EVALUATION OF PUSH OUT BOND STRENGTH OF GLASS FIBER POST RELATED WITH ULTRASONIC IRRIGATION

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Field of Study	Esthetic Restorative and Implant Dentistry
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น้อมจิต วิทยพูม : การทดสอบความแข็งแรงในการยึดของเดือยฟันชนิดไฟเบอร์เมื่อทำการล้างคลองรากฟันด้วยอัลตราโซนิก (EVALUATION OF PUSH OUT BOND STRENGTH OF GLASS FIBER POST RELATED WITH ULTRASONIC IRRIGATION) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ทพ. เฉลิมพล ลี้ไวโรจน์, 153 หน้า.

วัตถุประสงค์ เพื่อเปรียบเทียบความแข็งแรงในการยึดติดระหว่างเดือยฟันชนิดไฟเบอร์กับรากฟัน เมื่อล้างคลองรากฟันหน้าบนด้วยวิธีและน้ำยาที่ต่างกัน โดยใช้การทดสอบความแข็งแรงการกดออกเพื่อประเมินการยึดติดในระดับรากที่ต่างกัน

วิธีการทดลอง จำแนกฟันหน้าบนของมนุษย์จำนวน 100 ซี่ เป็น 10 กลุ่ม กลุ่มละ 10 ซี่ ด้วยวิธีการสุ่ม จากนั้นทำการรักษาคลองรากฟันและทำการเตรียมคลองรากฟันก่อนทำการปักเดือยฟัน โดยแต่ละกลุ่มจะใช้วิธีการล้างคลองรากฟันครั้งสุดท้ายที่แตกต่างกัน กลุ่มที่ 1 ถึง 3 ทำการล้างคลองรากฟันด้วยวิธีไซรินจ์ กลุ่มที่ 4 ถึง 6 ทำการล้างคลองรากฟันด้วยวิธีอัลตราโซนิก กลุ่มที่ 7 ถึง 9 ทำการล้างคลองรากฟันด้วยวิธีอัลตราโซนิกแบบไม่สัมผัสคลองรากฟัน โดยแต่ละกลุ่มจะใช้น้ำยาล้างคลองรากฟันที่ต่างกันได้แก่ 2.5% โซเดียมไฮโปคลอไรด์ (กลุ่ม 1,4,7) 17% อีดีทีเอ (กลุ่มที่ 2,5,8) และ 2.5% โซเดียมไฮโปคลอไรด์ตามด้วย 10% โซเดียม-แอสคอร์เบท (กลุ่มที่ 3,6,9)และมีกลุ่มที่ 10 ล้างคลองรากฟันด้วยวิธีไซรินจ์และน้ำกลั่น จากนั้นทำการยึดคลองรากด้วยเรซินซีเมนต์ชนิดพานาเวีย เอสเอ ซีเมนต์ พลัส และทำการตัดฟันให้มีความหนาชิ้นละ 1 มิลลิเมตร ในบริเวณปลายรากฟันและบริเวณคอฟัน จากนั้นทดสอบความแข็งแรงการกดทดสอบ

ผลการทดลอง น้ำยาล้างคลองรากฟันที่แตกต่างกันมีผลต่อแรงในการยึดติดอย่างมีนัยสำคัญทางสถิติ 0.05 พบว่ากลุ่มที่3 6 9ที่ล้างคลองรากฟันด้วย 2.5% โซเดียมไฮโปคลอไรด์ตามด้วย 10% โซเดียม-แอสคอร์เบทมีค่าแรงยึดติดที่สูงที่สุด ในกลุ่มที่ 6 มีค่าแรงยึดติดระหว่างปลายรากฟันและคอฟันแตกต่างกันอย่างมีนัยสำคัญ

สรุป น้ำยาล้างคลองรากที่ต่างกันมีผลต่อแรงในการยึดติดของเดือยฟันชนิดไฟเบอร์ กับเนื้อฟันส่วนรากฟันด้านในของฟันหน้าบนอย่างมีนัยสำคัญทางสถิติ การล้างคลองรากฟันด้วยน้ำยาล้างคลองรากฟัน 2.5% โซเดียมไฮโปคลอไรด์ตามด้วย 10% โซเดียม-แอสคอร์เบทมีค่าแรงยึดติดที่สูงที่สุด ระดับของรากฟันมีผลต่อแรงในการยึดติดในกลุ่ม6เท่านั้น

สาขาวิชา ทันตกรรมบูรณะเพื่อความสวยงาม และทันตกรรมรากเทียม ลายมือชื่อนิสิต .....

ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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KEYWORDS: PUSH OUT BOND STRENGTH / ULTRASONIC / IRRIGATE / SODIUM ASCORBATE

NOMJIT VIDHYAPHUM: EVALUATION OF PUSH OUT BOND STRENGTH OF GLASS FIBER POST RELATED WITH ULTRASONIC IRRIGATION. ADVISOR: ASSOC. PROF. CHALERMPOL LEEVAILOJ, 153 pp.

Objective This study compared the bond strength of glass fiber post to dentin using different irrigation methods and solutions and to evaluate the bond strength in different regions of the root.

