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Tensile Strength of Core Build up Material to Glass Fiber Post with Different Surface Treatment

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الخلاصة

الأهداف: الهدف الرئيسي من هذه الدراسة التحقق من الآثار المترتبة للمعالجات السطحية المختلفة على قوة الارتباط الانزلاقي للأوتاد من الزجاج المقوى بالألياف (FRP) بالمادة المستخدمة في بناء الجزء المركزي. **المواد وطرائق العمل** : تم اختيار خمسين وتد وتم تقسيمها إلى خمس مجموعات (ن =١٠) وكانت المجموعة الأولى المجموعة الضابطة غير المعالجة و كانت المعالجة السطحية للمجموعات الأربع الأخرى على النحو التالي : المجموعة الثانية تمثل الغمر في ٢٦٪ بيروكسيد الهيدروجين لمدة ١٠ دقيقة؛ المجموعة الثالثة تمثل الغمر في ٤ حمض الهيدروفلوريك؛ المجموعة الرابعة تمثل الرش الرملي لسطح الوتد بجزيئات الألمنيوم لمدة ١٠ ثواني ؛ والمجموعة الخامسة تمثل معالجة سطح الوتد بالليزر تحت قوة معينة (٣٠٠ملي جول في ٢ هرتز و١٠٠ ملي ثانية) لمدة ١٠ ثواني. تم استخدام قالب اسطواني من التفلون لتطويق الوتد المعالج ، وتم ملئ القالب بالمادة ثنائية التصلب. كل العينات نقوم بتصليبها بجهاز التصلب الضوئي لمدة ٤٠ ثانية من خلال الجزء العلوي من القالب. بعد ٢٤ ساعة من التخزين في الماء، يتم تعليق الوتد بجاكوب تشاك بالجزء العلوي من الجهاز ونجري التحميل بطريقة الشد أجريت اختبارات الشد بسرعة ٠ ، ٥ ملم / دقيقة باستخدام جهاز الفحص العام. وقد تم تحليل البيانات احصائيا . **النتائج**: لوحظ ان قوة الربط الانزلاقي المسجلة للأوتاد المعالج سطحها ببيروكسيد الهيدروجين والرش الرملي (المجموعة ٢ و٤) متقاربة لبعضها بعض، واعلى نسبيا من المجاميع الأخرى التي عولج سطح الوتد فيها بحمض الهيدروفلوريك، المجموعة الضابطة ومجموعة الليزر، على التوالي. **الاستنتاجات**: أن معالجة سطح الأوتاد ببيروكسيد الهيدروجين والرش الرملي تزيد من قوة الارتباط الانزلاقي للأوتاد بالمادة المستخدمة في بناء الجزء المركزي بصورة أكبر من حمض الهيدروفلوريك، المجموعة الضابطة ومجموعة الليزر على التوا

ABSTRACT

Aims: The purpose of this study was to investigate the effects of different surface treatments on the tensile retentive force of fiber reinforced posts (FRPs) to composite core material buildup. **Materials and methods:** A total of fifty FRPs were randomly divided into five groups (n = 10), the first group was the untreated control group, second group immersion in 24% hydrogen peroxide; third group immersion in 4% hydrofluoric acid gel; fourth group sandblasting with 50um Al_2O_3 powder, fifth group surface preparation with an Er:YAG laser under power setting (300m), at 2 Hz and 100 uS) for 10 seconds. A cylindrical polyethylene mold was used to surround the treated posts, and the mold was filled with dual cure composite core material buildup. All samples were light cured for 40 seconds through the top of the mold. After 24 hours of storage in water, the post was then grasped with Jacobs chuck attached to the upper member of testing machine and produced tensile loading. Tensile tests were performed at a cross, head speed of 0.5 mm/minute using a universal testing machine. Data were analyzed by One-Way Analysis of Variance followed by Duncan Multiple Range Test at significant difference ($p < 0.05$). **Results**: The post core tensile retentive force achieved following pretreatment with hydrogen peroxide and sandblast (Groups 2 and 4) were comparable to each other, and significantly higher than those of other groups in which the post surface had been treated with hydrofluoric acid gel, control group and laser, respectively. **Conclusions**: surface pretreatment of FRP has significance effect on the tensile retentive force. Sandblasting and hydrogen peroxide are increasing tensile retentive force of FRPs to composite core material buildup greater than those of hydrofluoric acid gel, control and laser group, respectively.

Key words: fiber post, core buildup, tensile force.

