A study into application of fiber technology for endo posts

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Chapter 8
Summary and conclusions

In Chapter 1, as an introduction to the main topic of this study, two major aspects of modern dentistry were presented. One is restoration with adhesive materials, which affects almost all restorative treatments and the other one is employing resin-based composite materials as alternatives for metals. These subjects are related as applicability of resin-based composites strongly relies on the proper use of adhesives. In the special case, where endodontically treated teeth have to be restored, fiber reinforced resin-based composite systems have recently been proposed as alternatives for metal posts. Besides the qualities of the materials, bonding is associated with technical problems, particularly in the narrow root canal.

After a short survey of the relevant essentials of composite materials, some considerations were made about the concepts for restoring endodontically treated teeth. Particular attention was given to the evolution of the restoring-concept from materials as strong and as stiff as possible to materials that sufficiently can resist mastication forces and distribute stress to the residual tooth structure, avoiding non-uniform stress concentrations, probably responsible of root fracture.

Arguments for replacing the cast post and core system by fiber posts for reconstruction of endodontically treated teeth were discussed. Beside aspects like less cost and time save, a comparable failure rate but at a definite more favorable prognosis for the tooth was reported. Instead of root-fracture as a traditional form of failure, with fiber posts only debonding was reported. An important part of the present study was dedicated to find materials and techniques reduce of debonding.

A critical review of the evolution of various bonding procedures was presented. Special attention was given to the use of "reduced number of steps" systems that might affect the "manipulation factor" connected with
tricky bonding procedures. With SEM investigations it was demonstrated that the deep region last apical third of the root canal has to be considered as the most difficult area for proper bonding. Interest was given to self-curing bonding systems as a solution to overcome the problem of non-appropriate cure in the apical third of light curing systems by lack of sufficient light transmission into this area. Moreover, the design and use of micro-brushes, that vehicle bonding solutions to narrow and deep regions, were discussed.

In Chapter 2, treatment of endodontically treated teeth with fiber posts was compared with treatment with cast post and cores. A retrospective study was presented on 4 years of clinical experience with treatments with cast post and core and a fiber post system (Composipost®) on endodontically treated teeth in 200 patients. The patients were divided in two groups of 100 each. In one group Composiposts® were luted into root canal preparations with a traditional technique. The patients were recalled after 6 months, 1, 2 and 4 years and clinical and radiographic examinations were completed. Endodontic and prosthodontic results were recorded. These results were compared with those obtained from studying the clinical success of endodontically treated teeth restored with cast post and core. For the group of teeth restored with Composiposts®, 95% showed clinical success; 3% of these samples were excluded for noncompliance and 2% showed endodontic failure. In the group of the teeth restored with cast post and core, clinical success was found for 84%. 2% of these samples were excluded for noncompliance, 9% showed root fracture, 2% crown dislodgement and 3% endodontic failure. Statistical evaluation showed significant differences between the two groups (p<0.001). From the results of this retrospective study was concluded that, for a period of 4 yrs clinical service, the Composipost® system was superior to the conventional cast post and core system and that Composiposts can be used routinely for restoring endodontically-treated teeth. Fiber posts might eliminate the risk of root fracture.
In the second part of this chapter, clinical experience with three different fiber post systems in combination with four bonding systems was presented. This time, the performance of C-Posts®, Æsteti Posts® and Æsteteti Plus Posts® placed into endodontically treated teeth, was followed for a period, ranging from 1-6 years of clinical service. 1,304 posts were included in the study: 840 Composiposts®, 215 Æstheti posts® and 249 Æstheti Plus posts®. The patients were recalled every six months and clinical and radiographic examinations were completed. Endodontic and prosthodontic results were recorded and Actuarial Life Table statistical analysis and Mantel-Haenszel comparison of survival curve were performed at 95% level of confidence. From this study it was learned that a 3.2% failure rate was due to two reasons: 25 posts dislodged during removal of temporary restorations, and 16 teeth showed peri-apical lesions at the radiographic examination. No statistical significant differences were found among the four groups of bonding systems. The results of this retrospective study indicated that fiber posts in combination with bonding materials can be routinely used and root fracture could not be correlated to these types of posts.

