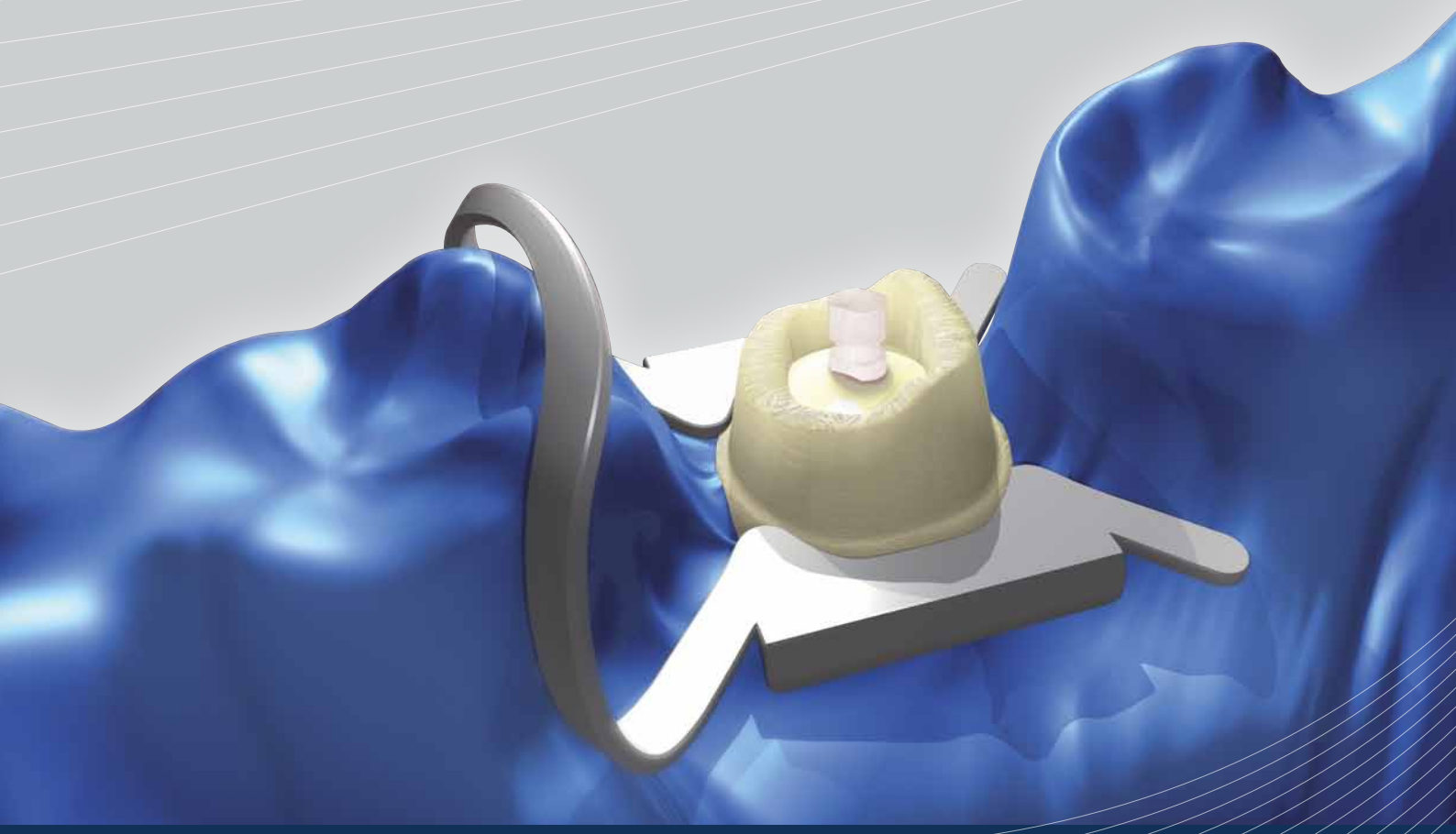
CONTEMPORARY RESTORATION

OF ENDODONTICALLY-TREATED TEETH



RTD

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OVERVIEW

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Coordinator of Tuscan School of Dental Medicine, University of Siena and Florence

Dean, Chair of Fixed Prosthodontics and Dental Materials University of Siena-Italy

I placed a fiber post for the first time more than 20 years ago. I have placed thousands of them since.

My group at the university was introduced to the original fiber reinforced composite post in 1989 by the inventors, two French dentists. These first posts were unusually shaped, made of unesthetic Carbon fibers and were radiolucent at best, but were engineered to do everything that traditional metallic posts do but without the usual risk of catastrophic root fracture. Many years later, fiber posts have evolved markedly, but that original promise remains the most compelling reason for their use. Moreover, my paradigm for treating badly broken down endodontically treated teeth (ETT) has been changed forever.

The fiber posts available to the clinician today offer a variety of shapes, sizes, colors, surface morphology and levels of radiopacity. Some very much resemble their metallic ancestors, others present a design all their own that bear only the primary purpose of a post with their ancestors; the retention of the core build-up and crown. And, though at a quick glance, the majority of fiber posts appear to be all the same, nothing could be farther from the truth.