Methods One hundred human anterior maxillary teeth were randomly divided into 10 groups (n=10). Root canal filling and post space preparation were carried out followed by diverse final irrigation techniques. Groups 1 to 3 underwent syringe irrigation, groups 4 to 6 irrigation with ultrasonic instrumentation and groups 7 to 9 passive ultrasonic irrigation. Different irrigant solutions were used in each groups as 2.5% NaOCl (groups 1,4,7), 17% EDTA (groups 2,5,8) and 2.5% NaOCl followed by 10% sodium ascorbate (groups 3,6,9). Group 10 was done by syringe irrigation with distilled water. Fiber post luting was performed with Panavia SA Cement Plus. Slices of 1 mm thickness were divided into cervical and apical root regions. Push-out bond strength tests were performed.

Results Bond strengths were significantly affected by different irrigants ($p<0.05$; 2-way ANOVA). Irrigant solution groups 3, 6, and 9 with NaOCl followed by sodium ascorbate gave higher bond strengths with group 6 showing a significant difference between cervical and apical root regions.

Conclusions Bond strengths are significantly affected by different irrigant solutions. An irrigant solution of NaOCl followed by sodium ascorbate resulted in high bond strength values. The region of the root was affected only in group 6.

Field of Study: Esthetic Restorative and Implant Dentistry Student's Signature .....

Advisor's Signature .....

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Background and rationale

Endodontically treated teeth have been restored with post whenever have to retain core in case of coronal excessive loss.[1-2] Nowadays, glass fiber post has been used widely because of proper elastic modulus which similar to dentin and esthetically preferred as well. However, clinical failure is still presented which is mainly caused by de-cementation of glass fiber post to intra-radicular dentin which can lead to post fracture.[3-5] Boschian et al. shown that a weak link of bonding interface has been shown at dentin-cement interface more than post-cement interface.[6] Sidoli et al. shown that minimize wedging effect of the post within the root canal by successful bonding can lead to lower susceptibility to fracture.[7]

Irrigation in root canal treatment is an essential step to provide better cleaning of intra-radicular dentin. Studies have demonstrated that mechanical instrumentation only cannot sufficiently disinfect root canal wall.[8-9] Ultrasonic irrigation has been introduced in endodontics by using ultrasonically activated files which provide acoustic micro streaming.[10] It is the rapid movement of fluid in a circular motion around the vibrating file

in the root canal. The shear flow caused by acoustic micro streaming produces shear stress along the root canal wall, which can remove debris and bacteria from the wall. Two types of ultrasonic irrigation have been described in literature.[11,12] First is a simultaneous ultrasonic instrumentation (UI). Second is a passive ultrasonic irrigation, operated without simultaneous instrumentation (PUI). Studies demonstrated that when PUI was used with different concentration of NaOCl, complete removal of smear layer was shown. On the other hand, Cheung et al. shown that it could not completely remove the smear layer by using PUI with 1% NaOCl for 10 seconds.[13] Moreover, Gu et al. demonstrated that PUI with EDTA or a combination of EDTA and NaOCl did not completely remove smear layers from the apical third of the canal walls.[14]

The use of irrigant provides an additional antibacterial effect in combination with mechanical preparation. EDTA and NaOCl solutions are used to remove the inorganic and organic portion of smear layer.[15] It has been shown to enhance bacterial removal significantly. According to Barbosa et al., the study shown that the use of irrigant before cementation with self-adhesive cement allow the dentinal tubule to open for better

adhesion.[16] Gu et al. shown that EDTA could effectively improve the bond strength of the self-etching adhesive resin cement compare to NaOCl.[14] Marques et al. shown that NaOCl alone may have oxidizing effect that might decrease bond strength.[17] Sodium ascorbate is a sodium salt of ascorbic acid and well known as effective antioxidant that could reverse the compromising effect of NaOCl on bond strength to enamel and dentin. Celik et al. claimed that Sodium ascorbate application after NaOCl conventional syringe irrigation improved the bond strength value.[18]

As a result, to minimized post de-cementation problem we conduct this research to study and compare bond strength of post bonded in root canal wall which effected by ultrasonic irrigation versus syringe irrigation with various irrigant solutions including NaOCl, EDTA and NaOCl followed by Sodium ascobate.

Literature review

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1. Irrigation method

- Syringe irrigation VS Ultrasonic irrigation

Irrigation is an important part of root canal treatment for providing irrigant to clean beyond the root canal instruments. The aim of irrigation is to eliminate microorganism, pulp tissue and dentin debris which we known as smear layer in the root canal system. Goracci et al. shown that the efficacy of irrigation relys on working mechanism of irrigant and ability to bring the irrigant in contact with intra-radicular dentin.[19]

The flushing action from syringe irrigation is relatively weak and dependent not only on the anatomy of the root canal but also on the depth of placement and the diameter of the needle. It has been shown that irrigant can only progress 1 mm beyond the tip of the needle. Moreover,

Abou-Rass et al. shown that an increase in volume does not significantly improve their flushing action and efficacy in removing debris.[20]

Ultrasonic irrigation has been introduced in endodontic by using ultasonically activated files which provide acoustic micro streaming.[10] It is the rapid movement of fluid

in a circular motion around the vibrating file in the root canal. The shear flow caused by acoustic micro streaming produces shear stresses along the root canal wall, which can remove debris and bacteria from the wall.[21,22] Hence, A possible explanation for the improved action is that a much higher velocity and volume of irrigant flow is created in the canal during ultrasonic irrigation.

