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Er-YAG Laser Effect on Push-out Bond Strength of MTA and Bio-dentine in Furcal Perforation Repair: A Comparative Study

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ABSTRACT

Objective: The aim of the present study was to evaluate the effect of Er-YAG laser activated irrigation of sodium hypochlorite solution on the push-out bond strength of furcal perforations repaired with MTA and Biodentine.

Materials and Method: 50 freshly extracted human mandibular teeth with divergent roots were selected. Furcal perforations were created with the help of number three round diamond bur. Half of the samples were repaired with MTA and the other half with biodentine. Each group was divided into five subgroups. 1) Normal saline 2) 3% NaOCl 3) Normal saline with laser activated irrigation 4) 3% NaOCl with laser activated irrigation 5) no irrigation (control group). Push-out bond strength test assessed the bond strength of the specimens.

Results: Biodentine showed significantly higher push-out bond strength than pro root MTA ($p < 0.05$). Laser-activated irrigation of 3% NaOCl and normal saline did not significantly influence the push-out bond strength ($p > 0.05$).

Conclusion: Biodentine presented significantly higher resistance to dislocation than MTA as repair material in furcation defects. ErYAG laser activated irrigation did not significantly influence the push-out bond strength of bio dentine or MTA.

Introduction:

Perforation in furcation area is one of the common procedural complication that can occur during root canal treatment or post space preparation, and this requires skillful management.[1] Prognosis of perforated tooth depends on several factors, which mainly includes the location of perforation, delay in perforation repair, contamination of perforated area and biomaterial used for perforation repair.[2]In order to improve the prognosis of the tooth, perforation should be repaired prior to the endodontic

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treatment.[3,4]Repair is carried out with a biocompatible material that can provide adequate seal and good resistance to dislodgment.[5,6]

MTA has been widely used and accepted as furcation defect repair material. It has shown satisfactory results with long term follow up in many studies.[7, 8] MTA has various properties which favour its clinical use, however it has disadvantages, such as long setting time and discoloration potential.[9]Biodentine, a calcium based cement was introduced to overcome the drawbacks associated with MTA. It has superior handling property, reduced setting time and improved mechanical strength.[10, 11] Therefore biodentine can be used in most of the cases indicated for MTA, including perforation repair.[11]

Perforation repair should be carried out prior to completion of endodontic treatment which requires irrigation of the root canal system.[4] Studies have shown that contact with irrigating solution may alter the properties, and adhesion of the set material to the dentine.[12] Therefore, it can be presumed that the use of device-assisted irrigation can have a more pronounced effect on the properties of the repair material.

Laser activation of irrigating solution produces transient cavitation effect causing an optical breakdown in irrigating solution through absorption of laser energy.[13, 14] Cavitation is the process of formation of bubbles in the fluid which result in the agitation of liquid and production of shock waves leading in depth cleaning and disinfection of root canal system.[15] This process makes the irrigation more effective in comparison to needle irrigation and passive ultrasonic irrigation. Dostalova et al.showed that Er: YAG laser (100mJ energy, 30 pulses, and 4Hz) is effective in disinfecting canals.[16]Perin et al. evaluated the antimicrobial impact of Er: YAG laser and 1% sodium hypochlorite in reducing four types of bacteria and one type of fungus. Food and Drug Administration (FDA) in 1997had approved erbium-doped yttrium aluminum garnet (Er:YAG) laser (wavelength 2,940nm) for cleaning, shaping, and enlarging the root canal.[18]

Previous studies investigated the effect of different irrigating solutions on the adhesion and strength of perforation repair material.[4, 19] But effect of Er-YAG laser has not been evaluated. Therefore, the objective of the present study was to assess the effect of laser activated irrigation on pushout bond strength of MTA and Bio dentine.