Basically, fiber posts work because their Elastic Modulus is more or less the same as the dentin surrounding them, in their typical respective thicknesses. They distribute traumatic and masticatory stress in a manner coexistent with remaining tooth structures, resin cement and composite resins. And that's about where the commonalities between fiber posts end.

RTD, the French company that patented and commercialized the fiber post concept, has been at the forefront of the evolution of the technology. For example, some posts are composed using fairly common e-glass of s-glass fibers, some are enriched with radiopacifiers, including Ytterbium or Zirconia. RTD has laboriously created a high-silica fiber, optimized specifically for use in a dental post.

It should be emphasized that the clinical selection of a post should be directly correlated to the amount of remaining dentin, and a bonding system and cement. While the prevention of root fracture was the original goal of the inventors, some fiber posts nowadays offer other benefits, including a technique for practical re-treatment and a reasonable degree of radiopacity and light conductivity; all of importance to the clinician and patient.

No one involved with contemporary dentistry or research would deny the progress being made in dental implantology, but with a population that is keeping its natural teeth longer, endodontic and restorative treatment- even re-treatment- are still viable options for many socio-economic groups.

Over the last decade, my clinical and academic colleagues have investigated every relevant aspect of mechanical performance including Cyclic Fatigue. Fatigue is considered one of the principle causes of structural failure in restorative dentistry. Conservative restoration fails more often with cyclic loads than from the application of a single (Instron-type) load, even if relatively less. Fatigue tests can reveal the resistance value of every single post, simulating what takes place in the mouth during normal chewing.. The differences observed between different posts from different manufacturers are remarkable, and appear to be related to the composition, the microstructure and structural integrity of the posts themselves. We believe that this fatigue resistance will be related to clinical performance.

I have published no less than 8 clinical studies which include 9 or10 different brands of fiber posts. The longest observation group (7-11 years) included 3 generations of RTD fiber posts. Not only did we see a 92.8% clinical success rate, but we saw a consistent quality of performance between these 3 brands and compositions (Carbon and Quartz fibers) from the same manufacturer.

In a prospective clinical trial, Cagidago, et al have also determined that the insertion of prefabricated quartz fiber posts and customized fiber posts provided a significant contribution to the survival rate of pulpless posterior teeth (premolars), with varying degrees of remaining tooth structure. The RTD quartz fiber post was more effective than the custom-fabricated version, and both of these were more protective than the corresponding groups with composite resin alone. This was true at 3 year and 6-year recalls. Although a "ferrule effect" is absolutely recommended, the study group with the RTD post- and without remaining coronal walls OR dentin ferrule – had a 6-year survival rate of 94.4%; 45% higher that the NO-POST group (composite alone). This, along with other studies, indicates that there are clinical motivations for fiber posts besides core retention.

After the review of nearly 100 clinical and scientific papers, as well as several review articles and two textbooks bearing my name I have come to the conclusion that cast or prefabricated metal post are no longer useful, and more dentists owe it to themselves to investigate the data and products available in this dynamic area of restorative dentistry. The following pages should give you good suggestions in what to look for.

Conclusions:

- **Fiber posts show distinctly different mechanical properties than metal and ceramic posts**
- **The differences in these properties affect their clinical performance**
- **All fiber posts share some commonalities, but in vitro testing shows major differences between brands**
- **From a clinical and research standpoint, ceramic and metallic posts are obsolete.**

START OUT WITH HIGH-TECH MATERIALS

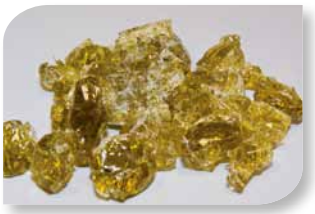
Starting out with building materials specifically made for the specific challenge puts us miles ahead before we ever touch the patient.

RTD, who pioneered the fiber post made huge development investment and 5 years' time to obtain a special fiber exclusively for use in their range of endodontic posts and other potential dental reinforcement products.

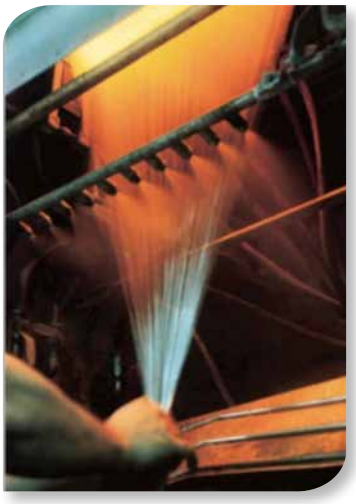
This proprietary process involves creating a special Silica (Quartz) glass with an elevated content of radiopacifier, for added tensile strength and radiopacity. In developing its own expertise, RTD has concluded that it is advantageous to make the base fibers more radiopaque than to impart the radiopacifiers into the resin matrix between the fibers.