- Types of ultrasonic irrigation

Two different types of ultrasonic irrigation have been described in endodontic literature.[11,12] First is a combination of ultrasonic irrigation and instrumentation occurring simultaneously. This is called as ultrasonic irrigation (UI). During UI, the ultrasonic tip is intentionally contacted with intra-radicular dentin while irrigant solution is delivered into the canal. Second is a way to operate without simultaneous instrumentation. It is known as passive ultrasonic irrigation (PUI) and occurred when activated file is allowed to oscillate freely in the canal with no contact the root canal wall. Ultrasonic irrigation has been shown to be less effective than PUI to remove smear layer in the root canal. Reduction of acoustic streaming and cavitation can be explained for this reason. It could

result in uncontrolled cutting root canal wall.[12] Recently, Boutsioukis et al shown that even PUI may also result in uncontrolled removal of dentin in straight root canals as well.[23]

- Mechanism of ultrasonic irrigation

During ultrasonic irrigation, two mechanisms can be explained, acoustic streaming and cavitation.[12] First is a acoustic streaming which is the rapid movement of fluid in a circular motion around a vibrating file.[10] The acoustic streaming that occurs in the root canal during ultrasonic irrigation has been described as acoustic microstreaming.[24] This is defined as the streaming which occurs near small obstacles placed within a sound field, near small vibrating wires, which arise from the frictional forces between a boundary and medium carrying vibrations of circular frequency. Several papers have confirmed that acoustic microstreaming occurs during PUI.[25,26] When file is activated in the canal, the displacement amplitude is at its maximum at the tip of the file, probably causing a directional flow to the coronal part of the root canal. When the file is unable to vibrate freely in the root canal, acoustic microstreaming will become less

intense, however, it will not stop completely. The intensity of the acoustic microstreaming is directly related to the streaming velocity. It can be concluded that the higher the streaming velocity and the more powerful the acoustic microstreaming will be. Ahmad et al. shown that the shear flow caused by acoustic microstreaming produces shear stresses along the root canal wall, which can remove debris from the wall.[26]

Second is a cavitation. Leighton et al. explained that it is the impulsive formation of cavities in a liquid through tensile forces induced by high-speed flows or flow gradients.[24] These bubbles expand and then rapidly collapse producing a focus of energy leading to intense sound and damage. Acoustic cavitation can be defined as the creation of new bubbles or the expansion, contraction and/or distortion of pre-existing bubbles in a liquid, the process being coupled to acoustic energy. According to Roy et al., two types of cavitation could occur during ultrasonic irrigation of root canal : stable cavitation and transient cavitation.[25] Stable cavitation could be defined as linear pulsation of gas-filled bodies in a low amplitude ultrasound field. Transient cavitation occurs when vapor bubbles undergo highly energetic pulsations. Transient cavitation only occurs when the

file can vibrate freely in the canal or when the file unintentionally touches the canal wall. Increased contact with the canal wall, as in UI, exclude transient cavitation.[25] In contrast, other researchers claim that cavitation provides only minor benefit in ultrasonic irrigation, or that it does not occur at all.[26]

- Time of ultrasonic Irrigation

Irrigation time on the ultrasonic irrigation is still varied among studies. In general, the literature recommends between 30 seconds and 3 minutes for NaOCl irrigation, although there is no defined consensus on the exact length of time. Munley et al. demonstrated that shorter passive irrigation makes it easier to keep the file in the center of the canal and therefore prevents it from touching the walls and creating aberrant forms.[27] Sabins et al. demonstrated no significant different of smear layer removal between 30 and 60 seconds of PUI.[28] On the other hand, Cameron et al. shown an increased removal of the smear layer after 5 minutes of PUI as opposed to 3 minutes. [29]

- Application of irrigant during ultrasonic irrigation

According to Cameron et al., two flushing methods can be used during ultrasonic

irrigation, including a continuous flush and an intermittent flush.[30] The continuous flush is from ultrasonic handpiece itself whereas the intermittent method, the irrigant solution is injected into the root canal by a syringe, and replenished several times after each ultrasonic activation.

Despite two methods, both flushing methods were equally effective in removing dentin debris from the root canal in an ex vivo model when the irrigation time was set at 3 minutes. Druttman et al. confirmed that application of irrigant is more likely to influence by time than by volume used.[31] Passarinho-Neto et al. shown that 5 minutes of PUI removed more dentine debris from the root canal than 1 minute when the volume was the same.[32] They explain that intermittent flush from a syringe can control the amount of irrigant flowing through the apical region of the canal because both volume and depth of syringe penetration are known, which is not possible in the continuous flush from the handpiece. The apical flow is important because frequent replenishment of irrigant is essential.

2. **Irrigant solution**

Not only the mechanical action of the endodontic instruments is responsible for

the root canal cleaning, but also chemical irrigant solution plays an important role in removing debris and the smear layer.[33,34] The irrigation of the root canal is an essential cleaning procedure in endodontic treatments. Currently, a final irrigation with chemicals such as ethylenediaminetetraacetic acid (EDTA) and Sodium hypochlorite (NaOCl) is recommended to remove the inorganic and organic components of debris and the smear layer.

