post end (mm)  | 0.70       | 0.80       | 0.90        |
| Diameter of coronal post end (mm) | 1.30       | 1.60       | 1.90        |
| Taper                             | 3.44° (6%) | 4.58° (8%) | 5.72° (10%) |
| Length                            | 20 mm      | 20 mm      | 20 mm       |

Tab. 1: RelyX Fiber Post color-coding and sizes

RelyX Unicem Aplicap Elongation Tips are designed to also fit into root canals prepared for the smallest size RelyX Fiber Post (yellow).

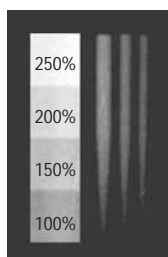
#### 3.1.2. Shape

RelyX Fiber Posts have a tapered shape, i.e. they are parallel-walled (cylindrical) at the coronal end and conical at the apical end. This special design is similar to the anatomical form of the root. Therefore, the root canal preparation can be done in a conservative way, i.e. without overly removing of root canal dentin. Additionally, the transmission of forces from the coronal part into the root area is reduced. The coronal end of the cylindrical part of the RelyX Fiber Posts offers a large surface area for the adhesion of the core build up material and the highest material thickness to withstand mastication forces.

#### 3.1.3. Radiopacity

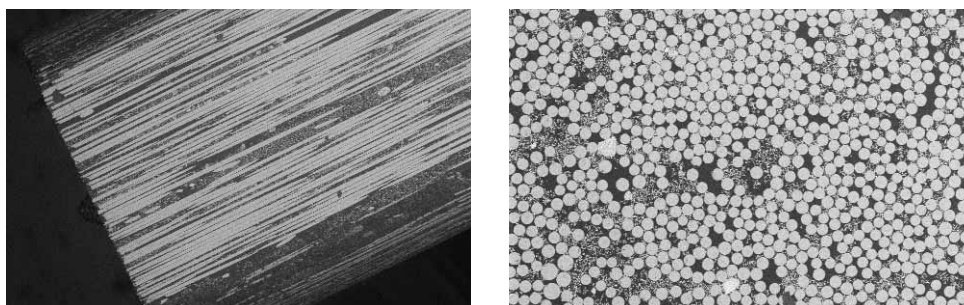
RelyX Fiber Posts are radiopaque. The radiopacity of RelyX Fiber Posts size 3 (blue) equals approx. 200 – 250% Al. In combination with the radiopaque RelyX Unicem cement the outline of the posts is clearly discernible.

X-ray image of RelyX Fiber Posts. (3M ESPE internal data)



### 3.1.4. Composition

RelyX™ Fiber Posts are made from glass fibers embedded into a composite resin matrix. For superior mechanical properties the glass fibers are oriented parallel and are distributed equally over the surface area. Additionally, during the manufacturing process the glass fibers are pre-tensioned for enhanced post stability. Therefore, during the clinical application RelyX Fiber Posts have to be cut with a diamond disc. Wire cutters or instruments alike must not be used. Otherwise, the glass fibers will be ripped from the composite matrix leading to a loss in mechanical stability. A two-step manufacturing procedure that includes chemical and thermal curing assures a virtually complete curing of the composite resin matrix.



**Fig. 1:** Longitudinal cut (left) and cross section of a RelyX Fiber Post (size 3). Scanning electron microscopy (SEM) image; magnification 60x (longitudinal cut) and 200x (cross-section). The glass fibers are depicted as white lines in the longitudinal cut and white spots in the cross section. The glass fibers are surrounded by composite resin matrix with fillers. (3M ESPE internal data)

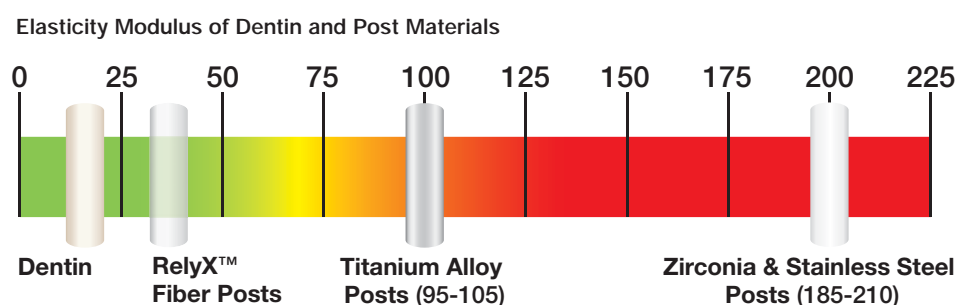
## 3.2. The Shift from Metal Posts to Fiber Posts

### 3.2.1. Translucency

Due to their advantageous combination of mechanical and esthetic properties fiber posts have gained increased popularity in recent years. Translucency plays an important role for their remarkable esthetics. RelyX Fiber Posts are translucent to meet the particular needs of highly esthetic anterior restorations (e.g. full ceramic restorations). During the post cementation the translucency facilitates light-curing in the root canal.

### 3.2.2. Elasticity

The “wedge effect” of root posts (Lit. 1) can be overcome when the cemented root post and the surrounding root canal dentin represent a system with uniform mechanical properties. A prerequisite is that the modulus of elasticity (Young’s Modulus) of all system components are similar to each other. The higher a material’s modulus of elasticity the less flexible it is. The modulus of elasticity for RelyX Fiber Posts is in the same range as that of dentin while the modulus of metal and ceramic posts are many times higher (Fig. 2).