Under a sophisticated heat & stretching process, the glass is turned into the patented X-RO fibers.

Quartz-glass



X-RO Quartz-glass



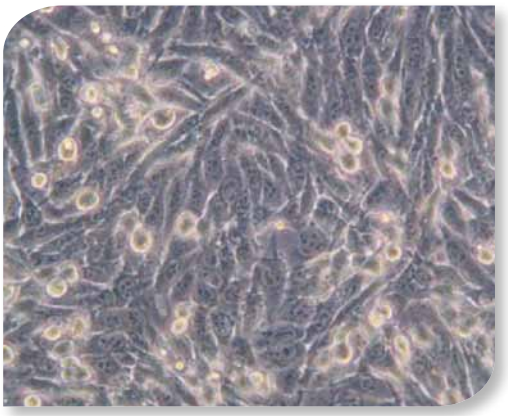
These fibers are industrially coated / saturated with a coupling agent formulated for this application, to promote an exceptional bond between the 12 micron fibers and the epoxy resin matrix; Interlaminate Shear Strength.

The X-RO fibers, saturated in the matrix, are "pulltruded"(may be pretensiled) under tension and heat to create an industrial composite mass that is several millimeters in diameter and more than 99% cross-linked, as confirmed by DSC testing.

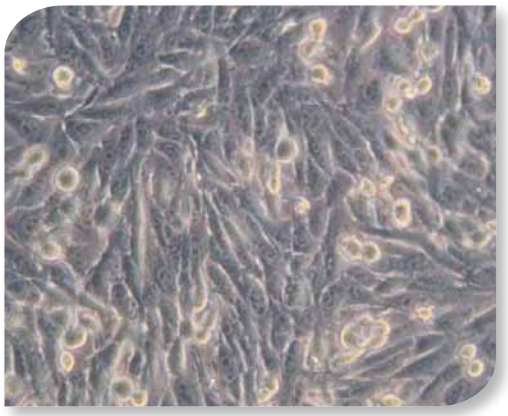
Comp	Industrial E-Glass	1st Gen Quartz Fibers	X-RO Gen Quartz Fibers
SiO_2	50-55%	99,5%	55-60%
Al_2O_3	14-16%	-	-
CaO	17-23%	-	-
B_2O_3	6-9%	-	-
ZrO_2	-	-	-
MgO	1-4%	-	3-10%
BaO	-	-	5-10%
SrO	-	-	10-20%
ZnO	-	-	3-10%

Fully biocompatible

Corrosion potential and corrosion by-product are significant and persistent drawbacks to base metal cast posts, steel prefabricate posts, and amalgam cores. In contrast, fiber posts are corrosion – free and the X-RO fiber posts have been subjected to all relative ISO biocompatibility testing protocols #10993:



Blank: negative control



X-RO sample: morphology and cell density as comparable to those of blank

Conclusions:

- **Cytotoxicity colony forming assay**
- **Intradermal reactivity**
- **Genotoxicity**
- **Systemic toxicity**
- **Hypersensitivity**

The use of superior raw materials continues to impart superior mechanical properties to these medical devices and this is recurrent in the mainstream literature.

Interlocked components; similar mechanical properties

One of the major causes of clinical failures with last-generation dental materials was the mis-match in electrolytical potential and the mechanical behavior between the functional elements, particularly Young's Modulus of Elasticity.
In contrast, utilization of materials for reconstruction that posses similar properties creates /allows an organic assembly engineered to be compatible in function. Some have labeled this harmony a "MONOBLOCK' restoration. Furthermore, in today's clinical practice, etchants and resin chemistry exist to have these elements chemically or micro-mechanically bound to one another, which in turn, helps prevent micro-leakage.

The tooth

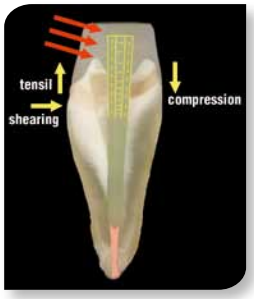
Most in vivo and clinical trials imply that the greater the amount of remaining tooth structure (the "ferrule effect"), the greater the chance of survival, regardless of the clinician's choice of post or core materials.

The post

The post should be designed with an Elastic Modulus (Stress/Strain) of 30 – 45 Gigapascals, when tested at an angle of 30 - 45°; the typical angle of masticatory force. With the preservation of radicular dentin and anatomy in mind, the post should have a tapered apical section; optimal adaptation and low cement film thickness.

The core

To prevent show-through the ginigiva or an esthaetic crown, a core build-up is easily and directly placed utilizing Light-cure or Dual-cure composite resins. This should have appropriate optical and mechanical properties. These materials will typically have an Elastic Modulus of less than 20 GPa.



Flexural strength 1600 - 1900 MPa

Flexural Strength may not be the most important aspect, but any clinician could agree that "more is better". In clinical service the post must undergo COMPRESSION on one side TENSION on the opposite side and SHEARING between the fibers and matrix in the middle….simultaneously. This property is most accurately tested in ISO Specification 14125, performed on a length of the raw material (Fig. 1).

