Scientific and clinical insights about fibre posts
This manual is based on the work accomplished in the course of studies “Dottorato in Biomateriali Odontostomatologici” (Doctorate class in biomaterials in odonto-stomatology) of Siena University, Italy, and was written with the participation of

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Scientific and clinical insights about fibre posts has been written in collaboration with the University of Siena (Italy) and the RWTH Aachen (Germany).

This brochure is an update of the clinical evaluations and scientific publications of fibre posts.
1. Introduction

1.1. Function of a Root Canal Post

Scientific research has given up the claim that a root canal post could reinforce the remaining tooth structure of an endodontically treated tooth. It is now widely known and confirmed that the main function of a root canal post is to allow and support the coronal prosthetic core.

Using a root canal post should not increase the risk of root fracture but avoid stress concentration in areas at higher risk thanks to its ability to evenly distribute the stress along the root canal.

1.2. Classification of the Posts

The classification according to Dallari (Lit. 1) differentiates the posts according to the different methods of reconstruction.

A) Self-retentive metal posts
B) Metal posts with passive retention
C) Non-metal posts with passive retention

A) The first group is comprised of self-retentive posts which develop close contact to the endodontically prepared root canal walls: e.g. metal cast posts bonded with zinc oxide phosphate and systems with self-cutting threads or different types of standard root canal screws (see Fig. 1).

B) The second group is comprised of metal posts with passive retention and cast posts using different adhesive techniques for bonding, as proposed by Nathanson (Lit. 2). These techniques eliminate direct contact between the post and the root canal wall, by creating a space which is filled with composite bonding material.

C) The third group is comprised of non-metallic root canal post systems such as ceramic posts and fibre-reinforced posts with passive retention.

Many studies have examined the efficiency of different post systems. In some studies, proof was found that the extreme contact between post and canal wall found in post systems with self-retention could be the cause of longitudinal root fractures.

In their retrospective study Sorensen und Martinoff (Lit. 3) examined 1237 teeth which had been endodontically treated between 1 and 25 years previously. Out of the 420 teeth restored with cast posts 36 failed due to loss of retention, root fracture or perforation.

A study published by Isidor (Lit. 4) showed that in bovine teeth restored with Composipost® (RTD) and submitted to a force of 250 N for up to 1 million cycles no root fracture occurred. Coltène Parapost titanium posts and cast posts, on the contrary, caused root fractures after 600,000 and 100,000 cycles respectively.

After reviewing the existing literature one finds that the use of cast posts and pre-shaped passive retention posts is to be recommended due to the fact that the composite between post and wall is able to absorb and eliminate the load transmitted from the crown to the root.

Until the end of the 80s the dentist's choice was limited to either pre-shaped metal posts or cast posts. At the beginning of the 90s though, due to new technologies, his choice was extended to ceramic posts as well as fibre posts.

VDW has made this technological development to a priority and offers a variety of new quartz fibre posts such as DT White®, DT Light®, DT Light®SL.

DT Light®Post has been voted best product several times in a row by The Dental Advisor, the CRA group and REALITY:
1.3. History of the Fibre Post

The history of the root canal fibre post begins in 1983 with Lovell and continues with Duret-Reynaud, who in 1988 invented the Composipost® system which incorporates carbon fibres in an epoxy resin matrix.

Duret and colleagues recognised the great advantage of combining materials with the same physical and mechanical properties in order to create a unit of tooth-cement-post-restoration material which would allow the functional load from the prosthesis to be absorbed in the same way as with an intact tooth.

In fact, the fibre post presents a modulus of elasticity very similar to dentin (Fig. 2) thanks to its anisotropic behaviour, i.e. its capacity to adapt its physical properties to the load direction of an endodontically treated, restored tooth undergoing dangerous lateral loads.

The post’s anisotropic behaviour, its dentin-like modulus of elasticity and the use of a BisGMA based cement ensure a homogenous structure improving the absorption and distribution of mastication loads.

In contrast, materials with a high modulus of elasticity in a restored tooth favour the risk of root fracture as, due to the high rigidity, the loads are concentrated mainly in the apical region and along the walls of the tooth. (Fig. 3)

In addition, the risk of corrosion of the pre-shaped metal post, and therefore treatment failure, presents a further argument in favour of fibre posts. (Fig. 4)
1.4. Indications

Based on the following study, a fibre post should be placed in an endodontically treated root canal if there is more than one missing dentin wall, as shown in Fig. 5.

The effect of post and core build-up on the fracture resistance of endodontically treated premolars restored according to various techniques. (Lit. 5)

Objective: Determine to which degree the fracture resistance of endodontically treated pre-molars is influenced by the post and by the system used for core build-up, as well as by the amount of remaining tooth substance.