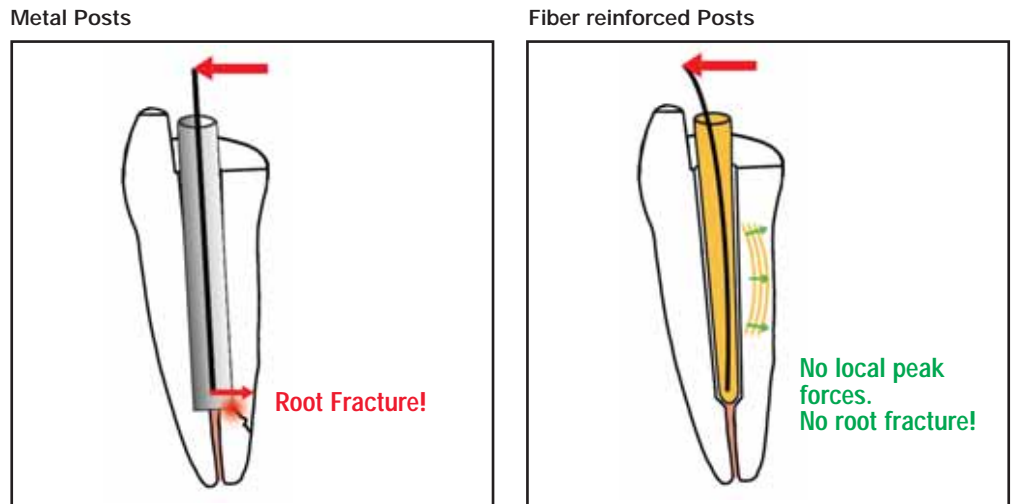


**Fig. 2:** Elasticity Modulus (GPa) of Dentin and post materials (3M ESPE internal data and Lit. 2)

Light transmission in a RelyX Fiber Post lit from coronal end with a Freelight 2 (3M ESPE) curing light.



Due to this similarity of elastic properties, RelyX™ Fiber Posts are able to distribute the forces taken up at the corona evenly and attenuated to the root without causing peak forces – like metal posts – that may lead to root fractures (Fig. 3). The tapered shape of the RelyX Fiber Posts further contributes to this effect.



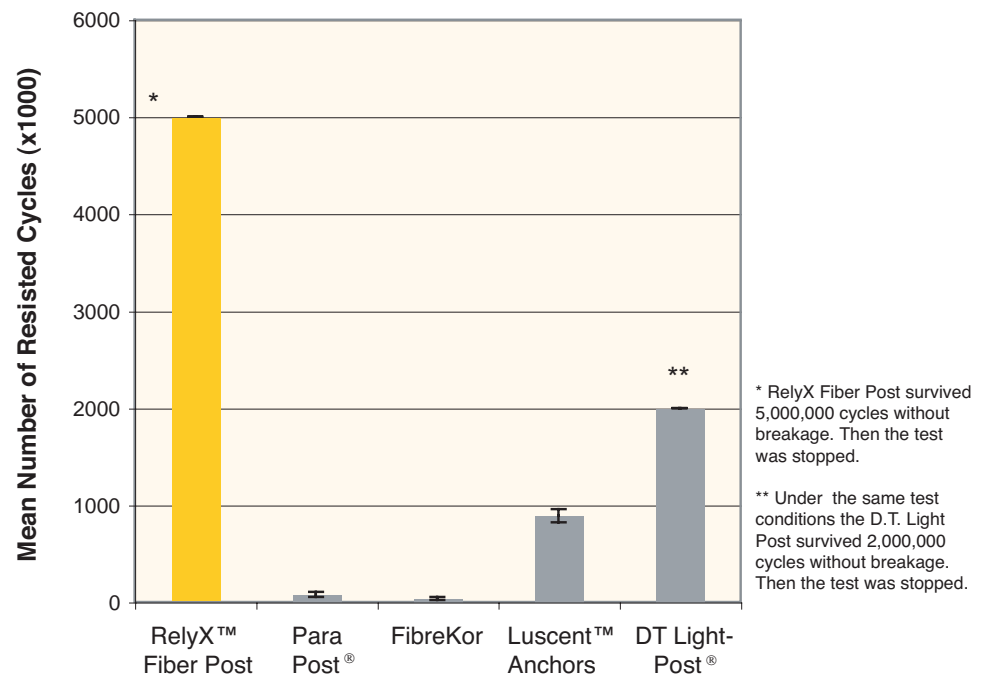
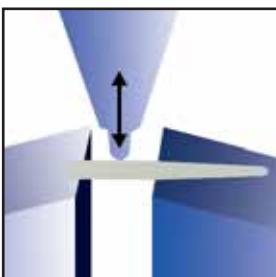
**Fig. 3:** Root fractures may result from root posts with little flexibility like metal posts (left) that transmit forces from the coronal end deep into the tooth. In contrast, due to their elastic properties fiber reinforced posts are able to spread such forces along the post (right).

### 3.3. The Long-Lasting Post

#### 3.3.1. Fatigue Test

Root posts need to withstand repeating mastication load over a long period of time. In order to test their long term stability root posts are subjected to cyclic loading comparable to mastication simulation. RelyX Fiber Posts withstand at least 5,000,000 load cycles without breakage. Some other types of fiber posts break after far less than 2 million cycles.

Schematic depiction of the fatigue test setup. The root post is fixed at both ends of the cylindrical part of the post. Then a cyclical load is applied centrally.



**Fig. 4:** In the fatigue test RelyX Fiber Posts survive at least 5,000,000 load cycles without breakage. (Study by Prof. Ferrari, University of Siena, Italy, Lit. 3)

### 3.3.2. Shear strength test

Next to the preparation technique (“ferrule design”) the shear strength of the root post contributes to the overall stability of the restoration. The shear strength of RelyX™ Fiber Posts equals or exceeds other brands (Fig. 5).