NaOCl has low superficial tension and has the antimicrobial action, the ability to reduce endotoxic load, and the capacity to dissolve organic tissue. But NaOCl does not alter the inorganic content of the intra-radicular dentin and does not remove the smear layer.[35] It has de-proteinisation effect and acts as biological oxidant which breaks down to Sodium chloride and oxygen. However, according to Nikaido et al., oxygen has been demonstrated a negative effect on polymerization of the adhesive system that caused reduction of bond strength.[36] The presence of reactive residual free radicals in Sodium hypochlorite-treated dentin may compete with the propagating free radicals generated during light activation of the adhesive, resulting in premature chain termination and

incomplete polymerization. Most of these studies demonstrated that NaOCl application decreases dentin bond strength. If decreased bond strength to NaOCl-treated dentin is the result of the oxidizing effect of this irrigant, it may be possible to reverse this reaction by a biocompatible antioxidant such as Sodium ascorbate.[37-39] It was reported that these antioxidants could reverse the compromising effect of NaOCl on bond strength of enamel and dentin by restoring the altered redox potential of the oxidized bonding substrate. Sodium ascorbate allows free radical polymerization of the adhesive to proceed without premature termination. Akgun et al. also reported that the use of Sodium ascorbate reduced the microleakage induced by NaOCl.[40]

Irrigation with EDTA known for its mild demineralization and low abrasion on dentinal substrates, has been reported to remove the smear layer effectively.[41] EDTA could effectively improve the bond strength of a self-etching adhesive resin cement compared to NaOCl.[14] Although, many adhesive resin cements bond well to intra-radicular dentin, the durability of dentin bonding remains a concern.

In this regard, it should be considered that NaOCl and EDTA are common

endodontic irrigants, although their prolonged use at high concentrations may have negative effects on the physical properties of root canal dentin, such as reduced flexural strength, elastic modulus, and microhardness.[42] Consequently, irrigation after post space preparation and its effects on the bond strength of different adhesive strategies are a topic of interest because manufacturers' recommendations vary from the use of NaOCl to no recommendations at all. Bitter et al. conducted five different irrigation protocols after post space preparation to analyze their effects on bond strengths of fiber posts to root canal dentin using three different adhesive strategies.[43] Besides a control group using distilled water, the irrigation protocols were passive ultrasonic irrigation (PUI) using NaOCl 1% and 5.25 %, respectively. Additionally, irrigation using 18 % EDTA followed by 5.25 % NaOCl as well as 2 % Chlorhexidine was tested after post space preparation. Fiber posts were luted using a self-etch and an etch-and-rinse adhesive system as well as a self-adhesive resin cement. The effects of the irrigation protocol on bond strengths were significantly affected by the adhesive strategy. For the etch-and-rinse adhesive system, irrigation using EDTA and 5.25% NaOCl resulted in significantly lower mean bond

strengths compared to the control group, whereas irrigation using 1% NaOCl with PUI revealed the highest mean bond strengths.

During PUI, NaOCl removes significantly more smear layer, pulp tissue or dentine debris from the root canal than distilled water.[32] When a greater concentration of NaOCl is used the efficacy appears to increase ; on the other hand, some studies demonstrated no statistically significant different was found when increase concentration of NaOCl.[44] Moreover, Cheung et al. has shown that it could not completely remove the smear layer by using PUI with 1% NaOCl for 10 seconds.[13] Mozo et al. also demonstrated that PUI with EDTA or a combination of EDTA and NaOCl did not completely remove smear layers from the apical third of the canal walls.[45] Schmidt et al. demonstrated that PUI by using 1% NaOCl and ultrasonic tip placed within 1 mm of the apical foramen did not show higher efficacy in smear layer removal compared with conventional irrigation.[46]

3.Region of bonding to root canal dentin

Differences in the histology of dentin have been shown in different levels of the root. Accordingly, from coronal to apical root region, the dentinal tubule density and its

diameter decrease so the increase in density of dentine tubule would lead to a decrease in the availability of intertubular dentin for micromechanical retention[47]. Moreover, moisture control and removal of debris from the apical part is still a difficult issue. Study has concluded that the intensity of the light diminishes as the distance of the light source increases. Hence, dentin in the deeper part of the root canal might be a challenging for adequate resin bonding through light-polymerization of the resin. In vitro studies on resin bonding to intra-radicular dentin mostly examined and compared bond strength data between different root regions[48] accordingly, the studies compared the bond strength between cervical, middle and apical root regions. Results from published studies on regional bond strength in the root canal and post space are quite variable. It has been shown that the strongest adhesion is achieved in the most coronal regions because that tubule density is greater in the coronal and middle thirds than in the apical region of the root canal,[49] and the diameter of the tubules also decreases in the apical direction.[50] On the other hand, several other studies did not report any variations in bond strengths in different root regions.[51-53]

4. Pre-treatment of fiber post

A reliable bond of the post surface to the root canal dentin is required for establishing a predictable post-endodontic restoration. Although more often failures has been shown at the interface between root canal dentin and luting agent,[6] numerous pretreatment procedures of fiber posts have been suggested to enhance the bond strength between fiber post surface and luting agent. Current fiber posts consist of unidirectional fibers that are embedded in a resin matrix which different matrixes are used by the manufacturers such as epoxy resin, methacrylate resin. It has been demonstrated that different glass fiber posts may vary in flexural properties and micromorphology and that flexural properties may be affected by mechanical properties of the resin matrix and interfacial adhesion between fiber and matrix.[54] Moreover, differences in micromorphology, surface texture and composition may have an impact on the effects of post-pretreatment on fiber post bond strength.[55] The use of a silane solution to enhance the bonding characteristics of fiber posts is still controversial. While some authors have reported increased bond strengths, most peer-reviewed research publications on the

subject have reported that the use of a silane solution chairside does not improve the bonding ability of fiber posts to root canal dentin[55]