Materials and Method

Preparation of specimen: 50 freshly extracted, sound human mandibular molars with divergent roots were selected. Access opening was done after confirming canal patency by radiograph. Working length was recorded with number 10 k file by subtracting 1 mm from the root apex. The distal and mesial canals were enlarged up to ProTaper Next file size X3 (0.30mm tip; Dentsply Maillefer, Ballaigues, Switzerland) and ProTaper Next X2 (0.25mm tip), respectively. The tooth was then decoronated 5 mm above from the pulpal floor. (Fig 1)Furcal perforations were created by number three diamond bur in the pulp chamber floor. The defect was then instrumented with Gates Glidden drill till no 3 to standardize the diameter of the defect up to 0.9 mm. The height of the defect was adjusted to 2mm by wheel shaped diamond bur. (Fig 2)

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Fig 1. Showing decoronated sample

Fig 2. Showing artificial furcal perforation

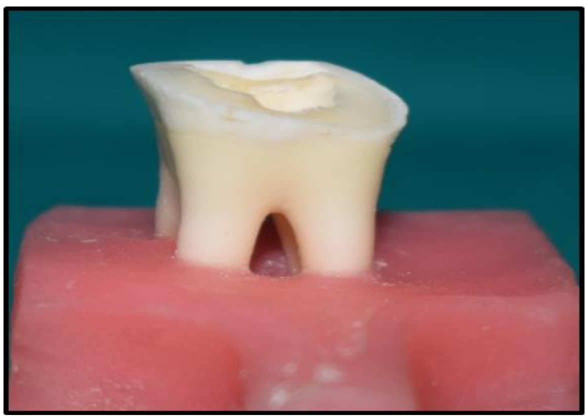

Fig 3. Mounting in the acrylic block

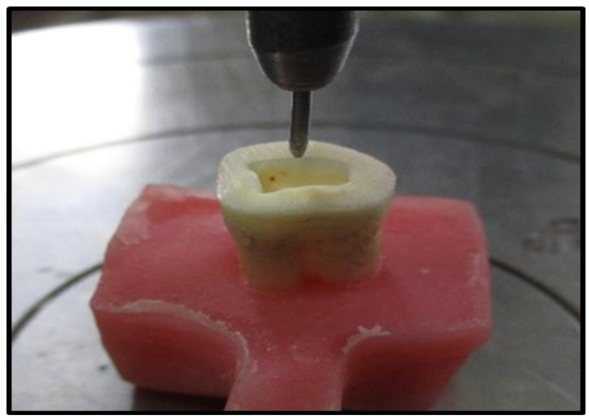

Fig 4. Tool to apply pressure on universal Testing machine

Teeth were mounted on the acrylic block leaving at least 3 mm space below the furcation for packing of gelatin foam against which repair material can be placed.[20] (Fig 3) Perforation defect was created by using no 3 round diamond bur at high speed. The pulp chamber and perforation defect were irrigated with normal saline. The specimens were then randomly divided into two groups of 20 teeth according to two repair material MTA and Bio dentine. Perforations were repaired, and then specimens were stored at 37^{o} C for one week. Specimen were then subdivided according to irrigation protocol. a) 5 ml of normal saline per canal by the side vented 30 gauze needle by placing the needle tip 1 mm from the apex. b) 5 ml of 3% NaOCl per root canal by the side vented needle. c) An Er: YAG laser with a wavelength of 2,940 nm (Fidelis; Fotona) was used to irradiate the root canals with a newly designed 12 mm long, 400 µm quartz tip. The laser operating parameters employed for all the samples were as follows: 40 mJ per pulse, 20 Hz, at very short pulse mode. The tip was placed into the coronal access opening of chamber only and was kept stationary and not moved into the orifice of the canal. During the laser irradiation cycles, the root canals were continuously irrigated with normal saline. d) Laser activated irrigationdone with the same protocol as with 3%NaOCl as irrigant. e) No irrigation.

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Push out test: Loading test was applied by the universal testing machine (Instron, Model 1334; Instron Corp, Canton, MA). A stainless steel plunger of 0.7 mm diameter was customized to apply force on the prepared specimen at the cross head speed of 1mm/ min. (Fig 4)

Statistical evaluation: Values were analyzed by using SPSS v11.5 software (SPSS, Inc., Chicago, IL). Multi variance analysis was used to determine the effect of different factors: repair material (MTA and bio dentine), irrigating solutions (normal saline and NaOCl), and skillful technique (needle irrigation and laser activated irrigation).