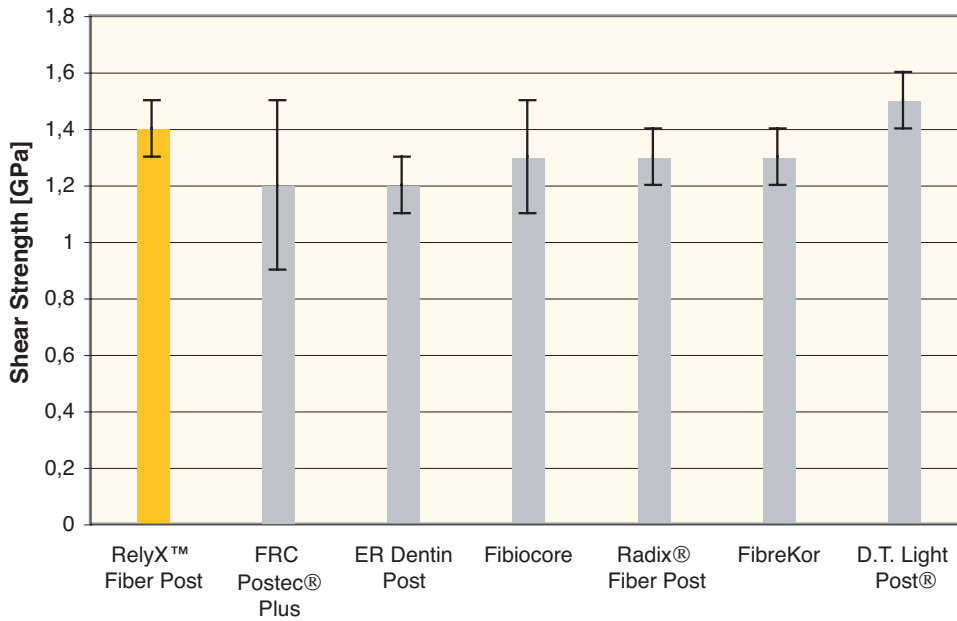


Fig. 5: Shear strength testing of RelyX Fiber Posts and other brands. (3M ESPE internal data)

Thermocycling tests assess the long-term stability under simulated aging conditions. RelyX Fiber Posts exert high shear strength values even after 10,000 thermocycles (Fig. 6) and thereby meet a key prerequisite for the longevity of restorations.

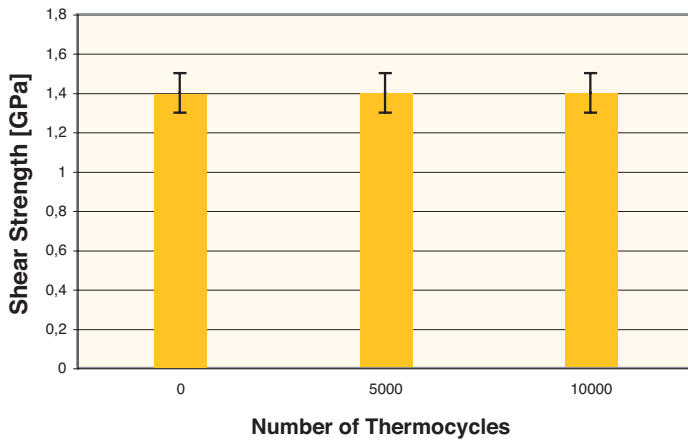
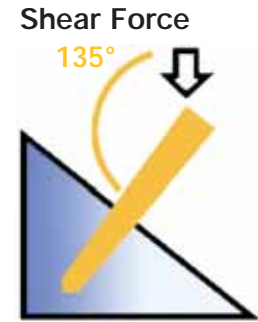
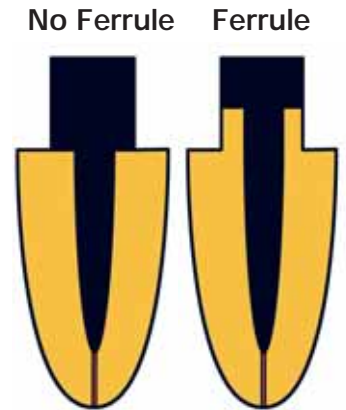


Fig. 6: The shear strength of RelyX Fiber Posts stays unaffectedly high even after 10,000 thermocycles (5°C / 55°C). (3M ESPE internal data)

Schematic depiction of the shear strength test setup. The root posts are loaded at an angle of 135 degrees until breakage occurs.



Coronal extension of dentin above the shoulder provides an effective ferrule.