Material and method: After the endodontic preparation of 90 human extracted teeth, several cavities were prepared simulating various clinical situations and different restoration methods were applied. The static fracture resistance was examined to find out at which load the fracture occurred and to assess the failure mode of each tooth. In the group of healthy teeth (control group) the endodontic access to the pulp was filled with X-flow™ and Esthet-X® (Dentsply). The DT Light® Posts were silanised, primed with Prime&Bond® NT/X-flow™ and cemented with Calibra™. The access, the cavity and the core build-up were prepared with the composite X-flow™ and the restoration material Esthet-X®.

Results of fracture resistant teeth

<table>
<thead>
<tr>
<th>Walls</th>
<th>Post</th>
<th>Mean value (N)</th>
<th>N</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Walls</td>
<td>No post</td>
<td>856</td>
<td>10</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>649</td>
<td>10</td>
<td>163</td>
</tr>
<tr>
<td>1 Wall</td>
<td>No post</td>
<td>488</td>
<td>10</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>573</td>
<td>10</td>
<td>169</td>
</tr>
<tr>
<td>2 Walls</td>
<td>No post</td>
<td>422</td>
<td>10</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>513</td>
<td>10</td>
<td>121</td>
</tr>
<tr>
<td>3 Walls</td>
<td>No post</td>
<td>416</td>
<td>10</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>422</td>
<td>10</td>
<td>103</td>
</tr>
<tr>
<td>4 Walls</td>
<td>No post</td>
<td>502</td>
<td>10</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>502</td>
<td>10</td>
<td>152</td>
</tr>
<tr>
<td>Total</td>
<td>No post</td>
<td>537</td>
<td>50</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>539</td>
<td>40</td>
<td>160</td>
</tr>
</tbody>
</table>

Table 1 Results Mean value in N

Conclusions:
- A post used in combination with restoration material allows restoration of endodontically prepared pre-molars achieving biomechanical properties close to the properties of an intact pre-molar.
- The number of remaining walls influences the mechanical resistance.
- Under similar circumstances (same number of remaining walls), the specimens restored with a fibre post showed the highest fracture resistance.
- Fractures that could be repaired were found among the specimens prepared with posts. Even though specimens with no remaining walls and without post showed higher fracture resistance than those with post, the rebuilt pre-molars without post suffered irreparable root fractures, while the teeth restored with fibre posts had only partial and reparable fractures of the crown.
2. Properties of the DT Post

2.1. Composition

Fibres: Quartz at 64 vol. -% and 70-80 weight -%
Diameter 12 micron
Pre-tensioned

Matrix: Epoxy resin

Bonding agent: Silane

2.2. Fibres

The fibres represent the inorganic component of the post, at the same time they are its supporting structure. The composite materials fibre/resin, including the fibre posts, show their highest resistance to tensile stress when the load is exclusively borne by the fibres. For this reason the type of fibre is of great importance (Lit. 6).

DT posts are made of resin fibres which feature high tensile resistance and appropriate elasticity modulus, while glass fibres are less resistant and have a higher E-modulus. When comparing the tensile strength of the different fibres with metal and ceramic the quartz fibre posts are the most resistant (Fig. 6).

![Comparison of tensile resistance](image)

Fig. 6 Tensile resistance of several materials (Source Oral Health, 2002)

The differences and properties of the various post systems also depend on other parameters, such as fibre diameter or density, bond between fibre and resin matrix, absence of bubbles or cavities in the post as well as the external surface of the post. All these parameters can be easily examined by scanning electron microscope (SEM).

Table 2 Comparison of 8 groups of posts (Source S. Grandini et al (Lit. 7))

<table>
<thead>
<tr>
<th>Type of post</th>
<th>Diameter of the post (mm)</th>
<th>Diameter of the fibres (micron)</th>
<th>Density of the fibres (number of fibres per mm²)</th>
<th>Occupied surface per mm² of post surface (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy Post (Krugg)</td>
<td>1.6</td>
<td>12</td>
<td>29</td>
<td>34.8</td>
</tr>
<tr>
<td>Parapost Fiber White</td>
<td>1.5</td>
<td>6</td>
<td>18</td>
<td>10.8</td>
</tr>
<tr>
<td>Fibrekor</td>
<td>1.5</td>
<td>18</td>
<td>28</td>
<td>50.4</td>
</tr>
<tr>
<td>Ghimas White</td>
<td>1.8</td>
<td>12</td>
<td>30</td>
<td>36.0</td>
</tr>
<tr>
<td>DT Light®Post</td>
<td>2.0</td>
<td>12</td>
<td>32</td>
<td>38.4</td>
</tr>
<tr>
<td>FRC Postec</td>
<td>2.0</td>
<td>12</td>
<td>25</td>
<td>30.0</td>
</tr>
<tr>
<td>Luscent Anchors</td>
<td>1.7</td>
<td>15</td>
<td>29</td>
<td>43.5</td>
</tr>
<tr>
<td>Snow Post</td>
<td>1.6</td>
<td>7</td>
<td>36</td>
<td>25.2</td>
</tr>
</tbody>
</table>
Any fibre of a post which is not placed parallel to its axis - this is the case with most of the posts on the market - distributes the load towards the matrix, whereas the fibres of the DT posts run parallel to the longitudinal axis of the post. The manufacturer of the DT post (RTD) uses a device to pre-tension the fibres, i.e. to keep them taught while the resin matrix is applied to the fibres.