5. Type of resin cement

Resin cement was used to bond between root canal wall and fiber post. The high and durable bond strength of fiber post to intra-radicular dentin is essential to ensure a long-term success of any coronal restoration procedure over time. The durability of bonding is related to the hybrid layer created by combination of dentin organic matrix, hydroxyapatite crystallites, resin monomers and solvents. Degradation of polymer network in hybrid layer plays important role for shortening success in this treatment.[56]

In etch-and-rinse adhesive system, polymer degradation becomes more crucial because of wet bonding technique. In this strategy, acid etching demineralizes the dentin surface, then rinsed off by water that must remained to some extension to avoid collagen collapse and allowed resin monomers to infiltrate the demineralized dentin. Organic solvents are added to allow easier and faster evaporation of both water and remaining solvent; nevertheless, complete solvent elimination is difficult.[57] As a result, the remnant

of solvent and water may prevent the complete hybridization. Then the poorly polymerized resin will eventually fasten water sorption and compromise the long-term integrity of adhesive–dentin interface.

According to Nakabayashi et al., self-etching adhesive system does not require acid etching or wet bonding because it has acidic monomer which capable of partially involving original smear layer in the hybrid layer.[58] However, it has high hydrophilic monomer and solvent contents so it exhibits higher water sorption rate and hydrolytic degradation.[59]

To simplify adhesive system, recently manufacturers have launched self-adhesive resin cement which elimination of previous application of bonding. These products contain acid functionalized monomers such as 10-MDP (10-methacryloyloxydecyl dihidrogen phosphate) and 4-META (4-methacryloxyethyl trimellitic anhydride) to demineralize and bond to tooth structure. The acidic monomers create a pH ranging between 1.5 and 3 to gently demineralize dentin and enamel surfaces. The acidic groups bind with calcium in the hydroxyapatite to form a stabilizing ionic attachment between the

methacrylate network and dentin. First, the cements are hydrophilic, which allows proper wetting and adaptation to the tooth surface. As the acid functionality is consumed through reaction with calcium from hydroxyapatite and a variety of metal oxides from the cement ion-leachable fillers, these materials become more hydrophobic, so these products would be less prone to hydrolytic degradation.[60]

Radovic et al. reported better performance of the association of etch-and-rinse or self-etch adhesives with self-adhesive cements. It demonstrated that the self-etching adhesives may offer less favorable adhesion to root canal dentin in comparison with etch-and-rinse and self-adhesive approaches.[63] Recently, Sarkis-Onofre et al. conducted meta-analysis of laboratory studies which indicated that the use of self-adhesive resin cements could improve the retention of fiberglass posts when compared with etch-and-rinse or self-etch adhesives.[61] Even though some studies have been shown that limited interaction in terms of smear layer removal and tag formation have been demonstrated in self-adhesive resin cement, a good chemical interaction with calcium of hydroxyl apatite has been described.[62] This is corroborated by a recent review that revealed that the use

of self-adhesive resin cement might improve bond strength of fiber posts inside the root canal indicating that this simple and less-technique-sensitive procedure is advantageous. [61]

6. Endodontic sealer

Some authors observed a loss of retention when eugenol-based sealers were used before post luting with resin cements.[64] Eugenol is a radical scavenger that inhibits the polymerization of resin based materials.[65] However, other studies found no significant difference when comparing eugenol and non-eugenol containing root canal sealers in terms of post retention when using resin cements. The similar chemistry of luting cements and resin sealers and the lack of contamination with eugenol are responsible for this improved bonding.[64]

7. Insufficient light curing for polymerization

Light activation within the root canal wall is very difficult because of canal geometry that light cannot penetrate through the length of the post. Hence, high bond strength of entire root canal is difficult as well.[66] A limitation in the distance of light

penetration results in a low degree of conversion at the apical area. When the distance from the light source to the irradiation surface was increased, the degree of conversion of resin monomers decreased.[67] Goracci et al. shown that even in the presence of translucent posts, the amount of light at the apical third of the root space might not be sufficient to effectively cure the cement at that level.[67]

8. Operator experience

Bonding procedure is a technic sensitive which require highly susceptible to the operator's experience to get the acceptable quality of bonding. Miyazaki et al. shown that fiber post cementation procedure with etch-and-rinse adhesives may reduce bond strength when observed in less experienced clinicians.[68] On the contrary, when self-adhesive cement was used, Gomes et al. demonstrated that the role of operator was not significant. The reduction in clinical steps as well as no need to keep the dentin substrate moist prior to material application might explain why self-adhesive cement was not sensitive to the operator's skill.[69]

(II) method to evaluate bond strength of post to root canal dentin

Some methods are used to evaluate the bond strength of resin-based material to intra-radicular dentin including micro-tensile bond strength test and push-out bond test.