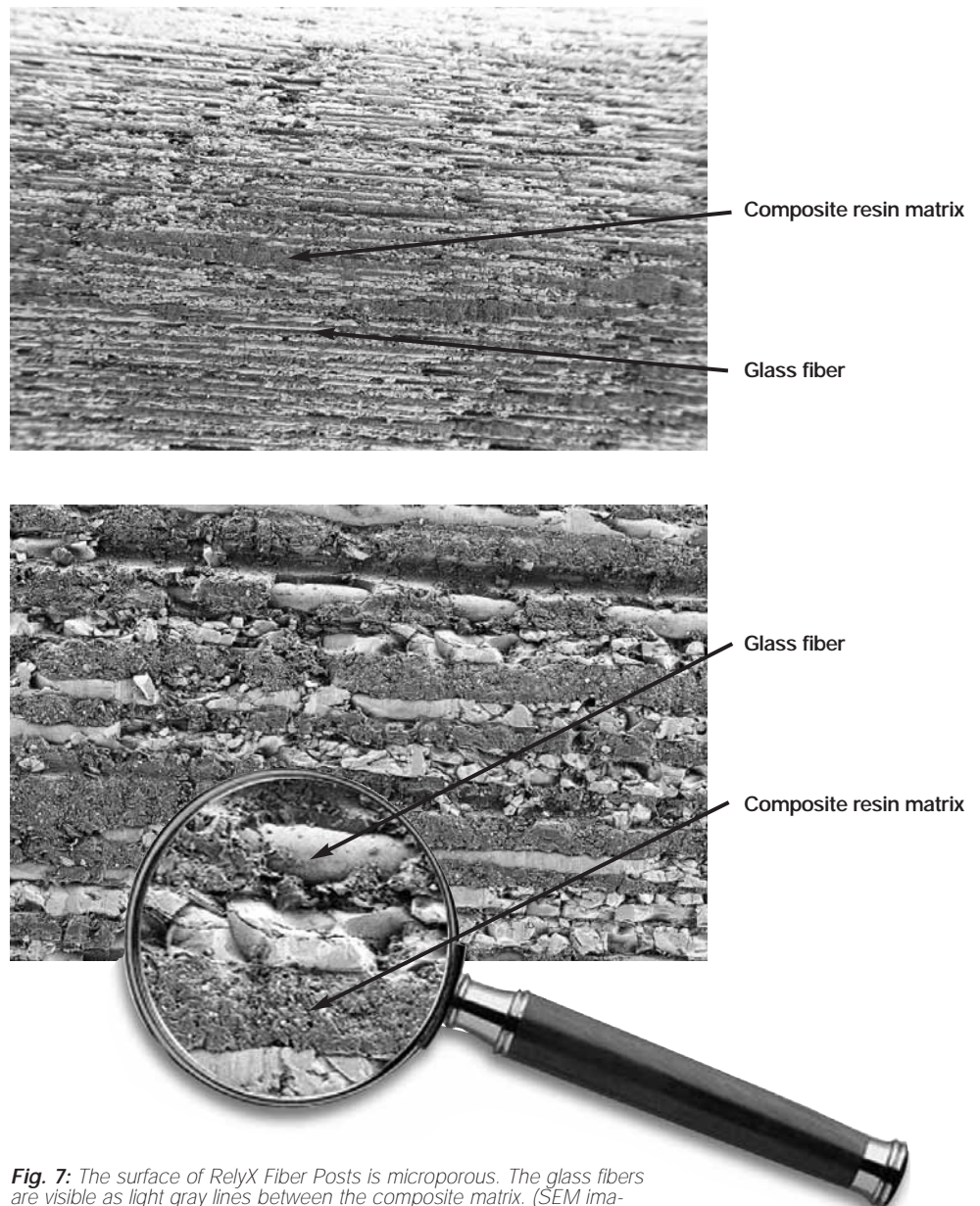
### 3.4. The Best Way to Cement it

RelyX™ Unicem cement adheres to RelyX Fiber Posts by 3 ways:

- Mechanical interlocking
- Covalent Bonds
- Hydrogen Bonds

During the manufacturing process RelyX Fiber Posts obtain a microporous surface (Fig. 7). The resulting indentations serve as micro-retentions when they fill up with cement. The mechanical interlocking contributes the most to the adhesive strength between the post and the cement. Apart from this the composite matrices of RelyX Fiber Post and RelyX Unicem cement are chemically compatible. Therefore, covalent, i.e. chemical bonds are established between RelyX Unicem cement and RelyX Fiber Posts. Additional adhesion is provided by non-covalent hydrogen bonds which develop between the RelyX Unicem cement and RelyX Fiber Posts molecules.

Due to these effects high bond strength values are achieved between RelyX Unicem cement and RelyX Fiber Posts without any chemical (e.g. silanating) or mechanical pretreatment (e.g. roughening) of RelyX Fiber Posts. This differentiates the RelyX Fiber Post / RelyX Unicem cement system from other combinations of fiber reinforced posts and cements.



**Fig. 7:** The surface of RelyX Fiber Posts is microporous. The glass fibers are visible as light gray lines between the composite matrix. (SEM images, magnification 100x, upper; 500x, lower). (3M ESPE internal data)

### 3.4.1. The Reliable Bond

#### Adhesion of RelyX™ Unicem cement to RelyX Fiber Post

RelyX Unicem cement exerts consistently high bond strength values to RelyX Fiber Posts without the need for post pretreatment (Fig. 8) such as etching, silanating (e. g. RelyX Ceramic Primer, 3M ESPE, or Monobond S, Ivoclar Vivadent), or a combination of silicatization (Rocatec System, 3M ESPE) and silanating. For determining bond strength RelyX Unicem cement was applied to the post surface in a disc shape (d = 6.0mm, h = 4.0mm) at the conical part of the posts. RelyX Unicem cement was light-cured for 40 seconds and water stored (24hrs at 36°C) before bond strength was measured in a pull-off setup.

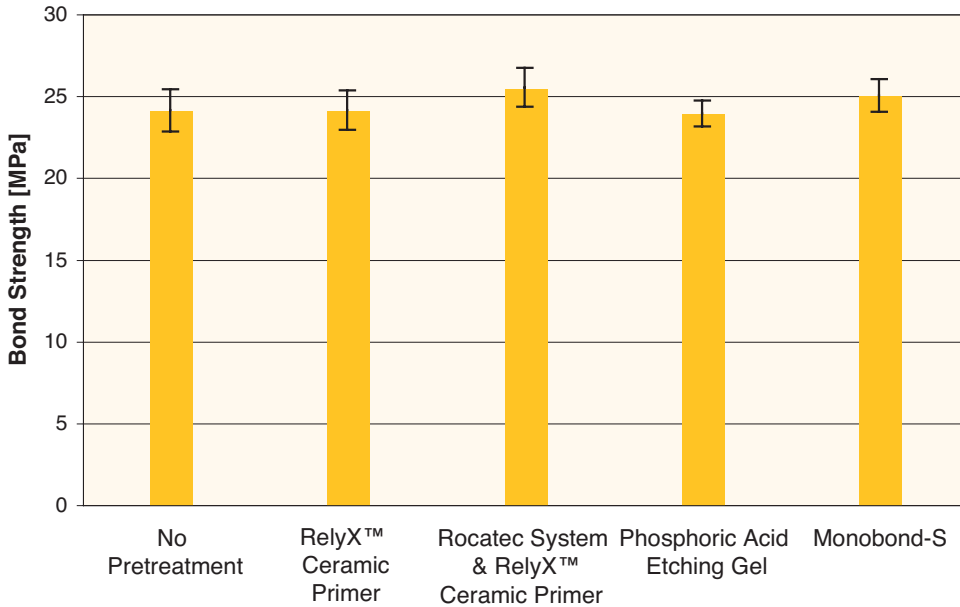


Fig. 8: Tensile bond strength (24hrs) of RelyX Unicem cement to RelyX Fiber Post with and without fiber post pretreatment. (3M ESPE internal data)

In contrast, for other adhesive cements pretreatment with a bonding agent is needed to reach as high adhesion values as with RelyX Unicem cement (Fig. 9). Here too, adhesion was tested at the conical part of the posts by applying the cements to the post surface (disc: d = 6.0mm, h = 4.0mm). All cements were light-cured (RelyX Unicem cement 40 seconds, Multilink Automix and Variolink II 60 seconds). After water storage (24hrs at 36°C) bond strength was measured in a pull-off setup.