![Figure 7](Source RTD)

**Pre-tensioning of the fibres**

- Tensioned Fibres
- Aligned Fibres
- Addition of the resin matrix and polymerisation
- Tension release

Fibres that are pre-tensioned in one direction along the axis enable the post to absorb considerable loads (Fig. 8):

- Tension/Pull (tensile)
- Pressure/Push (compression)
- Side force (shearing)

![Figure 8](Source Duret)

**Load distribution**

(Source Duret)
2.3. Matrix
The epoxy resin matrix incorporates and binds, through common free radicals, to the BisGMA resin, and enhances the bond between post and adhesive bonding systems.

2.4. Post Surface
The external surface of the DT post shows deep micro-roughness (5-15 microns) providing excellent micro-mechanic retention (Fig. 9) and minimizing the risk of loss or dislocation of the post. The coronal part of the root canal is perfectly sealed. Figure 10 shows the interface between post, cement (Calibra™, Dentsply) and dentin.

2.5. Radiopacity
DT Light®, DT White® and DT Light®SL Posts are radiopaque and, therefore, easy to identify on x-ray images. According to the aesthetic study conducted by the CRA group in 2004, the radiopacity of the DT Light®Post is 200 % Al (Fig. 11a and 11b).

2.6. Quality Control
The mechanical properties and probably also the clinical success of the posts depend to a great extent on how advanced the production techniques used by the different manufacturers are and on their quality control procedures. In order to supply the market with constant and high quality production, RTD has developed a production process integrating synchronized non-stop operation equipment, comprising not less than 6 separate production phases. Amongst them tests for bending resistance (Fig. 12 and 13).
3. Double Taper Design (DT)

In 1990 some Endodontists and Prosthodontists at the University of Montreal thought it was about time to design a post that would fit the root canal, instead of adapting the canal to the post’s design, as was often the case at that time. The outcome of this idea was the double tapered DT post. In order to determine the correct anatomic shape, 967 canals in extracted teeth were analysed after they had been endodontically treated with various techniques. Hundreds of measurements were taken and calculations made in order to optimise the diameter and taper of each canal in each tooth. This radiographic investigation generally showed a double taper, i.e. a smaller diameter in the apical third and a larger one in the coronal section (Fig. 14).

Figures 15-17 show how well the DT Light® Post fits the taper created by the NiTi instruments. A thin post bends more under lesser load than a post with a larger diameter and the same elasticity modulus. The diameter of the DT post, being relatively thin inside the root canal, provides a flexibility similar to dentin, whereas, where greater stability is needed, i.e. where the post exits the root canal and inside the build-up, its diameter is larger. (Lit. 6)

The authors Scotti and Baldassara (Lit. 8) suggest in their study that in clinical cases with no remaining coronal dentin, the posts with a larger diameter are able to better resist dislocation of the build-up and, therefore, reduce the risk of fracture of the restoration.

DT Light® and DT Light® SL are available in 4 sizes (Fig. 18). DT White® posts are available in 3 sizes (Fig. 19).

<table>
<thead>
<tr>
<th>DT Light® Post / DT Light® SL Post dimensions (mm)</th>
<th>DT White® Post Post dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>overall length: 20 mm</td>
<td>overall length: 20 mm</td>
</tr>
<tr>
<td>0 1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>1,25 1,50 1,80 2,20 ø</td>
<td>1,50 1,80 2,20 ø</td>
</tr>
<tr>
<td>4% 6% 8% 10%</td>
<td>6% 8% 10%</td>
</tr>
<tr>
<td>2% 2% 2% 2%</td>
<td>2% 2%</td>
</tr>
<tr>
<td>0,80 0,90 1,00 1,20 ø</td>
<td>0,90 1,00 1,20 ø</td>
</tr>
</tbody>
</table>

As already mentioned, examining the post under a scanning electron microscope (SEM) provides a first opportunity to analyse the amount of fibres/resin, the number and the diameter of the fibres as well as the overall integrity of the post. The following illustrations (Fig. 21 and 22) show sections illustrating the density, homogeneous distribution of the fibres and the absence of defects in the structure of the DT posts.