Interlaminate shear strength: 65 - 75 MPa

This chemical binding between the fiber and matrix will affect both Flexural Strength and Fatigue Resistance. This must be done consistently during the manufacturing process.

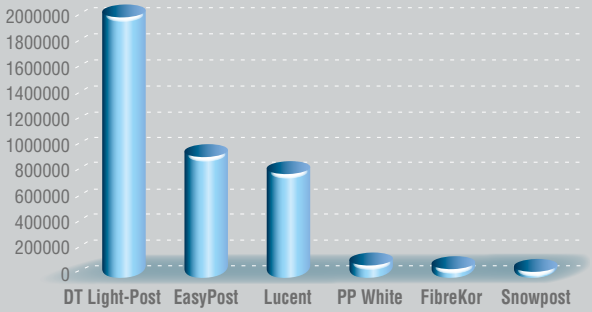
Fig. 1

Fatigue resistance: ten million cycles

This is where the structural integrity of the post and the quality of the raw materials come together. If one of these criteria is not met, then cyclic fatigue, which simulates what will happen in function, will either stretch the fiber to failure, or tear the fibers from their matrix (Figs 3, 4). In independent comparative testing, the RTD fiber post (Fig. 2) has survived 2 MILLION cycles (Table #2).

(Note: At RTD, samples of the fiber posts from each master batch must survive **10 MILLION** cycles as part of the internal QA/QC program).

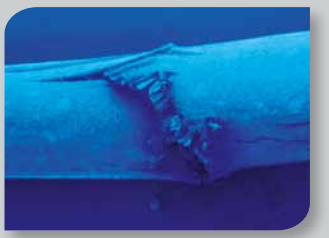
Table 2: Independent cyclic fatigue test results



Grandini, S., Goracci, C., Monticelli, F., Borracchini, A. F., Ferrari, M. An evaluation, using a "three-point bending" test, of the fatigue resistance of certain fiber posts. Il Dentista Moderno, March, 2004:70-75

RTD Fiber Post after 2,000,000 fatigue cycles

Fig. 2



Glass Fiber Post "B" after only 100,000 fatigue cycles

Fig. 3

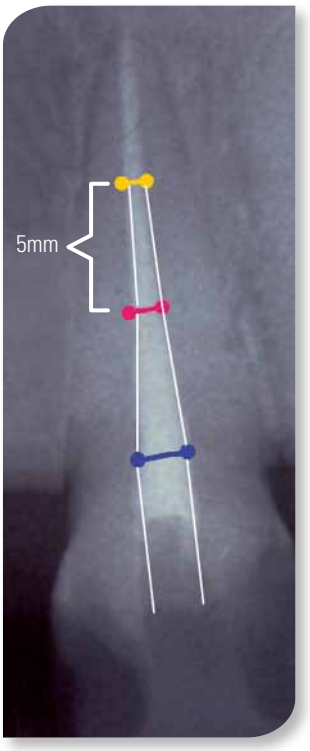
Glass Fiber Post "A" after only 800,000 fatigue cycles

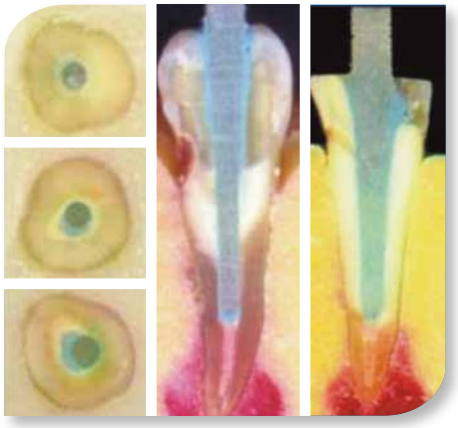
Fig. 4

FOLLOWING TRUE ANATOMY FORM

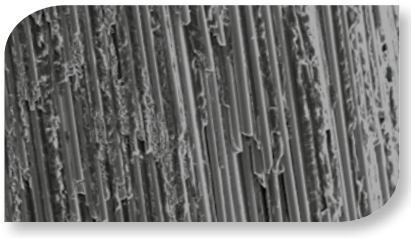
D.T Light-Post® Illusion® X-RO®

(Double-Taper) D.T Light-Post profile was designed by a team of Endodontic and Prosthodontic professors to maximize the adaptation of the post with minimal dentin removal inside the root, usually without further preparation and maximum bulk and strength to support the core build-up.



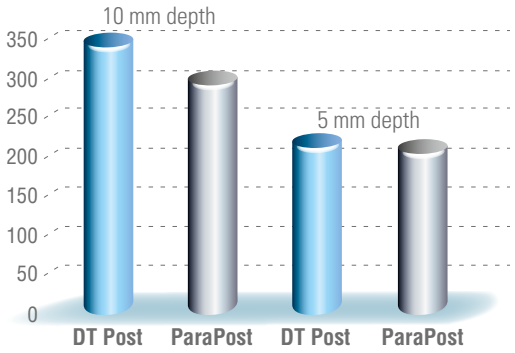


The prototypes were placed in over 400 extracted teeth, and evaluated for fit and adaptation.