In Chapter 3, problems were considered associated with bonding, particularly when applied under clinical circumstances in the most difficultly accessible area of root canals. The objective of this study was to evaluate the effectiveness of three ‘one-bottle’ and two ‘three step’ adhesive systems (as controls) in formation of resin tags, adhesive lateral branches and resin dentin inter-diffusion zone (RDIZ) when used to bond fiber posts under clinical condition. This study was performed by standardized SEM observations and scoring resin tag formation and density. Fifty endodontically treated teeth were selected, already scheduled for extraction for endodontic or periodontal reasons. The samples were randomly divided into five groups and of ten samples each and the following combination of adhesive and cements were used to cement Æstheti-Plus posts® (white quartz fiber posts): Group 1: All Bond 2 with C & B; Group 2: Scotchbond Multipurpose Plus® with Opal Luting Composite®, Group 3: Scotchbond 1® in
combination with Rely X ARC® resin cement; Group 4: One-step® with C & B® resin cement; Group 5: All Bond® Experimental with Post Cement HI-X®. A week later, the root samples were extracted and processed for SEM observations. The results of SEM observations showed for all adhesive systems RDIZ and resin tag and adhesive lateral branch formation. Microscopic examination of restored interfaces of the two groups cemented with "Three-step" adhesive systems (Group 1 and 2) showed a higher % of RDIZ than those found in samples cemented with "one-bottle" adhesive systems (Groups 3, 4 and 5). The standardization of SEM observations at three different levels (coronal, medium and apical third of post preparation) and scoring resin tag formation allowed statistical evaluations. At the coronal side, no statistically significant differences were found among the five groups, while at middle and apical thirds two 'one-bottle' systems (Groups 3, 4) showed significantly less resin tags than the "three-step" and the experimental "one-bottle" system (Group 5). No statistically significant differences were found among the three 'one-bottle' systems at the three evaluated areas.

For all the samples, RDIZ morphology was well detectable and uniform in the first two thirds of root canals while in the apical third the RDIZ was not uniformly present. Resin tag morphology and formation were significantly more detectable at cervical and middle areas than at apical zones. As conclusion of this study, the 'three steps' adhesive systems showed to be able to create a wider micro mechanical interlocking between adhesive materials and etched dentin than 'one-bottle' systems, even if for all the samples scarce RDIZ presence and consequently unsatisfactory micro mechanical interlocking was detected at the apical third.

In Chapter 4 the problem of obtaining a proper RDIZ formation and resin tag morphology at the apical third was taken into consideration. A series of preliminary observation suggested that the difficulty to carry the bonding solution at the apical third might be one of the reasons for the bonding failure at this area of post space. A series of carriers commercially available were
preliminary evaluated and two of them were selected for the study, which purpose was to evaluate the influence of this two carriers of one primer-adhesive solution in the formation of resin tags, adhesive lateral branches and hybrid layer when used to bond translucent fiber posts. For this reason, twenty endodontically treated teeth, extracted for periodontal reasons, were selected and the samples were randomly divided into two groups of ten samples each. The combination of Scotchbond 1® as bonding system and Rely X ARC® as luting cement was used in both groups, but in Group 1 the priming-adhesive solution was carried with a very thin micro-brush while in Group 2 the solution was placed by the small plastic brush provided by the manufacturer of the adhesive material. The priming-adhesive solution of the ‘one-bottle’ system was light-cured before placing the resin cement and the posts. After luting procedures, root samples were processed for SEM observations. Following the same pattern of the study described in Chapter 3, SEM observations were standardized at three different levels (coronal, medium and apical third of post preparation) and statistical evaluations were possible thanks to the scoring of resin tag formation. Microscopic examination of restored interfaces of Group 1 (micro-brushes) showed a higher % (P<0.05) of RDIZ than those found in samples of Group 2. In Group 1 samples RDIZ morphology was well detectable and uniform in all thirds of root canals, while in Group 2 RDIZ was not visible at the apical third. At the coronal site, no statistically significant differences were found between the two groups and at middle third, while the apical third of Group 1 showed significantly more resin tag formation than the Group 2. The characteristic reverse cone shape of resin tags was always noted in the coronal and middle third of the root canals of both groups and at apical third of Group 1. In the apical third of Group 2 root canals, the resin tags showed a less uniform morphology and a shorter length than those found in the other observed thirds.