Among the tests conducted, the three-point-bending test is quite significant. This test is used to evaluate the flexural strength of the posts and how they will fracture. It entails fixing the specimen at two points and applying a load to a third point equidistant from the other two. The load is released and reapplied at a predetermined speed in vertical direction to the longitudinal axis of the specimen until the specimen fractures. The values are normally given in GPa or converted into MPa.

<table>
<thead>
<tr>
<th>Product</th>
<th>Fibres</th>
<th>Bending modulus (GPa)</th>
<th>Tensile strength (MPa)</th>
<th>Bending strength (MPa)</th>
<th>Elasticity modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT Light® Post</td>
<td>Quartz</td>
<td>46</td>
<td>2050</td>
<td>1600</td>
<td>15</td>
</tr>
<tr>
<td>Post A</td>
<td>Glass</td>
<td>13.5</td>
<td>1200</td>
<td>960</td>
<td>26.5</td>
</tr>
<tr>
<td>Post B</td>
<td>Glass</td>
<td>29.2</td>
<td>1200</td>
<td>990</td>
<td>29.2</td>
</tr>
</tbody>
</table>

Table 3 Property data of current posts (Source RTD)
**Fatigue Test**

The fatigue test provides more reliable predictions on the durability of the restoration than any other test. In restorative dentistry, fatigue is one of the main reasons for structures to fail. It is proven that fracture of a restoration occurs more often due to light but repeated load exertion than to a single and major load.

The fatigue test gives information about the fatigue resistance of the posts by submitting them to cyclic loads simulating the occlusal functions and masticatory movements.

The test is run on a three-point-bending machine (Fig. 23 and 24). The load cycles can be weaker than those causing a fracture. A counter counts the number of load cycles and stops when the specimen breaks.

In a study published on fatigue resistance of posts by Grandini et al (Lit. 7) the three-point-bending machine was used to compare the fatigue resistance of 8 different posts. Ten specimens of each group were tested at a 3Hz frequency. Figure 25 shows the mean number of cycles every type of post withstood until it broke. The testing device was calibrated to carry out 2,000,000 cycles corresponding to approximately four years of occlusional contact and physiologic masticatory movements.

The fatigue test has shown statistically significant differences between the different groups. The DT Light® Posts and the FRC Postec (Ivoclar-Vivadent) resisted load cycles better than the other groups. None of the DT Light® Post specimens had fractured after 2,000,000 cycles.

![Mean number of cycles each type of post withstood until fracture](image)
Microscopic examination of the structure of the posts showed a connection between fatigue resistance and fibre density, their cross-section and the surface of the post (Fig. 26-27).

Fig. 26
The morphology of a DT post reveals excellent density of the fibres, integrity of the matrix and absence of interior defects

Fig. 28
Presence of internal bubbles, cavities and irregular surface

Fig. 30
Low fibre density and production defects result in an irregular surface

Fig. 31
Some fractured posts after the load test

Fig. 33
Some fractured posts after the load test
5. In-vivo-Test and Clinical Trial

Conducting in-vitro tests is the first step when trying out a new material or a new technique as they allow prediction of clinical behaviour in the course of time. Clinical in-vivo tests check the efficiency of new technologies.

In a clinical retrospective study conducted over a period of 4 years, Ferrari (Lit. 10) has investigated 200 patients of which one hundred (group 1) were treated with a reconstruction of fibre posts (ComposiPost®; Aestheti Post®, Aestheti Post Plus), and the other one hundred (group 2) received restorations with cast posts and a metal-ceramic crown. Control examinations took place according to their individual needs after 6 months, 1, 2 and 4 years. X-rays were taken at each examination. The following criteria were taken into account as parameters: restoration in situ, no debonding of the post, no post or root fracture.

In group 1, 95 successful treatments were observed, 3 patients did not come for an examination and 2 patients had a failure in form of endodontic complications.

In group 2, 84 successful treatments were observed, 9 root fractures, 3 periapical endodontic lesions, 2 dislocations of the post and 2 patients did not come for a control examination.

Differences among both groups were statistically significant.

Thanks to this study it was also possible to observe that the root fractures in case of cast posts were not reparable, whereas the ones in case of a restoration with fibre posts were still reparable.