Micro-tensile bond strength test method is performed by the bonded specimens are sectioned into smaller sized sub-specimens and then individually subjected to the pull out test.[70] Generally, there are two ways to perform this test, trimming and non-trimming method. It has demonstrated that the trimming procedure of the bonded roots luted with fiber posts led to an increased percentage of premature failure of the specimens. Moreover, previous studies have shown that the non-trimming version of the micro-tensile technique may be less traumatic to the bonding interfaces, but the study has been shown unsuccessful in providing intact specimens for bond testing. Most of the beams failed while being cut, suggesting that the root-post bond strength was too low to resist the stresses transmitted to the interfaces. This method has not yet been applied to quantify the adhesion achieved when a prefabricated post is luted into a prepared root canal simulating the clinical condition. Hence, Goracci et al. demonstrated that this test method

is not an optimal method for testing these bond strength.[71]

Push-out bond test is the most reliable and commonly used laboratory method to test the bond strength of a fiber post luted to intra-radicular dentin in a way to simulate clinical condition. It produces shear stress at both interfaces (post-cement and cement–dentin) of the luted fiber post to intra-radicular dentin with resin cements. This simulates the stress accumulation during clinical functioning of the restored tooth. The push-out test leads to less premature failures of the specimens and reduce variation in the distribution of bond strength data. Finite element analysis was confirmed that the push-out test method is a relevant bond strength test for fiber post luted to intra-radicular dentin.[71,72]

Research Questions

1. Does the different irrigation methods and irrigant solutions influence the bond strength?

2. Does the region of the post in root canal influence the bond strength?

Research Objectives

1. To evaluate and compare the push out bond strength of fiber post to intra-radicular dentin among test groups using different irrigation methods (syringe irrigation, ultrasonic instrumentation, passive ultrasonic irrigation) and different irrigant solutions (NaOCl, EDTA, NaOCl followed by Sodium ascorbate)
2. To examine the push out bond strength in different region of the post in root canal

Null hypothesis

1. There is no statistically significant different on push out bond strength of the different irrigation methods and irrigant solutions.
2. There is no statistically significant different on push out bond strength of the different regions of post in root canal.

Conceptual framework

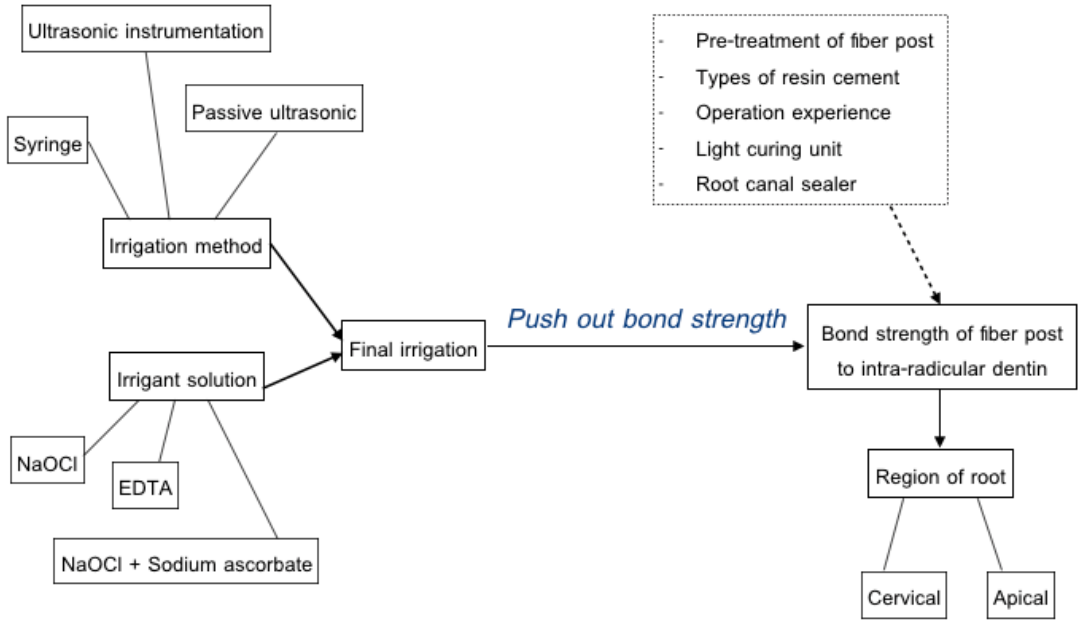
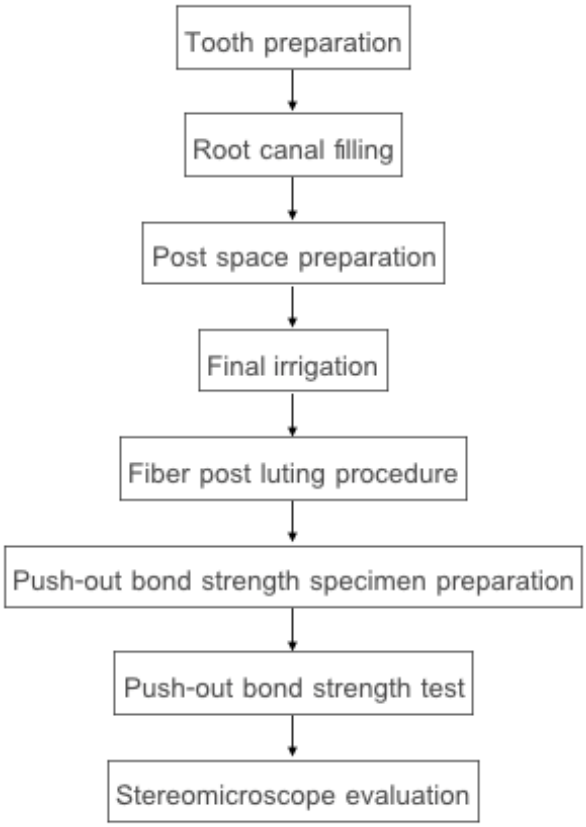