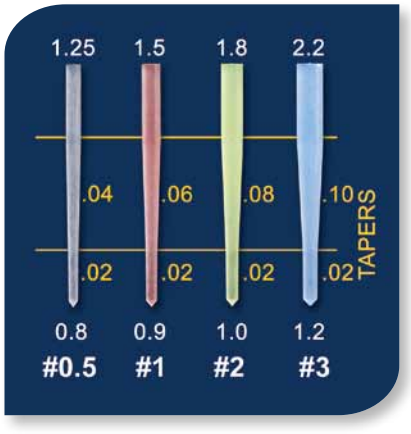


The "smooth" surfaces of the posts are actually machined to present a MICRO-mechanical surface to the resin or cement for retention.

Fiber versus metal post retention



Borer, R., Leandro, R and Haddix, J. Effect of dowel length on the retention of two different prefabricated posts. Quintessence Int. 2007;38:173.e164-168



To that end, each of the 4 DT Light-Post sizes has two separate tapers and a parallel coronal section, all based on thousands of measurements of hundreds of root canal treatments.

Doctor en Odontologia
Especialista en Protesis
e Implantes U.N.C.
Profesor Adjunto Catedra
de Protesis Clinica

Dr. Daniel Torassa, Cordoba, Argentina

Single post, narrow canal space

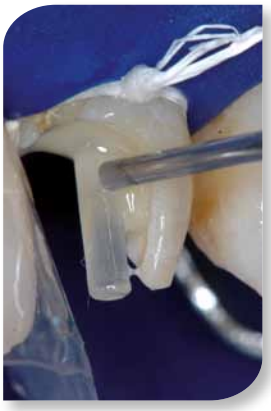
In the case of a first treatment, the conservative root canal treatment is typically narrow, round and slightly tapered; usually the result of treatment with several file sizes, 0.02 – 0.10. Because of the process by which their dimensions were determined, I can usually find one of the 4 DT Light-Post sizes that fits correctly, "right out of the package" and without much further preparation or dentin loss.

1

Though badly broken down coronally, this lateral incisor had NOT previously received a post. After removal of the defective tooth structure and gutta percha, the DT Light-Post is trial-fitted, then removed and the excess removed with a bur.

2

After etching, rinsing and air-drying, an adhesive primer is placed on all involved tooth structure according to manufacturer's instructions.



3

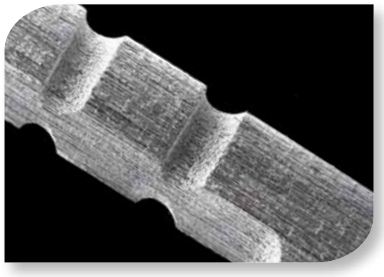
Dual-cure resin cement is injected, the post placed and additional composite placed to form the core build-up.

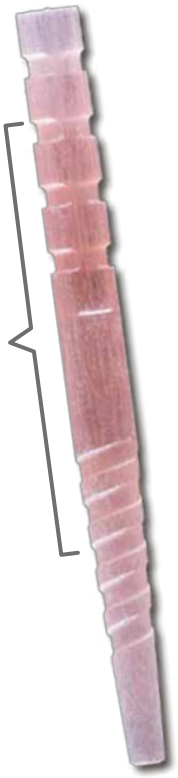
4

After thorough light curing, the build-up is trimmed in the usual way.

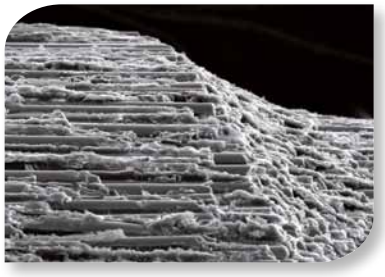
View this entire clinical case at ***www.rtd.fr/torassa***

INCREASING RETENTION WITH ALL TYPES OF CEMENTS

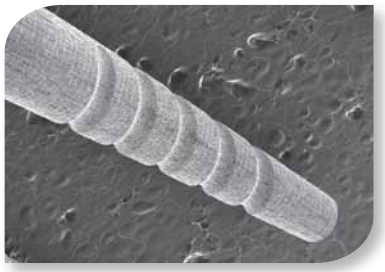




The post locks, by Micro and Mechanical retention, into the cement and core material.