Malferrari et al (Lit. 11) have published a prospective study over 30 months on the use of quartz fibre posts (Aestheti Plus, RTD; same composition as DT White® Post, but with a different design). 180 endodontic treated teeth were restored (132 patients treated by 13 practitioners). After 30 months, 3 failures were observed: the first failure happened 2 weeks after the posts placement and was a cohesive fracture of the composite used for the core build-up. The other 2 failures were due to a loss in adhesion, which only lead to the debonding of the post-cement core build-up system from the dentin wall.

All 3 failures happened during the removal of the temporary restoration and did not lead to the fracture of either the post or the root, and in all 3 cases it was possible to restore the tooth again.

Results of placed carbon and fiber posts at international universities

<table>
<thead>
<tr>
<th>University</th>
<th>Cases</th>
<th>Post fracture</th>
<th>Root fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paris VII, France</td>
<td>400</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nice, France</td>
<td>137</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Toulouse, France</td>
<td>150</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Montreal, Canada</td>
<td>320</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Modena, Italy</td>
<td>470</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Siena, Italy</td>
<td>2450</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Padua, Italy</td>
<td>450</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Karolinska, Sweden</td>
<td>236</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4643</strong></td>
<td><strong>3</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Table 4

Clinical Trial of DT Light® Post placed with Prime&Bond® NT/X-flowTM and CalibraTM: prospective study over 2 years

Premolars (maxillary teeth) of 40 patients who needed an endodontic treatment were selected. After the canal preparation with an adapted drill, DT Light® Post size 2 and 3 were luted with Prime&Bond® NT/X-flowTM and CalibraTM. The core build up was done with the flowable composite X-flowTM, ceramic crowns were cemented. After 12 months all the posts were still in place without loss of retention or fracture. No micro-cracks in the ceramic crowns were observed.
6. The Adhesive System

Metallic and ceramic posts are cemented and their retention is based on friction. Fibre posts are luted with adhesives and their retention is based on adhesion.

The successful bonding of a fibre post depends on many parameters:
- Lapse of time between the root canal treatment and the restoration with fibre post.
  (The shorter the interval, the better the adhesion with dentin will be.)
- Combination of the different adhesive products (primer, cement and core build-up materials) should work well together.
- Conditioning of the post surface. (The post should at least be conditioned with a primer. Silanisation further increases adhesion.)
- Homogeneity of the cement layer. (The cement layer should be homogeneous and bubbles should be avoided.)
- Quality of the fibre post. (The surface of the post and its polymerisation level have an impact on the adhesion.)
- All-in-one adhesive products. (Self-etching primer can be used, if the product is classified as minimally aggressive to the dentin.)

6.1. Recommended Adhesive Systems

VDW recommends the following products in combination with DT Light®Post, DT Light®SL and DT White®Post:
The conditioning of DT Light®SL is not necessary.

<table>
<thead>
<tr>
<th>Conditioning of the post</th>
<th>silane+primer ✓</th>
<th>Both procedures are possible. Adhesion is high in both cases.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer only</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

| Etching of the canal    | Etchant ✓       |                                                               |

| Primer                  | Self curing ✓   | Light curing alone is not recommended. The adhesive products listed below are mostly light curing products and need to be mixed with a self curing activator. |
|                        | Dual curing ✓   |                                                               |
|                        | Light curing only ✓ |                                                               |


| Self-etching primer: no data available |

| Cement                   | Self curing ✓ | Light curing alone is not recommended. VDW recommends composite cements. |
|                         | Dual curing ✓ |                                                               |
|                         | Light curing only ✓ |                                                               |


| Core Build Up            | Self curing ✓ | VDW recommends composite materials. Cure layer after layer. |
|                         | Dual curing ✓ |                                                               |
|                         | Light curing only ✓ |                                                               |
6.2. Adhesion Post-Root Canal

The results of a push out test together with the ones of a pull out test are the most reliable indicators of the bonding strength between post and root canal. The root with the cemented post is first cut in 5 to 6 sections of 1 mm thickness. The apical side of the sections are then submitted to a force with a device equipped with a cylindrical piston of 1 mm diameter.

The piston is positioned so as to ensure that the force is only applied to the post. The pressure only appears along the bonding interface and is exerted in an apical to coronal direction, so that the post is pushed towards the widest part of the root. The pressure happens with a speed of 0.5 mm per minute until the post segment is pushed out of the root section.

The push out value of the bond DT Light®Post - Calibra™ to the intraradicular dentin is 9 MPa. Analysis under a transmission electron microscope (TEM) was done to morphologically evaluate the adhesive surface. Figure 34 shows the complete dispersion of the smear layer and the presence of a hybrid layer of 8 to 10 microns.