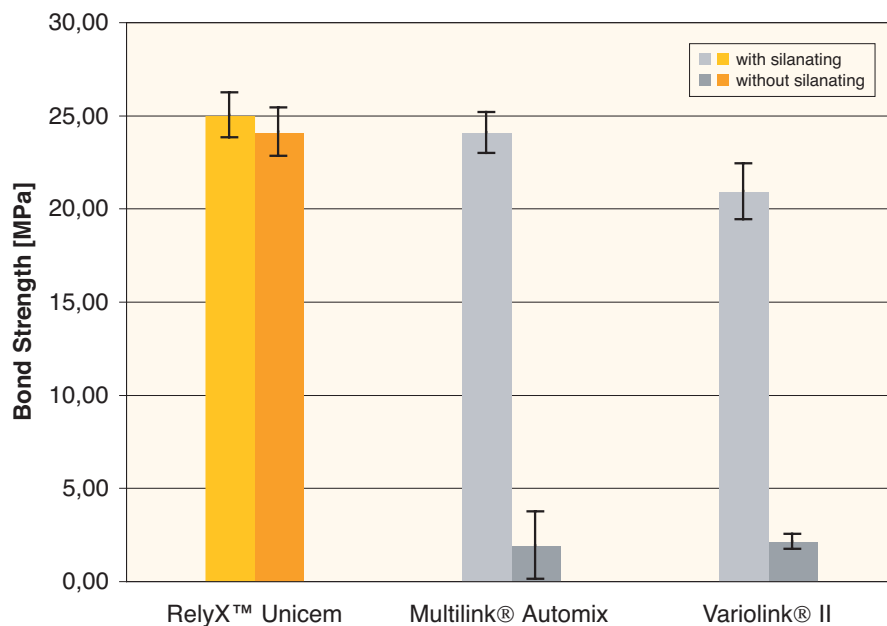


Fig. 9: Tensile bond strength (24hrs) of RelyX Unicem cement and other adhesive resin cements to RelyX Fiber Post with and without silanating the fiber post. (3M ESPE internal data)

Independent of the curing mode (self- or light-curing) RelyX Unicem cement develops high bond strength to RelyX Fiber Posts without the need of prior post pretreatment (Fig. 10). Bond strength values of other adhesive cements are comparably high only if the cement was light-cured and, for some cements, if the posts were treated with bonding before cementation. Testing conditions were as described above. Cements were either self-cured (stored for 1hr at 36°C / >95% r. h.) or light-cured (RelyX Unicem cement and Maxcem cement 40 seconds, Multilink Automix and Variolink II 60 seconds). After curing all samples were stored in water at 36°C. Again, bond strength was measured in a pull-off setup 24hrs after applying the cements.

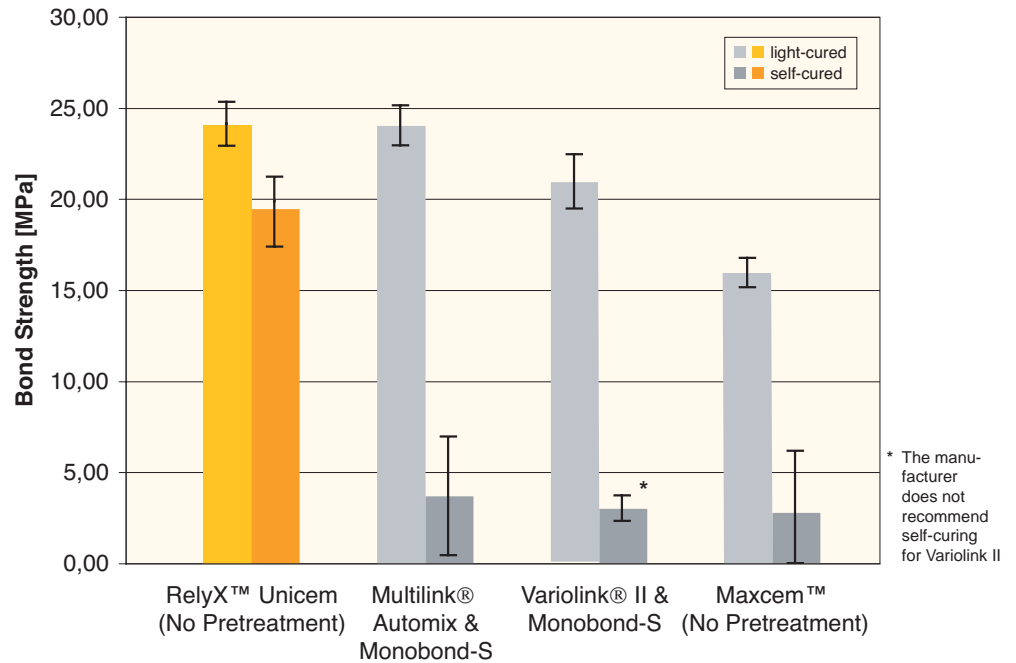


Fig. 10: Tensile bond strength of RelyX Unicem cement to RelyX Fiber Post (size 3) in comparison to other resin cements. (3M ESPE internal data)

### Adhesion of RelyX Unicem cement to Root Dentin

Since its market introduction in 2002 numerous in vivo and in vitro studies and evaluations of independent research institutes proved the safe and reliable cementation with RelyX Unicem cement. A microtensile bond strength study to both bovine crown and root dentin from the University of North Carolina (Lit. 4) showed RelyX Unicem cement had higher adhesion values compared to than other brands (Fig. 11). For testing, incisors were ground with 600 grit silicon carbide, pretreated according to manufacturers' instructions, and the luting cement was applied and cured. After water storage (24hrs at 36°C) the bond strength was tested using 1mm x 1mm beams.