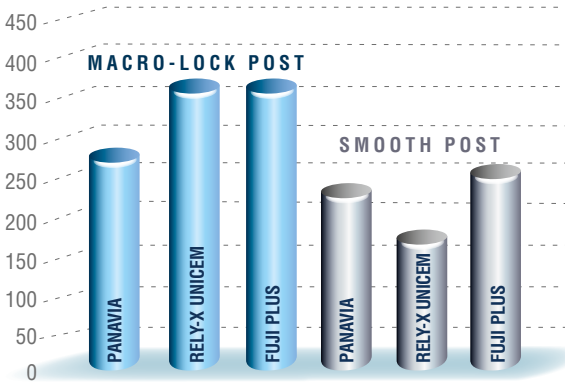


Post design and surface morphology can be as influential as the post and resin composition. The Macro-Lock Illusion post design includes a "positive" macro-retentive feature for added retention.



Tapered apical segments precious dentin, maximize adaptation and minimize cement film thickness.

In vitro bond strength of smooth and serrated fiber posts



Retention of quartz fiber posts using different luting cements Baldissara, P., Monaco, C., Valandro, LF, Scotti, R.J Dent Res. Vol 88 (Spec. Issue A) Abstract #976, 2009 (www.dental-research.org).

Full-time private practice with an emphasis on aesthetic rehabilitation, international lecturer, published author, clinical evaluator for several major dental manufacturers.

Dr. Tony Pensak
Calgary, Alberta Canada

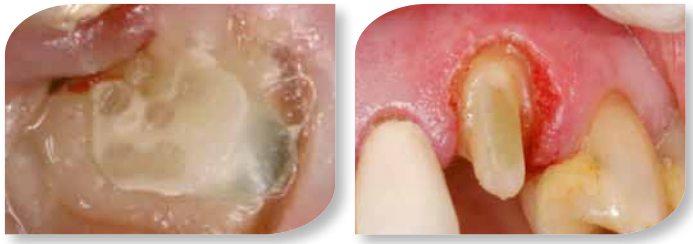
Multi-post restorations in The Over-Flared Canal

If the width of coronal orifice of the prepared space exceeds 50% of the widest fiber post available, the utilization of secondary "Accessory Posts" is indicated. Research indicates that this will be superior to a space filled with cement or composite only. The additional posts add some cost, but can still be provided in one appointment at a fraction of the cost of a cast post. With this direct technique, undercuts created in the preparation are not critical.

1 This patient had lost a cast-post to corrosion leaving a WIDELY TAPERED space, and a weakened tooth. After removing the corrosion product and contaminated gutta percha, the apical section was trial-fitted with an appropriate sized Macro-Lock post.

2 The post and post space is cleaned, etched and treated with primer compatible with dual-cure resin cements and composites. Primer is air-dried and light-cured. Dual-cure resin cement is injected into the post space and the Master post (Macro-Lock) is inserted, IMMEDIATELY followed by Fibercone accessory posts, and light-cured.

3 Additional core material is placed on and between the posts, sculpted and light-cured. Use of a dual-purpose flowable resin, such as Corecem, for the cementation and core build-up can save waste and chair-time.

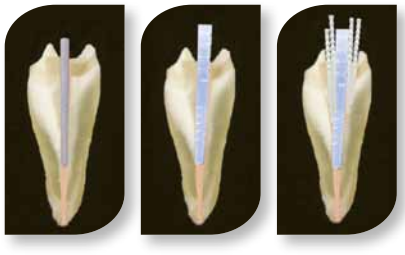


4 Due to an inadequate ferrule of tooth structure, approximately 2mm of gingival tissue was excised using a 980nm diode laser allowing for the apical repositioning of the labial margin onto sound dentin, creating a "ferrule effect".

View this entire clinical case at ***www.rtd.fr/pensak***

Conclusions:

- **The use of multiple posts, Accessory Posts, reduces the amount of cement and polymerization shrinkage to counteract a C-Factor**
- **Accessory Post technique increases the fracture resistance of the restoration of endodontically - treated teeth.**
- **Placement of multiple posts in wide flared canals provides better adaptation, as you might imagine a "Low-Modulus Cast Post"**



Dr. Alejandro Bertoldi Hepburn

Professor at the postgraduate course of Oral Rehabilitation. Dental School

Universidad del Desarrollo (City of Concepcion, Chile).

Dr. Alejandro Bertoldi Hepburn, Concepcion, Chile

Treating the Mildly-flared Canal

When the opening of the post space is 25% - 50% wider than the selected fiber post, there are two additional low elastic modulus techniques available. Direct-indirect chair-side techniques using composite resin over the post allow good adaptation. A light-cured composite can fill the flared space. Once the post is removed, the "supplementary" composite can be additionally cured and in this way enhance several of its properties.

A fiber augmented "build-down" offers the advantage of reinforcing the composite by up to 300%.

Anatomic Post and Core

1 This patient presented with a failed cast post and core which was exhibiting dark-root syndrome. The cast post was removed, undercuts removed, and the space cleaned. After the Try-In of a #3 Macro-Lock Illusion Post, a water-soluble separating medium was applied to all exposed hard surfaces.

2 After cleaning the post, a compatible resin adhesive was applied to the post, air-dried and light-cured. A high-strength light-cured composite was adapted over the coronal third of the root canal portion of the post.