6.3. Evaluation of the Sealing Effect and Adhesive Mechanism of the Recommended Adhesive System to the Dentin

In order to evaluate the sealing effect and the adhesive mechanism of the recommended adhesive system (here DT Light®Post with Prime&Bond® NT and Calibra™) to the dentin, a micro-infiltration test and a SEM analysis were conducted. The analysis under SEM allows the interface composite/dentin and the presence of resin tags to be seen. Fifteen front teeth extracted for periodontal reasons were endodontically treated, prepared for the post placement and restored with the system DT Light®Post – Prime&Bond® NT and Calibra™.

After storing in water at room temperature for one week 10 samples were selected for the evaluation of the micro-infiltration and the rest were used for the SEM evaluation.

Each sample was given a certain number of points for the micro-infiltration Parameters

- 0 points for the complete absence of infiltrations at the interface between the apical gutta-percha and the cement.
- 1, 2, 3 and 4 points when the infiltration was spread under 0.5 mm, 0.5-1 mm, 1-2 mm and over 2 mm respectively.
- The resulting average shows that the colouration was not spread over 0.5-1 mm.

Under SEM analysis it was observed that Prime&Bond® NT and Calibra™ reached a high RDIZ (resin dentin interdiffusion zone) rate and that the resin tags were present in all areas of the root and installed deeply in the dentin tubuli (Fig. 35, 36).
Images under scanning electron microscope

Different tooth substances are in contact with the fibre post adhesion system. All of them are treated with the same adhesive technique and all the bonding interfaces should have a high adhesion level.

6.4. SEM Evaluation of the Adaptation Post to Cement

5 posts type DT Light®Post Nr. 2 with 1.8 mm diameter were silanised, 60 seconds after the application of the silane the coronal part was restored with a flowable composite (X-flowTM).

The presence of bubbles or cavities inside the core build up and at the interface post/core build up was analysed under SEM.

An excellent bonding interface between X-flowTM and the fibre post was observed.
6.5. Adhesion between the Post and the Core Build Up

The micro tensile test allows the evaluation of the quality of the adhesion between the post and the material used for the core build up. The micro tensile bonding strength between DT Light® Post in combination with the flowable composite X-flow™ and the core build up material Ceram·X™ was evaluated.

Silanised posts with a 1.6 mm diameter were positioned straight on small glass plates and fixed with sealing wax. A cylindrical plastic matrix with a 10 mm diameter was then put around the post, so that the post was exactly positioned in the middle. The matrix was only on the cylindrical part of the post.

The composite was then applied in layers of 1-2 mm to the post, each of the layers was light cured with a halogen lamp for 20 seconds. The material was always directly cured from the upper open side of the matrix. Once the matrix had been fully filled, the cylinder was removed from the glass plates and further light cured for 20 seconds. The plastic matrices were then cut and the created composite cylinders around the post freed from the matrices. Sections of equal thickness were taken, where the post was in the middle, surrounded on all sides by the core build-up.

The sections were then fixed on a device, so as to apply a tensile strength on the opposite interfaces post/core build-up. Each section was put under pressure until one of the interfaces fractured.

In the micro-tensile test (see table 5) X-flow™ got better results. This can be explained by the high permeability of the material which improves the adhesion to the post surface.

<table>
<thead>
<tr>
<th>Material</th>
<th>Microtensile (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT Light® + X-flow™</td>
<td>8.65</td>
</tr>
<tr>
<td>DT Light® + Ceram·X™</td>
<td>6.38</td>
</tr>
</tbody>
</table>

Table 5 Micro-tensile test

6.6. Conditioning of the Post

In order to evaluate the impact of the silane on the adhesion of the post to the core build up, a micro-tensile test was conducted, for which 20 DT Light® Posts with a 1.8 mm diameter were used. Half of the posts were silanised with Calibra® Silane (Dentsply) for 60 seconds. Following groups were generated:

- **Group 1**: DT Light® Post and X-flow™
- **Group 2**: DT Light® Post, silanised and X-flow™
- **Group 3**: DT Light® Post and Ceram·X™
- **Group 4**: DT Light® Post, silanised and Ceram·X™

The method used was identical to the already described micro-tensile test. The bonding strength of the composite to the post surface was significantly higher when the post was silanised (see table 6).