Diagram of study design



Sample calculation

Group	Type of irrigation	Irrigant material	MPa mean(SD)
4	Passive ultrasonic (Irrisafe)	NaOCl	10.614 (6.255)
5		EDTA	
6		NaOCl+Sodium Ascorbate	
7	Ultrasonic (ET20D)	NaOCl	7.001 (3.759)
8		EDTA	
9		NaOCl+Sodium Ascorbate	

Due to Pilot study (study code HREC-DCU-P2016-003), Sample can be calculated by focus on first objective which is type of irrigation by followed equation

$$n = \frac{(\sigma_1^{\,2} + \sigma_2^{\,2})(Z_{1-\alpha/2} + Z_{1-\beta})^2}{(\mu_1 - \mu_2)^2}$$

(Group1-3 were positive control and were not included in calculation)

whereas μ_1 and σ_1 were obtained by passive ultrasonic test group (G4-G6)

μ_2 and σ_2 were obtained by ultrasonic test group (G7-G9)

$\alpha = 0.05$ $\beta = 0.2$

μ_1 = 10.614 μ_2= 7.001

σ_1 = 6.255 σ_2 = 3.759

n = 30 = sample size in each type of irrigation

so in each group (G1, G2, G3 ….. G9) when divided by both type of irrigation and irrigant, sample size will be 10 teeth per group. After proposal defense, advisor added negative control group (syringe irrigation with distilled water group) so total of 100 teeth were collected in the study (n=10)

Materials

1. 100 Human maxillary anterior teeth
2. 100 D.T. Light-Post Illusion X-RO No.2 (RTD, Lancon Provence, France)
3. D.T. Finishing Drill (RTD, Lancon Provence, France)
4. Absorbent paperpoint (Dentsply, Maillefer, Ballaigues, Switzerland)
5. AH Plus Sealer (Dentsply, Maillefer, Ballaigues, Switzerland)
6. Panavia SA cement (Kuraray, Tokyo, Japan)
7. ProRinse Endo Irrigation Needles (Dentsply, Maillefer, Ballaigues, Switzerland)

8. Irrisafe (Acteon Satelec, Merignac, France)

9. Endotip, ET20D (Acteon Satelec, Merignac, France)

10. Luer Vac Adapter (Ultradent Products, South Jordan, Utah)

11. Protaper Next X3 –X5 (Dentsply, Maillefer, Ballaigues, Switzerland)

12. K-file (Dentsply, Maillefer, Ballaigues, Switzerland)

13. Cavit (3M,ESPE, St. Paul, MN)

Solution

1. 2.5% NaOCl (Faculty of dentistry, Mahidol university, Thailand)

2. 17% EDTA (Faculty of dentistry, Chulalongkorn university, Thailand)

3. 10% Sodium ascorbate (NutriBiotic, California)

4. 0.1% Thymol Solution (Faculty of dentistry, Mahidol university, Thailand)

Equipment

1. Low speed cutting machine (ISOMET 1000, Illinois)

2. Digital caliper (Mitutoyo, Tsukuba, Japan)

3. Universal testing machine (SHIMADZU, Kyoto, Japan)

4. Stereo Microscope (ML 9300, MEIJI Techno, Saitama, Japan)

5. Ultrasonic unit (Acteon P5 Newtron XS, New Jersey)

6. ATR Motor (ATR Technika Digital motor, Pistoia, Italy)

Methods

Sample Preparation and root canal filling

One hundred maxillary human anterior teeth with straight or slightly curved canals, no sign of crack and fracture, no root caries and fully developed apices with complete root length were collected in this study. The teeth were cleaned of soft tissue and calculus and stored in 0.1% Thymol solution at 4°c not more than 6 months.

The crowns were cut above cento-enamel junction 2 mm with diamond disks and slow speed saw under water cooling, which exposed the pulp chamber. The teeth with IAF 25-30 and root length 13-15mm were included in the study. Then the length of root canal was determined by # 10 K-file (Dentsply, Maillefer, Ballaigues, Switzerland) until

present at the point of apical foramen. The working length was obtained by deduct 1 mm from the tooth length.

Root canal preparation was done by Protaper Next X3-X5 (Dentsply, Maillefer, Ballaigues, Switzerland) with ATR Motor (ATR Technika Digital motor, Pistoia, Italy) at 300 RPM, 4 Ncm torque. Then 2.5% NaOCl was used to irrigate 3 ml in each change of instrument, then recapitulate and re-irrigate again. Each instrument was used to enlarge eight canals only. Apical patency was done by No.10 K-file. Final irrigation was done by 1 ml of 17% EDTA and 3 ml of distilled water, then evacuated out by Luer Vac Adapter (Ultradent Products, South Jordan, Utah) and dried with 3 absorbent paper points 3 second each (Dentsply, Maillefer, Ballaigues, Switzerland). Master apical file was 50.

Root canal obturation was done by using lateral condensation technique with AH Plus sealer and gutta percha cone. (Dentsply, Maillefer, Ballaigues, Switzerland) Temporary filling was done by Cavit (3M,ESPE, St. Paul, MN). Digital x-ray was done randomly to check the quality of canal obturation. Then teeth were stored in distilled water for 48 hours at 37°c.