3 The post and composite were re-inserted. The composite was adapted over the walls of the flared open space. It is "spot-cured" from the occlusal aspect, then withdrawn. It was also further cured extra-orally to increase its degree of conversion and in this way its resistance.

4 The space was cleaned again, etched and rinsed with water. Afterwards a compatible resin adhesive was applied. The customized post was cemented with dual-cured resin cement. Additional core material was added, light-cured and the core trimmed as usual.

View this entire clinical case at ***www.rtd.fr/bertoldi1***

Fiber Augmented Post and Core

1

Due to an infection, a cast metal post has been removed from the root of an upper canine. The root canal was retreated. A properly – sized Macro-Lock Post was tried-in. The post fit correctly in the apical third, but in the middle and coronal third of the preparation there were important spaces between the post and the walls that represented the lack of adaptation of the post.

2

The post space was isolated with glycerin. The post was cleaned and a resin adhesive applied and light-cured.

3

The post, covered by the Quartz Splint Uni-Directional fiber strands, was placed into the post space. With care and light pressure the structure was positioned until the post fit correctly in the apical end. The coronal excesses of the fiber strand were kept for creating the core. Once positioned and correctly adapted the fibers should be light-cured, and removed. It can be further light-cured extra-orally.

4

After cleaning, etching and rinsing the post space a resin adhesive was applied. The dual cure resin cement / core material was injected with a long point applicator in order to reach the bottom of the post preparation.

5

Placed back in position, the coronal portion of the post and the fibers were covered with same resin composite material and light-cured

6

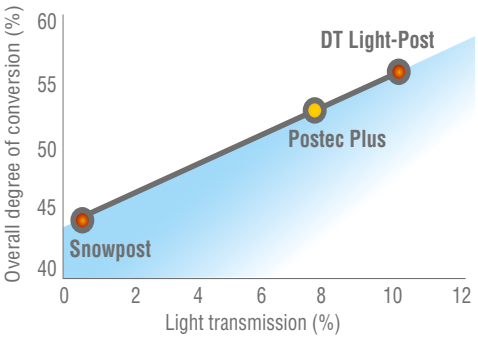
The core was trimmed as usual.

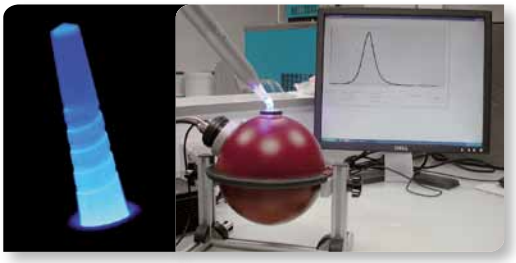
View this entire clinical case at ***www.rtd.fr/bertoldi2***

LIGHT CONDUCTIVITY

Capitalizing on post translucency

Most fiber posts are being placed with a dual – cure resin cement, whether matched with a bonding agent or another cementation system altogether. With "macro-retentive" fiber posts, some clinicians are also using Resin Modified Glass Ionomer cements. To expedite post-core placement technique, it is convenient to stabilize the posts once fully seated in the cement, well enough to proceed to the core build-up step; a "spot cure". This is not intended to completely polymerize the cement. RTD has optimized the need for superior light conductivity without compromising radiopacity. However, superior light conductivity enhances this result. The degree of light conductivity has been shown to influence the Degree of Conversion (%) in the surrounding resin.





Kim, Y.K., Kim, S. K. , Kim, K.H. Kwon, T.Y.. Degree of conversion of dual-cured resin cement light-cured through three fibre posts within human root canals: an ex vivo study. International Endodontic Journal Volume 42 Issue 8, Pages 667 – 674

CLINICAL FOLLOW-UP

Chief of Biomaterials Unit, Assoc Professor of Restorative Dentistry, School of Dental Medicine, East Carolina University, North Carolina, USA

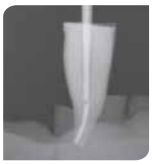
Waldemar de Rijk, PhD, DDS

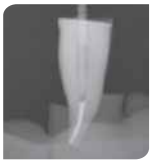
Radiographic Density

The radiopacity of an endodontic post is crucial in the placement of a post and for future clinical evaluations. Large variations in radiopacity are seen in currently available posts. These variations arise from the methods by which the posts are produced. Radiopacity is achieved by adding opaquing agents to the post, either by including them in the resin matrix or integrating them in the glass fibers.

When the opaquing agents are add to the resin matrix, the physical properties of the post are affected negatively, and the concentration of the agents that can be achieved is limited. Incorporating the radiopaquers in the glass phase has no influence on the physical properties, thus optimum radiopacity can be achieved.

In selecting a fiber post, the radiopacity of the available posts should be considered as a major factor in the decision process. This is illustrated in the figures at right showing the various levels of radiopacity of a few different fiber posts placed (without cement) into the same extracted tooth, for purposes of comparison.