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INTRODUCTION

Endodontically treated teeth with excessive wear result in a lack of coronal tooth structure and frequently need post to retain the coronal restorative portion. [1,2] The presence of significant coronal tooth structure loss requires abutment build up around fiber reinforced post (FRP). [1] Posts form a bonded unit between root and coronal dentin, adhesive systems, resin cements, and composite buildup. [3]

FRPs have been used since the beginning of the 1990s.[4] FRPs contain a high percentage (68%) of continuous reinforcing fibers embedded in a polymer matrix, commonly epoxy resin polymers or other resin polymers, with a high degree of conversion and a highly crosslinked structure. [5]

The major advantage of FRPs, used in alternative to metal and ceramic posts, is the similarity of their elastic modulus to that of dentin, which may lead to a better distribution of the occlusal loads along the root.[6] FRPs are translucent and therefore have aesthetic advantages. Currently, variety of FRPs are available with different sizes, tapers, and shapes. [7,8]. The most common failure of endodontic treated teeth restored with FRPs during fracture testing is failure involving core portion.[9] The retention and stability of the posts systems and core build up is an important factor for successful restoration. [10-14]

The purpose of this study was to investigate the effects of different surface treatments (24% hydrogen peroxide, 4% hydrofluoric acid gel, sandblast and Er:YAG laser) on the tensile retentive force of glass FRPs to composite core material build up and failure mode for the tensile retentive strength test.

MATERIALS AND METHODS

Fifty clear FRPs (DENTCOLIC, Itena, Paries France), parallel in the coronal part and tapered in the apical part of its design with diameter of 1.4mm and 18.5mm length were used in this study Figure(1:A).

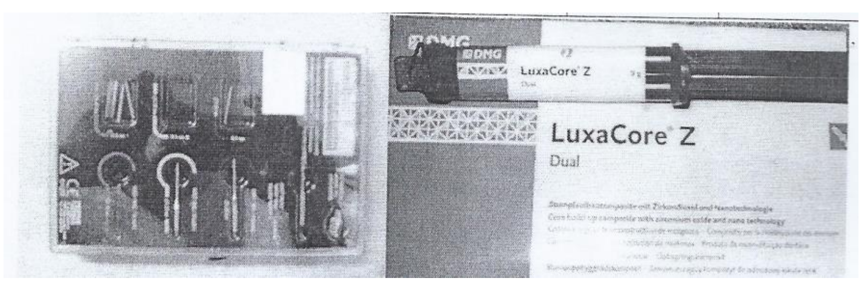

Figure (1): shows materials used in the study a: fiber post kit; b: core build up material.

Posts were randomly picked from the boxes and divided into five groups, 10 of each, depending on the post surface pretreatment to be performed. These pretreatments include: (Group 1) control group the post surfaces were cleaned with a 70% ethanol, water solution according to the manufacturer's recommendation. (Group 2) immersion in 24% hydrogen peroxide for 10 min at room temperature.[14] (Group 3) immersion in 4% hydrofluoric acid gel (Porcelain Etchant, Bisco, Schaumburg, IL, USA) for 60 s[14] . (Group 4) sandblast with 50um aluminum oxide (Blasting medium, Dentarum, Germany) at 60 psi for 10 seconds through a nozzle distance of 10 mm all around the posts after being positioned in plastic sheet for maintenance of post position [15]. (Group5) Post surface were prepared using an Er:YAG at power settings of (300 m), at 2 Hz and 100us) [15]. The specimens were treated with an Er:YAG laser working at 2940 nm. A 90 angled dental handpiece was used with a cylindrical sapphire (1.3 -1.2 mm) fiber-optic tip. The tip was used at an incidence angle of 45° under water irrigation. The air and water pressure was set to two bars. The application tip was moved from the bottom to the top and maintained in slight contact with the FRC post surface for 10 seconds from four direction Figure(2) after being positioned in plastic sheet for maintenance of post position.

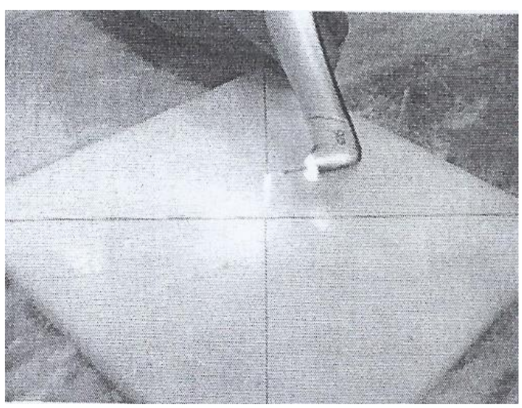

Figure (2): shows fiber post positioned in plastic sheet for maintenance of post position.