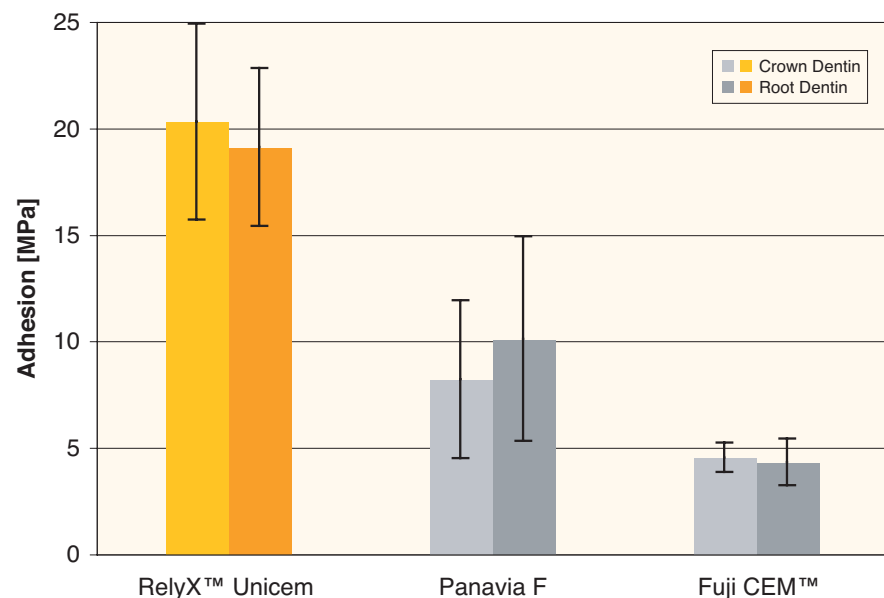


Fig. 11: Micro tensile bond strength of RelyX Unicem cement and other resin cements to bovine crown and root dentin (Lit. 4).

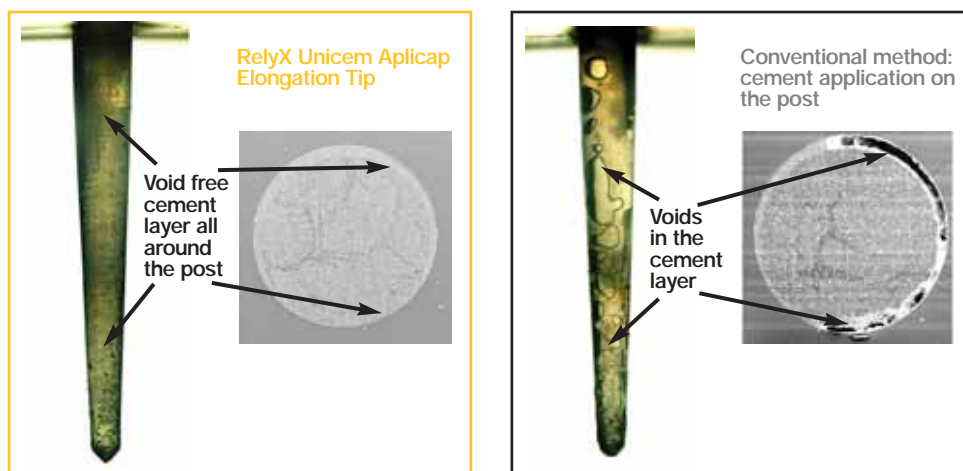
In another study (Lit. 6) with extracted human teeth, the authors find higher pull-off adhesion values for fiber reinforced posts cemented with self-adhesive RelyX™ Unicem cement than for those cemented with a conventional adhesive technique requiring etching and bonding.

### 3.4.2. The Smart Application

#### Virtually Void-free Cement Application

The use of a lentulo spiral for cement application is not recommended with RelyX Unicem cement as for many other resin cements because of the possible curing acceleration. Therefore, up to now the luting cement is applied to the post surface extra-orally. Then the post covered with the cement is seated in the root canal. However, this method may cause voids being trapped in the cement layer which may impact both the bond strength and the proper seal of the cement layer in a negative way. In order to avoid this effect an Elongation Tip for the RelyX Unicem Applicap was developed which can be attached to the Applicap nozzle and securely locks via a snap mechanism (page 17, picture 13). The Elongation Tip allows bottom to top filling of root canals. Keeping the Elongation Tip immersed in the cement during root canal filling reduces the chance of trapping air bubbles and creating voids.

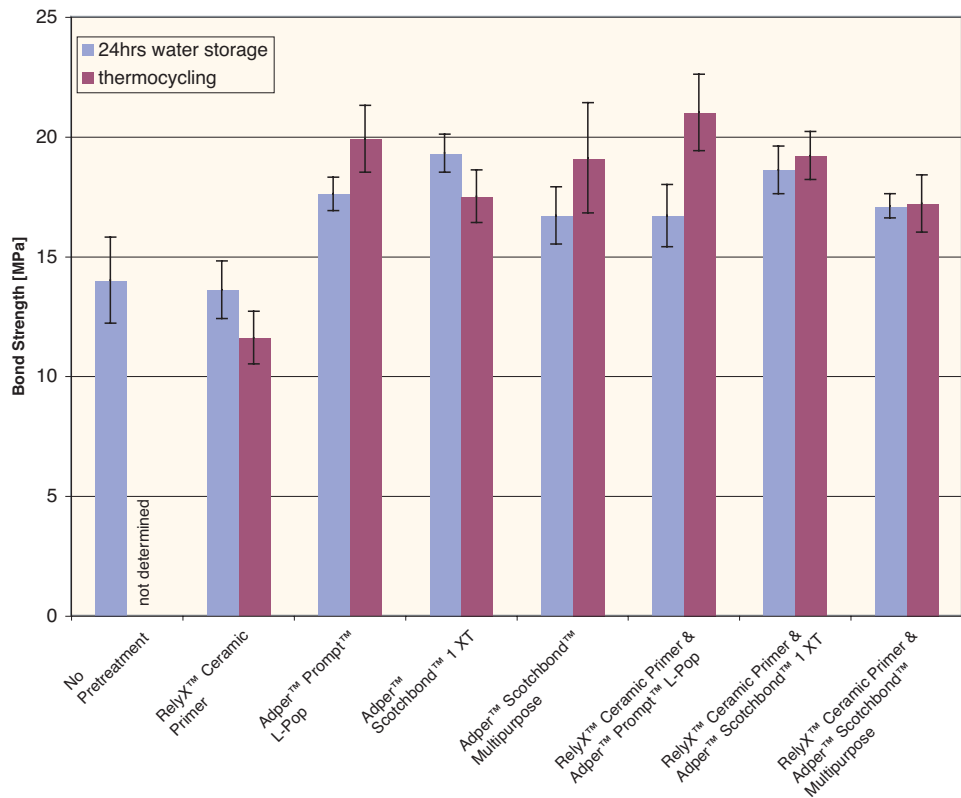
This has also been proven in a study conducted at the University of Berlin (Lit. 5). Light and electron microscopy images (Fig. 12) show a significantly reduced number of voids in the cement layer around posts when the RelyX Unicem Applicap Elongation Tip technique was used instead of a conventional technique where the cement is applied to the post before it is seated.