DT Light-Post XRO


Fiber Post B


Fiber Post C


Fiber Post D

Color-enhanced re-access technology

Another innovation patented by RTD involves the intrinsic colorization of the X-RO fiber posts. The small but significant portion biocompatible colorant gives each DT Light-Post Illusion and Macro-Lock Illusion size a distinctive color identity, which matches the corresponding placement drill, to reduce errors and expedite placement and post removal. The color disappears when the post is placed in the tooth and the rubber dam is removed, and it becomes neutral in color. Once the crown is placed, the color cannot return. If re-access / removal becomes necessary, after removal of the crown, the cold water spray on the end of the post returns the color. This makes it easy to determine which post is present, and which post drill sizes with which to finish the removal, and when it has been completely removed.

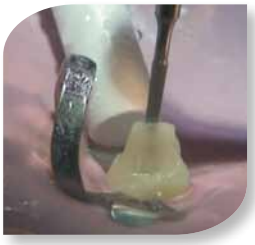
Courtesy of Dr Cheleux

DT Light-Post® Illusion® Removal Courtesy of Tony Pensak, DDS, Calgary Alberta, Canada

"Between 10% and 24% of endodontic treatments will eventually require re-retreatment, and sometimes fiber posts break doing exactly what they were designed to do....absorbing stress. The removal of a metal or ceramic post can be tedious and dangerous. RTD developed a simple re-access drill system that facilitates the removal the post and cement without sacrificing more dentin. To demonstrate, this is an in-vitro removal, done in "real time", in 90 seconds.

1 Remove the prosthesis or restoration to obtain access to the coronal and of the post, still surrounded circumferentially by the composite core. Make a new radiograph to determine the new length of the post. Spray cold water to restore the color and location of the post. Create a pilot hole in the center of the post.

2 With the special carbide drill included in the RTD Re-access Kit, remove the center core of the post, oscillating the carbide in and out at 500 – 2000 r.p.m. until it punches through into the cement and Gutta Percha at the end of the post. Now there is a clear, tapered channel the entire length of the post.



3 At slow speed, move through the increasing sizes of the Finishing Drills for that post design (DT Light-Post of Macro-Lock) using the same oscillating technique, until the final size is reached.

4 After the final size is used, all of the post and the cement should be removed. The GP and intra-radicular dentin should be visible. Treat the causative and place another fiber post.

View this entire clinical case at ***www.rtd.fr/removal***

TESTIMONIALS

Dr. Nicolas Cheleux

Private Practice.
Former Assistante
of Toulouse University

"I have used RTD fiber posts regularly for more than 10 years and I have had the opportunity to observe the constant improvement with each generation of fiber post. The replacement of the carbon fibers with quartz fibers has dramatically improved the bio mechanical properties, with a modulus of elasticity closer to the dentin, the adhesion with all of the bonding systems as well as the optical properties of the post, to optimize the aesthetics of the final restoration."

Dr. Simone Grandini

Professor Simone Grandini DDS MSc PhD Chair of Endodontics and Restorative Dentistry Department of Endodontics and Restorative Dentistry Dean of the School of Dental Hygienists Tuscan School of Dental Medicine University of Siena, Italy.

"Fiber posts have changed the way of thinking the restoration of endodontically treated teeth. Double-Taper posts represent the gold standard in this field: they ensure a very good adaptation to the root canal walls, and can really be of great help for the clinician. Post cementation and core reconstruction can be obtained at the same time with Corecem, limiting the amount of cement, of course saving time, and definitely with a high quality material."

Dr. Yining Wang

Professor Wang DDS PhD.
Director of Prosthodontics Department, School of Stomatology, Wuhan University, China.

"The validity of fiber post has been confirmed by both of the clinical data and experimental studies. I have been using MacroLock fiber post for more than three years. The clinic outcome is excellent. Meanwhile, the mechanical properties of MacroLock fiber post have been tested in our studies, experimental or numerical analysis.
The quality of MacroLock fiber post is outstanding."

Dr. Gilberto Henostroza

Specialist in Restorative and esthetic dentistry, is a dean at the University Peruana Cayetano Heredia since 1992, and the Chief of the Section for Operative Dentistry and Biomaterials.

"I have been using RTD composite fiber posts since their original Carbon fiber version. I have been very satisfied with the clinical results over these 15 years."

Dr. Enrique Kogan Frenck

Professor of Restorative Dentistry; Universidad Tecnológica de Mexico, visiting professor Nova Southeastern University College of Dental Medicine, Fort Lauderdale, Fla and has a private practice in Mexico City.

"Fiber posts are a reality and a better alternative for the reconstruction of teeth with endodontic treatment. RTD is the creator and the better systems I am recommending….why not use the best?"

Dr. Yaming Chen

Professor & Chair
Dept. of Proshodontics & Polyclinics Stomatological School& Hospital Nanjing Medical University, China.

"I like to use fiber posts for restoration of badly broken down teeth. I have used RTD fiber post for several years, and I am so happy because the clinical results are excellent! In my experiments, RTD posts also demonstrate very good properties. Now, RTD fiber post is one of our favorite fiber posts in our department."

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