Table 1. Push out bond strength of control and experimental group

Groups	n	Mean ± SD (Mpa)
Biodentine -control	5	12.32±1.30
Biodentine - saline	5	11.92±1.87
Biodentine – saline LAI	5	11.59±1.20
Biodentine – NaOCl	5	11.75±1.77
Biodentine – NaOCl LAI	5	12.37±1.03
MTA - control	5	7.14±2.02
MTA - saline	5	6.48±1.60
MTA - saline LAI	5	6.96±1.32
MTA - NaOCl	5	6.22±1.64
MTA – NaOCl LAI	5	5.98±1.45

Result: The push-out bond strength values are summarized in a table1. Irrespective of the irrigating solutions and technique used, Bio-dentine yielded significantly higher push out bond strength values than pro root MTA ($p<0.05$). In comparison to control group exposure of the repair material did not significantly influence the push out bond strength ($p> 0.05$). Laser activation of the irrigating solution also did not have significant effect on the push out bond strength ($p> 0.05$).

Discussion: An ideal perforation repair material should adhere to dentine and should resist dislocation under mechanical forces such as condensation forces and when the tooth is under function such as flexion.[21] For in vitro assessment of the adhesion of test material the push-out bond strength is very reliable and efficient method that can be comparable to the clinical situation.[22,23] In the present study the bond strength of MTA and Bio-dentine as a furcation repair material was tested by the push-out test. NaOCl was used for laser activation because it is most widely used root canal irrigation solution. In the present study second null hypothesis was rejected as bio dentine showed better resistance to dislocation than MTA in control group as well as in laser activated irrigation groups and manual irrigation groups. Previous studies also revealed that biodentine in the absence of any irrigating solution showed better dislocation resistance. [19, 24, 25] High bond strength of biodentine may result due to its smaller particle size which results in enhanced penetration inside dentine and ultimately improved bond strength.[19] This micromechanical retention can be further reinforced due to crystal growth inside the dentinal tubule.[26] The higher content of the calcium releasing substance in the bio dentine may also result in the increased biomineralization and bond strength.[19, 27]

The Er-YAG laser has been shown to be most effective in the smear layer removal and root canal disinfection.[16, 17] In previous studies, laser activated irrigation resulted in the higher bond strength values associated with the improved cleaning efficiency on the canal walls. In earlier studies, effect on bond strength of repair material has been tested, but the effect of laser activated irrigation was never tested [30, 32] From this point of view present study was designed to verify the push-out bond strength of set calcium silicate based cement. The Er-YAG laser used in this study equipped with the 400µm diameter radial and stripped off tip. Using laser at parameters (0.8 W, 40 mJ, 20 Hz) was found to be more effective for smear layer removal. This effect can be attributed to the photomechanical effect achieved when light energy is pulsed in the liquid. [32,34]When activated in a limited volume of fluid, the high absorption of the Er: YAG wavelength in water, combined with the high peak power derived from the short pulse duration results in a photomechanical phenomenon. A profound “shockwave-like” effect is observed when radial and stripped tips are submerged in a liquid-filled root canal. As a consequence of the very small volume, this effect may remove the smear layer and residual tissue tags and potentially decrease the bacterial load within the tubules and lateral canals. [35, 36, 37] In this study the bond strength values are very much similar to the previous studies showing that there is no effect due to NaOCl and saline irrigation on MTA and Bio dentine.[19] It is well proven that prolonged exposure of material and dentine to the irrigants may cause alteration in the chemical composition of material.[38, 39]However, in this study exposure is of short duration, and the only coronal surface of the repair material comes in contact with theirrigant, so the effect on the bond strength was insignificant. The future studies should test different protocol.

Conclusion: Within the experimental condition of the present study following conclusions are obtained. a) Biodentine showed greater resistance to dislocation than MTA as a furcal perforation repair biomaterial. b) Laser activated irrigation has no significant effect on the bond strength of MTA and biodentine, independent of irrigating solution used.

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