Evaluation of over-etching technique in the endodontically treated tooth restoration

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Summary

The main purpose of a post-endodontic restoration with posts is to guarantee the retention of the restorative material. The aim of the study was to examine, through the push-out test, how bond strength between the post and the dentin varied with etching time with 37% orthophosphoric acid, before cementation of a glass fiber post. Moreover, it has been examined if over-etching (application time of the acid: 2 minutes) was an effective technique to improve the adhesion to the endodontic substrate, after highlighting the problems of adhesion concerning its anatomical characteristics and the changes after the endodontic treatment. Highest bond strength values were found by etching the substrate for 30 sec., while over-etching didn't improve bond strength to the endodontic substrate.

Key words: endodontic substrate, etching time, dental bonding, glass fiber posts.

Introduction

The development of the materials and techniques in dentistry has recently took steps forward and succeed in preserving teeth instead of extracting them. Most of these improvements were evident in conservative dentistry and in particular, adhesive dentistry.

Enamel, dentin and cementum represent different adhesive surfaces due to the composition, morphology and biomechanical characteristics (1, 2). Adhesion obtained through adhesive systems is both chemical and micro-mechanical, with the formation of the hybrid layer (3) and resin tags achieved through etching which increases the available surface contact with the resin (4).
In endodontically treated teeth, the substrate with which adhesion is obtained is the dentin, pulp chamber and root canal (5, 6).
The presence of contaminants (intermediate medications, cements, gutta-percha) (7-9) the passage of irrigating solutions which destroy collagen fibers (10-12), the loss of the intrinsic humidity (13), the presence of a smear layer produced by the endodontic instruments (14) and other factors related to the endodontic treatment are an obstacle to adhesion of the post. An endodontically treated tooth is far weaker than a vital tooth, because of the loss of the dental substance (15) so the post is a key element in the post-endodontic restoration (16-18).
Adhesion problems are accentuated by the "C factor", which is very high in the post-space, like a first-class conservative cavity. The cavity shape is deeper than broader, with a consequent polymerization shrinkage stress of composite cements (19, 20), and is characterized by a lower accessibility and visibility of the area, which makes it difficult for correct execution of the adhesive protocols.
The principal aim of the study was to evaluate and compare the bond strength values obtained during the cementation of the glass fiber posts with etching-time.

Materials and methods

Forty dental monoradicular elements, with no decay and extracted for periodontal reasons, kept in balanced salt solution. Crown of all teeth was removed using a diamond cylindrical bur under water cooling at cemento-enamel junction, plumb to the tooth axis.
Roots were treated endodontically with simultaneous technique using nickel-titanium (NiTi) instruments *"Mtwo" (Sweden & Martina)*, following the manufactures instructions, namely 10/.04 taper - 15/.05 taper - 20/.06 taper- 25/.06 taper. The irrigation protocol used 5% sodium hypochlorite *(Niclor 5, Ogna)*, during the preparation, with a final irrigation for 2 minutes with 5% sodium hypochlorite warmed to 37°C. EDTA was used at the end of preparation in order to remove smear layer. Root canal filling was carried out with the lateral condensation technique with *ISO standardized gutta-percha points* and cement containing epoxy resin *Top Seal (Dentsply, Maillefer).* Then the experimental protocol established

the preparation of the post space, realized with *Largo 1* and *2 burs* at a length of 10 mm for each sample.
The samples were divided into four groups and restored, as following:

- ***Group A*** (10 samples): etching for 15 seconds using 37% orthophosphoric acid (*Superlux – Thixo etch – DMG*), using a 3 steps dual-curing adhesive system (*Luxabond – Total etch – DMG*), dual-cured resin-composite cement (*LuxaCore – DMG*) and glass fiber posts (*LuxaPost – DMG*).
- ***Group B*** (10 samples): etching for 30 seconds using 37% orthophosphoric acid (*Superlux – Thixo etch – DMG*), using a 3 steps dual-curing adhesive system (*Luxabond – Total etch – DMG*), dual-cured resin-composite cement (*LuxaCore – DMG*) and glass fiber posts (*LuxaPost – DMG*).
- ***Group C*** (10 samples): etching for 2 minutes using 37% orthophosphoric acid (*Superlux – Thixo etch – DMG*), using a 3 steps dual-curing adhesive system (*Luxabond – Total etch – DMG*), dual-cured resin-composite cement (*LuxaCore – DMG*) and glass fiber posts (*LuxaPost – DMG*).
- ***Group D*** or control group (10 samples): without the etching time step, using a 3 steps dual-curing adhesive system (*Luxabond – Total etch – DMG*), dual-cured resin-composite cement (*LuxaCore – DMG*) and glass fiber posts (*LuxaPost – DMG*).