In Chapter 5 proper polymerization of the resin bonding, especially at the apical third of the root canal preparation was examined. One of the problems
of obtaining a proper adhesion in that area was supposed to be difficult curing of the resin. Curing is hindered in two ways: The first one is the distance between the light source to the most apical portion of the post preparation, as the post length is considered to be at least 0.9mm. But clinically the actual distance may be more, e.g. because of the presence of the two adjacent teeth. The second aspect to be taken into consideration is that clinically, it is hard to distribute the bonding solution perfectly over the post space. If polymerized it may form an obstacles for the insertion of the post. For this reason a technique called "One shot polymerization" was proposed, in which the translucent post itself may act as carrier for the light. In this way, curing is performed after the placing of the post. To evaluate the efficacy of this technique, formation of resin tags, adhesive lateral branches and resin dentin inter-diffusion zone (RDIZ) formation was determined.

In Group 1: One Step® applied with the small brush provided by the manufacturer and light-cured before Dual Link® resin cement application; Group 2: One Step® applied with a thin micro-brush and light-cured before Dual Link® resin cement application; Group 3: One Step® applied with a small brush (Not light-cured) + Dual Link® resin cement; Group 4: One Step® applied with a thin micro-brush (Not light cured) + Dual Link® resin cement and light curing all resin materials once through the post ("one shot polymerization technique"); Group 5: All Bond 2® + C & B® resin cement (control). A week later, the root samples were processed for SEM observations.

The SEM examination revealed that RDIZ was usually well detectable and uniform in the first two thirds of root canals while in the apical third the RDIZ was not uniformly present. Usage of micro-brushes brought about an increased percentage of RDIZ. The samples with the "one shot" showed presence of resin globules along resin tags of apical area, possibly due to un-polymerized resin particles. For this reason, the "one shot polymerization technique" was considered to be not completely satisfactory in these experimental conditions. Like in the study described in Chapter 4, when micro-brushes were used, the bonding mechanism created between root
canal dentin and bonding system was uniform along canal walls and more predictable.

In the second and third part of this chapter, an innovative system for bonding posts was described. This system was based on the combination of micro-brushes and a self-curing adhesive system. The catalyst particles were sprayed on the top of the micro-brush fibers while a small cylinder that protected the tip of the micro-brush contained the base solution. The activation was realized at the very moment of the bonding procedure, by simply pushing the micro-brush deeply inside the cylinder. In order to examine the performance of this system, an in vitro test was carried out and described in the second part of this chapter, which aim was to evaluate the efficacy of this new bonding/luting system in combination with experimental fiber posts in resin tag, adhesive lateral branch and hybrid layer formation when used to cement fiber posts. In Group 1 Excite® light curing in combination with Variolink II resin cement was used; in Group 2 the above described Excite® dual-curing self-activated by an experimental micro-brush was used in combination with MultiLink® resin cement; in Group 3 One Step® bonding system in combination with Dual Link® resin cement was used. In Group 1 and 3 the priming-adhesive solution of the 'one-bottle' system was light-cured before placing the resin cement and the post, whereas in Group 2 the adhesive/resin cement combination was not light cured. Experimental Vectris® translucent posts were used for Group 1 and 2 and EndoAesthetic® translucent fiber posts were used for Group 3. A week later, the root samples were processed for SEM observations. The adhesive systems proved to be able to form a resin dentin inter-diffusion zone (RDIZ), resin tag and adhesive lateral branch formation. Microscopic examination of the interfaces in Group 2 revealed a higher RDIZ than in samples from Groups 1 and 3. In Group 1 and 3 samples, RDIZ morphology was only well detectable and uniform in the first two thirds of root canal. In the same groups (Group 1 and 3) resin tag formation was significantly more conspicuous at cervical and middle areas than at apical zones. At the coronal area, no statistically significant differences were found among the groups, whereas at apical and
middle thirds the samples from Group 2 showed significantly more resin tags than the other two Groups.