<table>
<thead>
<tr>
<th>Material</th>
<th>Number</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1: DT – PBNT – X-flow™ without Silane</td>
<td>15</td>
<td>15.32</td>
<td>3.20</td>
</tr>
<tr>
<td>Group 2: DT – PBNT – X-flow™</td>
<td>13</td>
<td>20.47</td>
<td>2.40</td>
</tr>
<tr>
<td>Group 3: DT – PBNT – Ceram·X™ without Silane</td>
<td>16</td>
<td>12.38</td>
<td>3.29</td>
</tr>
<tr>
<td>Group 4: DT – PBNT – Ceram·X™</td>
<td>19</td>
<td>14.26</td>
<td>3.18</td>
</tr>
</tbody>
</table>

Table 6 Results of bonding strength test
7. Pre-conditioned Fibre Post: SL coating

This part has been written with the contributions of Professor R. Marx, RWTH Aachen and Professor D. Edelhoff, LMU Munich, Germany.

Placing a fibre post means conditioning not only the root canal, but also the post’s surface. The conditioning of the post is commonly done chairside, which makes the treatment longer and increases the risk of failure. The fibre post could however be conditioned with the latest coating technologies in an industrial process. DT Light®SL has been developed together with the RWTH Aachen. The practitioner no longer needs to condition the post as the post is pre-conditioned to reach a high adhesion.

7.1. The Coating and its Activation

DT Light®SL is a DT Light® Post with an industrial coated surface. A coating made of silane and silicate is applied to the post in a PVD process.

In order to protect its activation before its use in the dental practice, an additional protective layer made of MMA is applied. This coating does not influence the dimensions of the post and is resistant chemically and mechanically to blood and saliva, for instance. It is, of course, compatible and easily polymerised with the widely used composites made of BisGMA and/or UDMA. Thanks to this protective layer the time between the manufacturing of the post and its use in the dental practice can be months or years. After the polymerisation, the composite and the protective layer are chemically one entity.
7.2. Bonding Stability of the Coating under Simulated Clinical Conditions (Lit. 13)

To check the long lasting mechanical stability of the coating, especially when simulating conditions in the mouth, the tensile strength of the post was measured after 180 days storage in physiological saline solution at 37 °C and compared with the initial tensile strength. Uncoated DT Light®Post, coated DT Light®Post and DT Light®SL were compared. All the posts were size #2. The recommended chairside conditioning of the post improves the bonding strength by 35% and gives a certain stability in hydrolytic conditions in comparison to uncoated posts. The PVD coating further increases the bonding strength by 50% and gives a clear stability to the system in hydrolytic (humid and warm) conditions.

Test of bonding stability

![Graph showing bonding strength in N for different post treatments and storage times](image)

Pull-out test

![Diagram of pull-out test setup](image)
7.3. Tensile Strength with Several Composite Cements (Lit. 13)

The goal of this test was to check that the effectiveness of the PVD coating (high bonding strength) was not influenced by the use of different composite cements, so that the practitioner can further use the composite of his choice. Material and method are identical to the test described in 7.2.

Figure 48 shows the tensile strengths of DT Light® SL with different composite cements. The results clearly show that the use of different cements does not influence the adhesion.

7.4. Coating Thickness

The coating has a thickness of 10 ± 5 μm (Fig. 49), is reproducible and homogeneous in production, and does not affect the dimensional aspect of the post, since its tolerance is smaller than that of the post diameter itself (20 ± 5 μm). This is not the case for the layer of primer, which can influence the seat of the post in the canal if a condition which is not homogeneous has been applied and already polymerised.
The post should not be cut with pliers or scissors. Cutting of the post should take place after the fit has been checked in the canal and before luting of the post. In this case, a diamond disc or a carbide disc can be used. If the post is cut after luting, a diamond bur should be used.

---

**Picture 1**
Initial situation

**Picture 2**
Removal of the temporary restoration and opening of the cavity

**Picture 3**
Preparation of the root canal with the drills

**Picture 4**
Checking the seat of the post in the canal

**Picture 5**
Checking the seat of the post after cutting

The post should not be cut with pliers or scissors. Cutting of the post should take place after the fit has been checked in the canal and before luting of the post. In this case, a diamond disc or a carbide disc can be used. If the post is cut after luting, a diamond bur should be used.

**Picture 6**
Etching with a 35% phosphoric acid gel, 15 sec. with a thin needle to spread the etchant along the whole canal.

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**Picture 7**
Thorough application of the etchant with a syringe and an endodontic needle

**Picture 8**
Cleaning the root canal

**Picture 9**
After cleaning, drying of the canal with a paper point, without dehydrating the dentin

**Picture 10**
Application of 2 coats of adhesive (Prime&Bond® NT/core-X™ flow + Self Cure Activator), left to work for 20 sec. The use of ComposiBrush is recommended to bring the adhesive along the whole canal.