Preparation of the samples for the mechanical tests

The portion of each roots corresponding to the bonded fiber post was transversally sectioned into 1 mm-thick serial slices, using a microtome, the *Micromet (Remet)* posting a low-speed saw (*Norton – Dia Wheel*), 0.2 mm thick, under water-cooling operating at 2.240 spins per minute.
The sections, were realized in apical-coronal direction and each section was marked on the apical surface to put it exactly under the punch of the machine for the push-out test. A number was assigned to each root and a progressive alphabetical letter to each slice from the apical surface to the coronal one.

The push-out test

Push-out load was applied using a universal testing machine *Galdabini- Sun 500* at a crosshead speed of 0.5 mm/min to obtain the extrusion of the post.
The punch was positioned to touch the post only, without stressing the surrounding dentinal walls. The load was applied on the apical surface of the slice in apical-coronal direction, with the purpose of preventing the conical shape of the canal from withstanding the dislodgement of the post.
Push-out strength data was in Newtons (N) which was converted to MegaPascals (MPa) by dividing the load by the bonded surface area.
In order to obtain the bonded surface area of each sample, we took pictures of the apical surface using an optical microscope (Zeiss laser scan). We used for each picture the same angle of view and enlargement (50x) after the push-out test (Fig. 1).

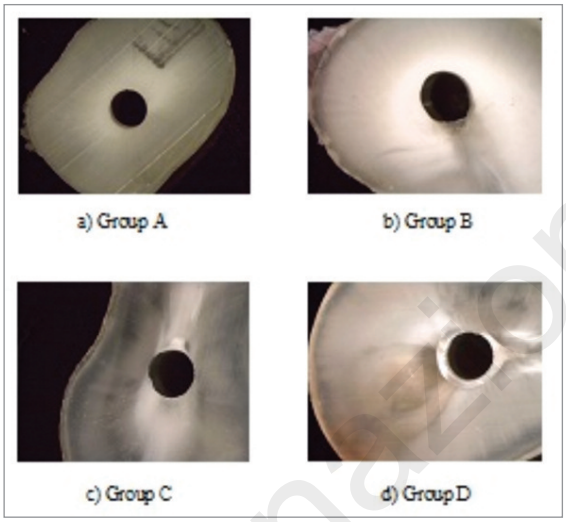

Figure 1. Slices of samples after the push-out test.

Similarly, we took a picture of a marked size (1 mm).
Image processing software provided with the optical microscope-Zeiss laser scan was used to analyze the pictures after calibrating the space using the marked size. The visible circumference size was found, following the line of the fracture.
Knowing the thickness of the sample (1 mm) and the taper of the apical surface of the post, we calculated the lateral surface area of a truncated cone which is the bonded surface area through the formula:
$S_L = \pi (R + r)[(h^2 + (R - r)^2]^{0.5}$, where R is the coronal post radius, r the apical post radius, and h the thickness of the slice.
Each section was submitted to the same procedure.
Statistical analysis was performed using SPSS Inc, ver. 13.0, Chicago, IL, USA. Chi-squared test was used for statistical evaluation of proportions. In cases with more than 2 independent means we used the ANOVA test. A p-value of less than 0.05 was considered significant. A 95% CI was used in all analysis. In order to assure data reliability data were entered in two different personal computers by the two examiners, the two data files were compared in order to detect entry errors. The two files resulted identical.

Results

For each analyzed section we obtained the bond strength between the post and the dentin (MPa). Then, the average values, between the section of every single root, between the roots of the same group were calculated to follow up the variations of the bond strengths of the different groups. There are the results obtained in Table 1.
Results were analyzed using the ANOVA test.

Table 1. Results of the bond strength between the post and the dentin.