In the third part of this chapter the successfulness of application of this system (self-activating dual-cure adhesive system in combination with proprietary self-curing resin cement for bonding Vectris translucent fiber posts) is reported for some clinical cases.

There exists still discussion about the composition of fiber posts. Not all types are white or translucent. In Chapter 6 a study is given on the influence of the color of two commercially available non-metallic opaque posts (Carbon fiber and Zirconium) and of an experimental esthetic post. To evaluate the ability of different thickness of the ceramic as well as shade and thickness of the luting cements, sample discs at diverse thickness values were made in ceramic (IPS-Empress®), an experimental fiber post material, a Zirconium and a Carbon fiber post material, a resin composite material (Z100®) as reference and a luting cement (Variolink II®). A laboratory procedure was followed, in which the three possible combinations of stapling of the discs was employed. This was done for four different substrates, three cement colors at two thickness values and three heights of ceramic discs. From this study it could be concluded that the final esthetic result of the all-ceramic IPS-Empress® restoration is not affected by the presence of different substrates with different colors when the thickness is more than 2.0 mm. When the thickness of the ceramic decreases to 1.5 mm, it is advised to take the substrate aspects into consideration. If the ceramic thickness gets below 1.0 mm, if the use of full ceramic crown was planned, color matching of the abutment is required to ensure an acceptable esthetic result. Differences in cement thickness (0.1 or 0.2 mm) may slightly affect the final result. As the operator only to a certain extent can control this parameter, it cannot be considered as a procedure to correct color. The availability of different cement shades allows only minor esthetic corrections, which might be instrumentally detectable but are clinically not relevant. As final consideration, in relationship with clinical aspects, it may be concluded that if
dark colored opaque posts have to be masked by more or less translucent, enamel-like all-ceramic restorations, the thickness of the ceramic layer is the dominant factor. At a thickness of 2 mm full masking is achieved and Carbon Fiber post may be used as well as more aesthetic post without influence on the final color of the restoration.

The various indications coming forth from the results of the studies performed and described before were used in Chapter 7, in which the planning for a perspective study is reported. The study is still under-go and at present time 12-month preliminary recall data are available. Purpose of this study was to evaluate the clinical performance of Vectris® translucent fiber posts cemented with a self-activating dual-cure adhesive system in combination with proprietary self-curing resin cement following the procedures studied in chapter 5. The patients will be recalled at 1, 6, 12, 24, 36 months and clinical and radiographic examinations will be completed. Endodontic and prosthodontic results will be recorded. An extensive series of parameters will be examined among which the retention rate is of a particular interest regarding the subject of this thesis. Preliminary results at 12 months recall showed overall good results with a retention rate of 100%.

Conclusions and Recommendations

The following conclusions and recommendations may be drawn from our laboratory and clinical retrospective studies on restoring endodontically treated teeth:

1. At a similar incidental failure rate, Carbon Fiber based systems only show repairable debonding failures, whilst in the cast post and core treatments, the malfunction might display terminal root fractures.
2. At a similar success rate, “one-bottle” adhesive systems significantly simplify the adhesive procedures when compared to the multi-step bonding procedures.

3. Debonding of fiber posts mainly has to be attributed to insufficient retention in the apical third of the post extent.

4. Reliable and predictable bonding is significantly enhanced by meticulous removal of the etching solution, which has to be done with a syringe and an endo needle, as well as in washing and drying.

5. Applying micro-brushes as carriers for the adhesive solution significantly enhances reliable and predictable bonding for the entire length of post area.

6. Application of a dual cure system, both for adhesive resin and luting cement, promotes the polymerization at the apical third of the post preparation.

7. The use of translucent posts as light carrier through the canal does not improve the curing in the apical third of the post extent.

8. Only for full-ceramic esthetic restorations of less thickness than 2.0mm, Quartz or Glass Fibers instead of Carbon Fibers are recommended.