**Fig. 12:** The method of cement application determines the number of voids. Light microscopy and SEM images (cross section) of a simulated root canal filling in an acrylic glass test device. Left: A simulated root canal filled with RelyX™ Unicem Cement using the new RelyX™ Unicem Applicap™ Elongation Tip. Right: Resin cement applied using a common method of putting the cement onto the posts before placement. Voids, which can compromise bond strength, are clearly visible in the cement layer around the post.

### 3.5. The Secure Core

To achieve a secure bond between the composite core build up material and the RelyX™ Fiber Post it is sufficient to apply the respective bonding system to the post and the surrounding tooth structure as recommended by the manufacturer. After cementation and cleaning off excess cement the coronal part of the post is treated with the bonding agent. For 3M ESPE composite materials (e.g. Filtek™ Supreme XT, Filtek™ Z250, and others) 3M ESPE bonding agents such as Adper™ Prompt™ L-Pop, Adper™ Scotchbond 1 XT, or Adper™ Scotchbond™ Multi-Purpose are recommended. The adhesion test data (Fig. 13) shows that silanating (e.g. with RelyX Ceramic Primer, 3M ESPE) can be omitted without a negative impact on bond strength.



**Fig. 13:** Influence of different post pretreatment methods on bond strength values for Filtek Z250 universal composite on RelyX Fiber Posts. Adhesion was tested at the conical part of the posts and measured in a pull-off setup. Tests were performed after water storage (24hrs at 36°C) only or additional thermocycling (5,000 cycles 5°C / 55°C). (3M ESPE internal data)



# RelyX™ Fiber Post

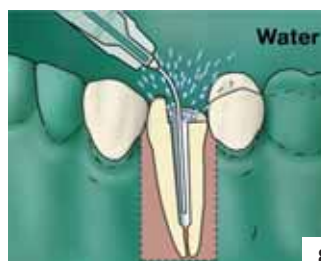
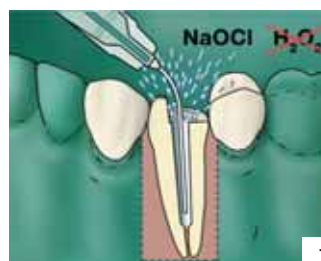
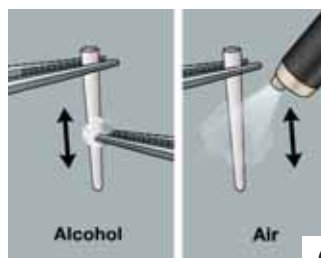
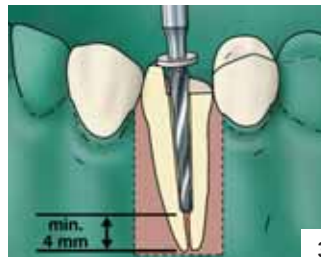
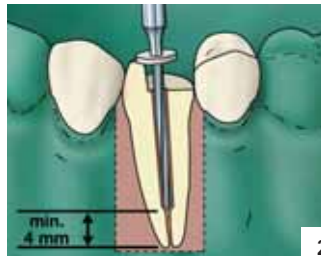
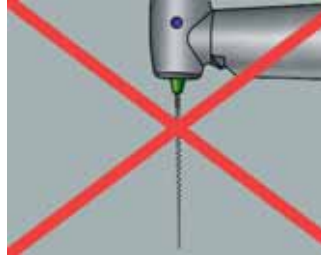
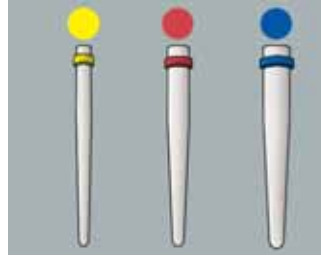
Glass Fiber Post

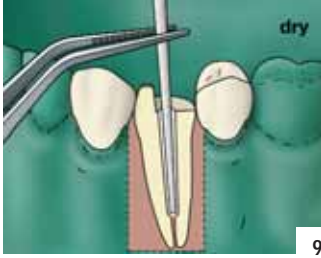
# RelyX™ Unicem Aplicap™

Self-adhesive Universal Resin Cement

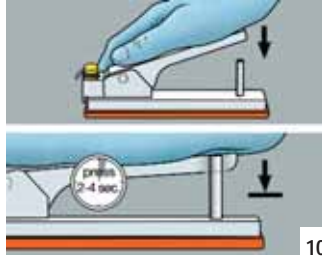


Technique Guides: RelyX Fiber Post / RelyX Unicem Aplicap  
Universal resin cement

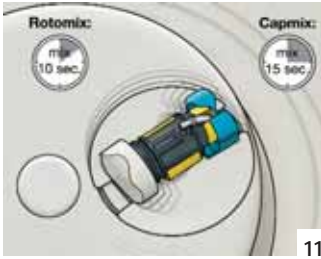




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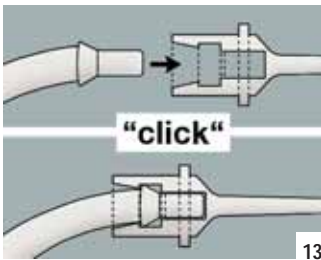
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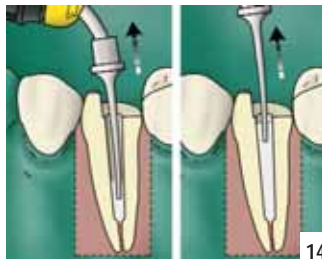
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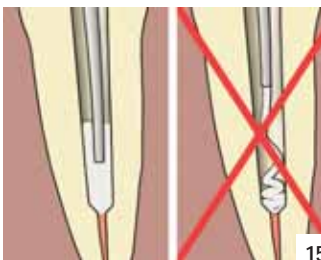
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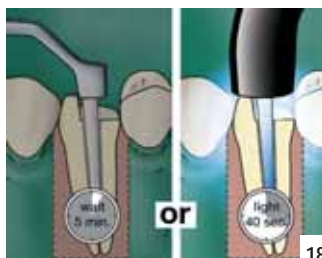
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## 5. Literature

**Lit. 1:** Stadler P., Wimmershoff M., Shookoi H., Wernisch J.: The stress transmission of pre-fabricated root canal posts; Schweiz Monatsschr Zahnmed. 1995; 105 (11) 1418-24.