After that, all the posts were rinsed with water and air-dried. The silane coupling agent (Monobond S; Ivoclar Vivadent, Schaan, Liechtenstein) was applied in a single layer with a brush on the post surface, and left to air dry for 60 s at room temperature (25+2°C). [13]

CORE BUILD UP PROCEDURE:

The material used for core build up was Luxa Core Z (Luxa Core2 DMJ, Germany), this material was handled according to instructions supplied by the manufacturer Figure(1:B). For the core build up procedure, each post was positioned up right on a glass slab, and secured with drop of sticky wax. [14,16] A cylindrical polyethylene tube was then placed around the post and adjusted so that the post would be exactly in the middle. The tube was used to form core cylinders with diameter of 5mm and 10mm length that equal to the parallel portion of the post. [14] Figure(3:A).

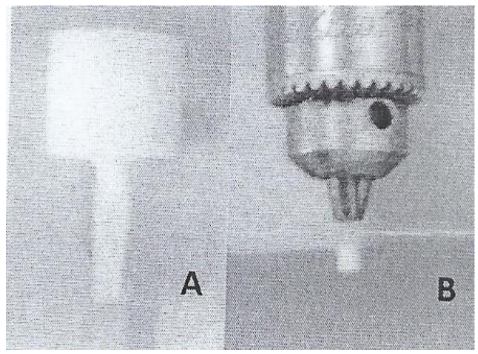

Figure (3): shows: A specimen of the study, B the specimen is placed in a fixture of the universal testing machine with post grasped with Jacob's chuck.

The core material was applied to the post in 2 mm thick increments. Each increment was carefully placed on to the post surface, and each layer was light polymerized for 40 seconds with LED (LEDition, wave length 430- 490nm, light output 500mW/cm^2, Ivoclar Vivadent AG, Schaan, Liechtenstein) the tip of light curing unit was positioned vertically on the top of the posts, at the same distance from buildup material for all specimens. [17] Irradiation was never performed through the polyethylene tube. [14] Once the matrix was completely filled, the core cylinder detached from the glass slab. The specimens were stored in distilled water for 24 hours at 37°C in humidor (100% relative humidity), to simulate conditions in the oral cavity. [18] After storage, the post was then grasped with Jacobs chuck attached to the upper member of a digital universal testing machine (TERCO, MT, 3037, Sweden). the fixture allowed the dowel to extend through a slot preparation through an aluminum plate, which was attached to the testing machine. [18] This fixture ensured that the post was perpendicular to the aluminum plate and produced tensile loading until failure occurred at cross head speed of 0.5mm/min. Failure loads were recorded in kilograms of force [18] Figure(3:B). Tensile retentive force was calculated according to the following formula:

Tensile Retentive Force =F/DPH (F=Applied force, D=diameter of post, P=22/7, H=Height).

An initial screening of the entire rounded post surface was done using a stereomicroscope (Motic, Taiwan) at 40 magnification. One non blinded operator assessed the failure mode for the tensile retentive strength test as 1 of 3 types [19] (1) adhesive no trace of core build up materials found on the post surface; (2) cohesive of core build up materials surrounding the entire post bond area; or (3) Mixed cohesive/ adhesive evidence of core build up materials adhering to any part of the post bond surface. One -Way ANOVA was applied with bond strength as the dependent variable, and the types of surface pretreatment as a factor. The Duncan Multiple Range Test was used for Post-hoc multiple comparisons of surface pretreatment ($p < 0.05$), and calculations were handled by the SPSS 11.0 software (SPSS Inc, USA). [14]

RESULTS

The result of One-Way ANOVA was present in Table (1).

Table(1): One-way ANOVA tests.

	df	Sum of squares	Mean squares	F	P
Between groups	4	2163.7	721.2	133.55	<.001
Within groups	45	197.4	5.4		
Total	49	2361.3			

Shows that there is a significant differences between groups. The results of the mean of tensile retentive force values for control and experimental groups are presented in Table (2).

Table (2): Mean standard deviation values and statistical significance of the tensile retentive force values measured in all experimental groups.

Groups	N	Mean (MPa)	+SD	Post-hoc[a]
Control	10	12.64	2.11	C
24% Hydrogen Peroxide	10	16.23	3.1	A
4% Hydroflouric Acid gel	10	14.31	2.3	B
Sandblast	10	16.1	3.2	A
laser	10	10.11	2.5	D

[a] Ducan Multiple Range Test: groups identified with the different letters are statistically different N=number SD= standard deviation.

Statistical analysis revealed that the post surface pretreatment procedures had a significant influence on tensile retentive force values (P < 0.05). More precisely, the post core strengths achieved following pretreatment with hydrogen peroxide and sandblast (Groups 2 and 4) were comparable to each other, and significantly higher than those of other groups in which the post surface had been treated with hydrofluoric acid, control and laser group, respectively. The lowest post core strength was achieved with laser surface treatment, and the difference was statistically significant from the other groups. Stereomicroscopy analysis revealed a significant amount of core buildup materials remain on the surfaces of the post specimens treated with the 24%hydrogen peroxide and sandblast treatment groups demonstrating a 100% cohesive/adhesive fracture mode for the core material Figure(4:A) and Table(3).