Group A	Samples	MPa	Group B	Samples	MPa
A1	3	9,24	B1	4	18,73
A2	5	18,8	B2	5	9,98
A3	5	6,854	B3	5	15,01
A4	6	7,861	B4	5	9,47
A5	6	6,08	B5	5	6,25
A6	6	6,743	B6	5	10,14
A7	5	11,08	B7	3	16,5
A8	5	7,8298	B8	5	17,23
A9	4	8,52	B9	3	11,33
A10	7	14,81	B10	4	11,2
		Average 7,026			**Average 12,584**
Group C	**Samples**	**MPa**	**Group D**	**Samples**	**MPa**
C1	5	5,01	D1	5	5,54
C2	4	12,36	D2	4	9,58
C3	4	13,87	D3	4	5,55
C4	4	10,812	D4	5	10,6
C5	5	6,05	D5	4	11,07
C6	4	11,49	D6	5	5,753
C7	4	11,85	D7	4	4,43
C8	5	18,87	D8	5	4,45
C9	4	14,78	D9	5	4,41
C10	4	8,33	D10	5	3,91
		Average 11,34			**Average 6,52**

Table 2. Descriptives.

Descriptives Mpa								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
A	10	9.7638	4.08128	1.29061	6.8442	12.6834	6.08	18.80
B	10	12.5840	4.03647	1.27644	9.6965	15.4715	6.25	18.73
C	10	11.3512	4.14027	1.30927	8.3894	14.3130	5.01	18.87
D	10	6.4753	2.68710	.84974	4.5531	8.3975	3.91	11.07
Total	40	10.0436	4.31323	.68198	8.6641	11.4230	3.91	18.87

Discussion and conclusions

After the experimental study, the results (Tabs. 1, 2, Fig. 2) show that etching time is crucial in the cementation of the posts. The lowest bond strength values were found in Group D, where the etching step was not performed.

As far as the time of application of the orthophosphoric acid, comparing Groups A (15 seconds), B (30 seconds), and C (2 minutes), highest bond strength values obtained result in the group B. Differences that are statistically significant occur between Group B and D and between C and D, therefore etching for 15s or eliminate the etching step with the acid ortophosphoric doesn't guarantee a satisfying bond strength. On the other hand etching for at least 30s guarantees a better bond strength, an over-etching doesn't improve or diminish bond strength. As a result, it would be interesting to analyze how the bond strength varies between 30 seconds and 2 minutes of application of the acid.

Yet, results cannot support the hypothesis of over-etching time as an effective technique to improve the adhesion to the endodontic substrate or, at least, not considering the times of application of the acid for 2 minutes.

Literature is still very controversial about this issue because, even though acid etching allows to look for the collagen fibers which were destroyed during the endodontic treatment but which are necessary for the adhesion, over etching could be counter-productive and lead to losing the normal structure of the dentinal tubules (21-27).

Further studies are required to be carried out on this issue, taking into account the substrate, its characteristics to enable to provide for its deficiencies. By applying the proper operating procedures and valuing the state of the dental element, we should be able to choose the appropriate direct or indirect restoration, which could assure the most reliable guarantees of a long-term prognosis.

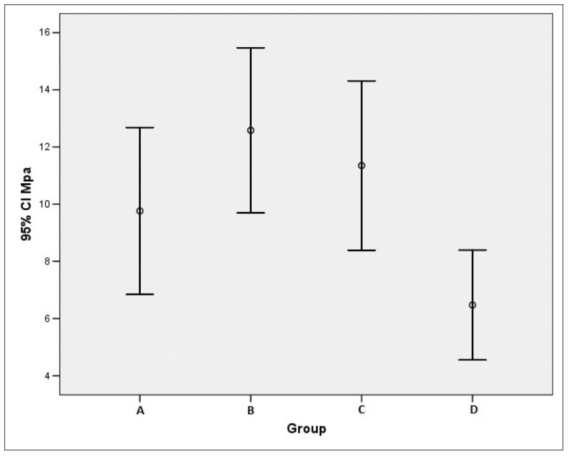

Figure 2. Range of value for every group.

Manufacturer's details

- Sweden & Martina SPA, Via Veneto 10 - 35020 Due Carrare (PD) – Italy.
- OGNA Laboratori Farmaceutici, Via Figini, 41 - Muggiò (MI) – Italy.
- DENTSPLY MAILLEFER, Chemin du Verger 3 - 1338 Ballaigues – Suisse.
- DMG Chemisch-Pharmazeutische Fabrik GmbH, Elbgaustraβe 248 – 22547 Hamburg – Germany.
- Remet s.a.s, Via Scarlatti 2 – 40033 Casalecchio di Reno, Bologna – Italy.
- NORTON SAINT-GOBAIN, Worcester – 01606 Massachussetts – USA.
- Galdabini, Via Giovanni XXIII 183 - 21010 Cardano al Campo (VA) –Italy.
- Carl Zeiss MicroImaging GmbH, Standort Göttingen – Vertrieb – Germany.

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