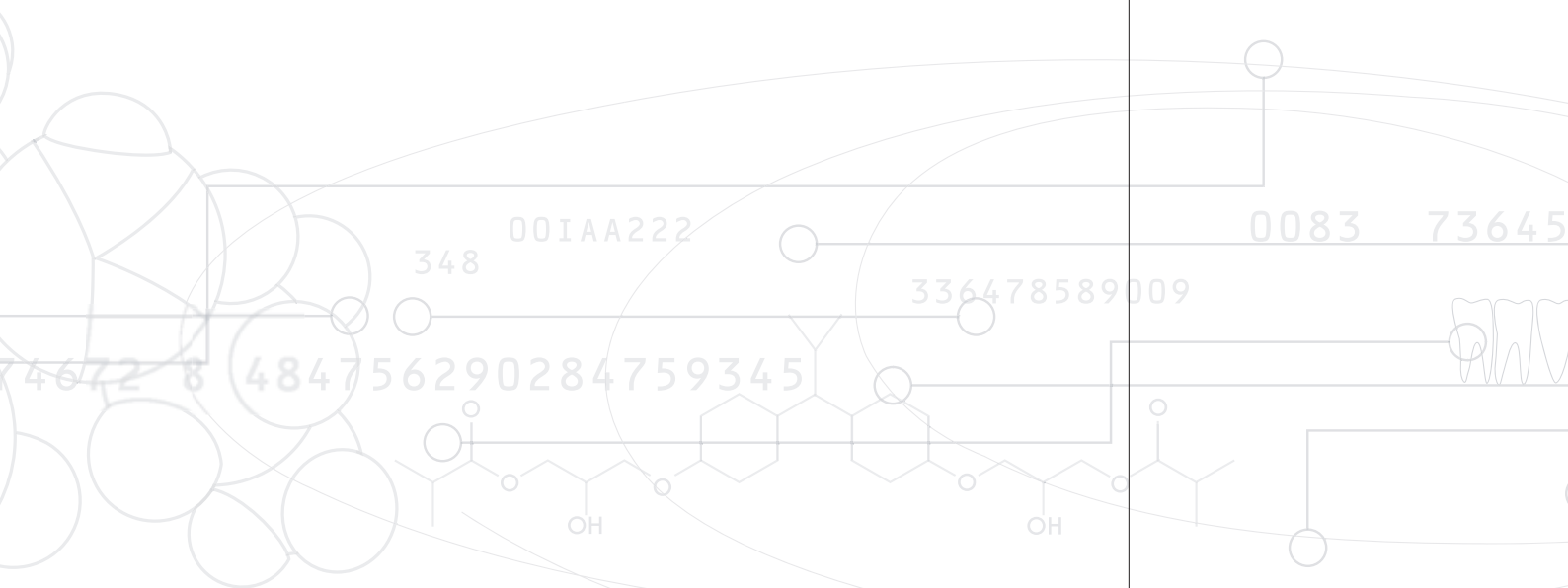
**Lit. 2:** Callister W.D.: Materials Science And Engineering. An Introduction. 5th Ed., Wiley, New York, p.793-795

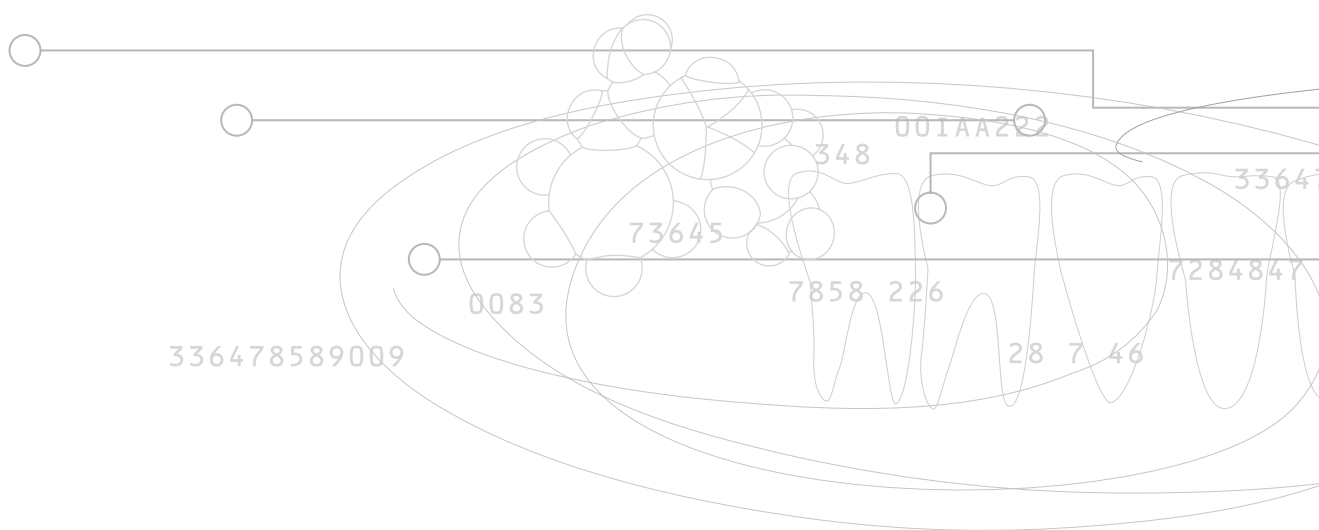
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