**Picture 11**
Removal of the excess with paper points

**Picture 12**
Light curing of the adhesive, 20 sec.
Picture 13  
Application of cement in the canal

Picture 14  
Reconstruction of the tooth before the prosthetic preparation

Picture 15  
Removal of the rubber dam

Picture 16  
Initial X-ray

Picture 17  
X-ray of the endodontic treatment

Picture 18  
X-ray after insertion of the post

Picture 19  
Reconstructed tooth before the prosthetic preparation

Picture 20  
Vestibular view

Picture 21  
Preparation of the core build-up

Picture 22  
End result, occlusal

Picture 23  
End result, vestibular

Picture 24  
Final X-ray of the case
9. Clinical Procedure with DT Light®, DT White® and DT Light®SL

1. Remove obturation with DT Universal drill.
2. Shape the canal with DT Finishing drill. This step is not necessary for size 0.
3. Remove the coloured ring from the post. Check seat of the post. Cut the post with diamond disc. Clean post with alcohol.

6. Apply silane and primer to the post. Air dry. Light-cure for 10-20 sec. DT Light®SL: This step should be omitted.
7. Apply self- or dual-cure cement in canal. For DT White® Post, use self cure cement only.

8. Place the post. Remove excess. For DT Light® Post and DT Light®SL, light-cure for 40 to 60 sec. For DT White® Post wait till cement is set.
9. Apply 2 coats of primer. Wait for 20 sec. Remove excess. Light-cure for 30 sec. For DT Light®SL this step is optional if the post is shortened by at least 5 mm at the post head and the dentine is coated with primer.
10. Proceed with the core build-up.

Please refer to the instructions of use for more details - DT Light® Post - DT Light® SL - DT White® Post
10. Questions and Answers

How deep in the root canal should a post be placed?
Provided that a minimum 2 mm of coronal dentin remains, the post does not need to be placed deeper than 2-3 mm apical to the bone limit.

![Picture 1]

How much coronal dentin is needed to secure the post?
A minimum of 2 mm coronal dentin is needed to provide stability for the post.

![Picture 2]

Which factors should be taken into consideration to decide if the post should be luted in an endodontically treated root canal?
The key factors to look at are: the quality of the root canal treatment, the damage level of the tooth crown and the coronal walls, the position of the tooth and the occlusion, the need to restore the tooth with a crown, the treatment plan, the patient’s characteristics and expectations.

Can the placement of a post be avoided when the treatment plan includes the prosthetic restoration of the endodontically treated tooth?
In this case it is often recommended to place a post in order to ensure a regular and intact prosthetic restoration.

![Picture 3](Picture 3) ![Picture 4](Picture 4)

Which kind of composite material can be used for the core build-up around the fibre post?
Some morphological situations recommend the use of so-called flowable materials, other adhesion tests recommend the use of micro-hybrid composites. Clinical data gives positive results for both types of materials. Thus, the personal preference of the dentist is decisive, provided that the restorative procedure always follows the incremental technique, and the material itself is adapted to the coronal surface of the post and the remaining root structure. X-flow™ (Dentsply DeTrey), for example, shows a very good adaptation to the post surface without bubbles in the core build-up (Pictures 5-6).

![Picture 5](Picture 5) ![Picture 6](Picture 6)
What kind of clinical failure can happen when placing a fibre post?
The most frequent clinical failure is the debonding of the post, which frequently occurs when removing the temporary restoration. In fact, the debonding of posts is only reported in cases of removable prostheses.

![Picture 7]

What can be done after the debonding of a post?
Either the same post can be re-luted, if it was possible to remove it intact from the crown, or a new post can be luted once the remaining cement has been carefully removed from the root canal walls with a large canal drill. Thereafter, the dentist should repeat the adhesive procedure.

![Picture 8]

Where is the weak point in the tooth-post-cement system?
The debonding often occurs at the interface between dentin and adhesive cement. This is the weak point in the system.

![Picture 9]

Can a translucent fibre post be placed following the one-shot technique (light curing of the adhesive after the post and cement have been placed in the canal)?
Even if the one-shot technique is very attractive, observations show that the light transmitted through the post in the middle and apical thirds of the root canal is not able to fully polymerise the adhesive materials. It tends to leave composite monomeres in a spheroidal form or even in some reports unpolymerised composites. Thus, it is recommended to first polymerise the adhesive, place the post and then to polymerise the dual-cure cement.

![Picture 10]  ![Picture 11]
11. Literature


3. Sorensen JA, Martinoff JT. *Clinically significant factors in dowel design.* J Prosthet Dent, 1984, 52: 28-34


DT Light® Post has been voted best product several times in a row by The Dental Advisor, the CRA group and REALITY:

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