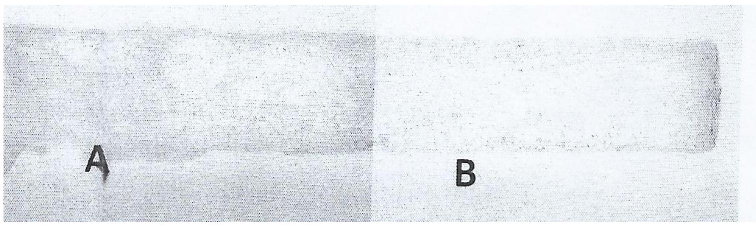

Figure (4): shows A: mixed failure mode, B:adhesive failure mode 40X

Table (3): Shows percentage of failure modes for all groups.

	Groups 1	Groups2	Groups3	Groups4	Groups5
Adhesive	100%	0	20%	0	100%
Adhesive / Cohesive	0	100%	80%	100%	0
Cohesive	0	0	0	0	0

Conversely, there was an absence of core buildup materials on the surfaces of the control and laser groups; thus, the mode of failure was determined to be 100% adhesive Figure(4:B) and Table(3). No completely cohesive fracture was found at all groups.

DISCUSSION

A number of studies particularly focused on the possibility of improving adhesion at the fiber post core material interface through various treatments of the post surface. [20-25]Within the limitations of the present study, it was concluded that our hypothesis was confirmed, i.e., bond strengths of core build up material to FRPs were significantly affected by the investigated surface treatments.

Previous studies[26-28] have shown that hydrogen peroxide is able to dissolve the epoxy resin matrix, breaking epoxy resin bonds and exposing the surface of fibers to silanization. This method of pretreatment was found to be effective for enhancing the retention between epoxy resin based of conventional fiber post systems and core materials. [28] In our study hydrogen peroxide was found to be the most effective treatment with respect to post core tensile retentive force. These data are in agreement with result of previous studies by Monticelli et al. [28] Vano et al.,[14] Mylswamy et al., [13] Khamverdi et al. [29] Valandro et al., [32] and disagree with Mosharraf, [30] and Amaral et al. [31] The second high result in this study was observed in the sandblast group. The mechanical action of blasting probably determines the removal of the superficial layer of the resinous matrix, creating micro retentive spaces on the post surface that can be engaged by core materials, although, this regimen did not produce visible changes of the shape of the post they resulted in increased surface area and mechanical interlocking with the core material. These data are in agreement with result of previous studies by Asmussen et al., [24] Balbosh and Kern. [25] Similarly, Radovic et al., [23] reported a significant increase in surface retention when aluminum oxide particles were used for treating FRPs. Ceramic etching with HF acid is able to create a rough surface that allows micromechanical interlocking with the resinous cement. [33]This methodology was recently proposed for etching glass fiber posts. [4]In our study

Post core bond strengths were also increased as a result of post treatment with 4% hydrofluoric acid, though to a lesser extent than following post immersion in hydrogen peroxide. One conceivable explanation for these results could be that hydrofluoric acid selectively dissolves the glass component of the fiber post, producing an irregular pattern of micro spaces on the post surface. This may increase the surface area and facilitate the penetration of the core material. (14)These data are in agreement with result of previous study by Vano et al. (14) The bond strength with hydrofluoric acid was also lower than sand blast group this result is in agreement with the result of Valandro et al. (32)

Laser applications for dental practice have been a research interest for the past 35 years. (4,34,35) Murray et al.(35) indicated that laser treatment or other surface may be a suitable alternative to sandblasting pretreatment techniques for enhancing the bond strength of dental materials to metal surfaces. As for laser treatment of FRPs, little experimental research was undertaken to date. (15). According to results of the present study, the Er:YAG laser group showed lower bond strengths even than the control group. It was apparent that the use of Er:YAG laser treatment resulted in exposure of the composite matrix and damage to fibers at the surface of the FRPs (15). Based on the results of the present study, these procedures cannot be recommended for clinical use due to possible weakening effects on the stability and integrity of the posts. Although laser treatment was indicated to be a promising technology in dentistry, there is still need for more research to determine appropriate parameters of laser treatment for application of this technology to dental materials, this result is in agreement with the result of Murat et al. (15)

The current study was limited to one FRPs and core buildup material. Nevertheless, these findings allow for a better understanding of the effects of different surface treatments on the bond strength of core build up material to FRPs. However, future studies evaluating the effects of different post and core materials are recommended. Conclusions: surface pretreatment of FRP has significance effect on the tensile retentive force. Sandblasting and hydrogen peroxide are increasing tensile retentive force of FRPs to composite core material buildup greater than those of hydrofluoric acid gel, control and laser group, respectively.

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