10% Sodium ascorbate solution preparation

Sodium ascorbate (Ascorbic acid sodium salt) was obtained from NutriBiotic (CA,USA). The solution containing Sodium ascorbate (10%) was prepared by dissolving Sodium ascorbate powder in distilled water under mixing at room temperature. For example, in each 500ml solution preparation, we use 25g of Sodium ascobate powder. We prepare it freshly before each using because it can be damaged easily by light.

Post space preparation

After storage, gutta percha was removed until 4 mm left behind for preserve apical seal. The post space was prepared by D.T. Finishing drill No.2 as recommened by manufacteror in a low speed handpiece (rotation speed 1000-2000 rpm).

One hundred maxillary anterior teeth were randomly divided in to 10 groups (n=10)

Group 1 : Syringe irrigation with 2.5% NaOCl

Group 2 : Syringe irrigation with 17% EDTA

Group 3 : Syringe irrigation with 2.5% NaOCl then 10% Sodium ascorbate

Group 4 : Ultrasonic irrigation with 2.5% NaOCl

Group 5 : Ultrasonic irrigation with 17% EDTA

Group 6 : Ultrasonic irrigation with 2.5% NaOCl then 10% Sodium ascorbate

Group 7 : Passive ultrasonic irrigation with 2.5% NaOCl

Group 8 : Passive ultrasonic irrigation with 17% EDTA

Group 9 : Passive ultrasonic irrigation with 2.5% NaOCl then 10% Sodium ascorbate

Group 10 : Syringe irrigation with distilled water (Negative control)

Syringe irrigation group (Positive control) was performed with 10 ml syringe and ProRinse Endo Irrigation Needles (Dentsply, Maillefer, Ballaigues, Switzerland) by placing 1 mm above gutta percha . Irrigant solution were injected into canal by in and out motion 10ml for 1 minute then evacuated out by Luer Vac Adapter then re-apply irrigant several times with total of 3 ml in 3 minutes in each group.

Ultrasonic irrigation group was performed with Ultrasonic unit (Acteon P5 Newtron XS) power setting of 7 along with a tip (EndoTip ; ET20D, Acteon) placing 1 mm above

gutta percha with simultaneous instrumentation the root canal wall using push-pull circumferential motion. During irrigation, intermittent flush were used which irrigant is injected into canal by syringe 1 minute then evacuated out by Luer Vac Adapter then re-apply irrigant several times with total of 3 ml in 3 minutes in each group.

Passive ultrasonic irrigation group was performed with Ultrasonic unit power setting of 9 along with a special file (Irrisafe, Acteon) 25-diameter and 21 mm-long placing 1mm above gutta percha at the center of canal avoided contact of root canal surface. During irrigation, intermittent flush were used which irrigant is injected into canal by syringe 1 minute then evacuated out by Luer Vac Adapter and re-apply irrigant several times with total of 3 ml in 3 minutes in each group.

Then group 1 to group 9 were irrigated with distilled water and evacuated out by Luer Vac Adapter then 3 absorbent paper points were used 3 second each.

Negative control group was performed with 10 ml syringe and ProRinse Endo Irrigation Needles by placing 1mm above gutta percha and irrigate with distilled water total of 3 ml in 3 minutes.

The D.T. Light-Post Illusion X-RO No.2 were prepared and cleaned with alcohol as recommended by manufacturers.

Fiber post luting procedure

Panavia SA Cement Plus (Kuraray, Tokyo, Japan), a dual-cure, self-adhesive resin cement was used in all groups by applying it in the post space from bottom to the top using a root canal tip. The posts were seated in to canal by finger pressure and excess cement were immediately removed. It was polymerized using LED for 10 seconds which tip of light cure unit place direct to the post, stabilized without pushing it. Digital x-ray was done randomly to check the quality of post placement.

Push-out bond strength test

After cementation specimens were stored in distilled water for 48 hours at 37°c. and then section with Low speed cutting machine (ISOMET 1000) divided into 2 pieces which identified into cervical and apical sections.

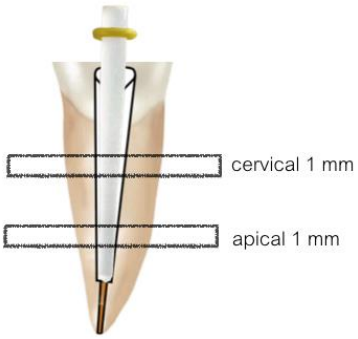


Figure1. Preparation of specimens: Low speed cutting machine was used to prepare two sections; 1 mm cut below cement-enamel junction for cervical part and 1 mm cut above gutta percha for apical part, each 1 mm thick.

The thickness of each root sections was verified by Digital caliper (MItutoyo, Japan) and radius of post was measured by Stereo Microscope (ML9300, Meiji Techno, Japan). Push-out bond strength was tested with universal testing machine (SHIMADZU, Japan) with push out jig 0.5 mm at a crosshead speed 0.5 mm/min until post dislodgment.

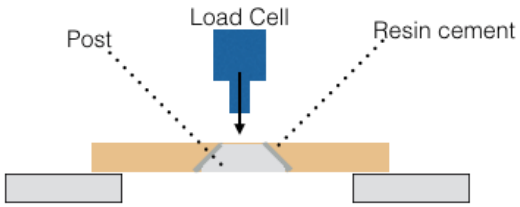


Figure2. Push-out bond strength was tested with universal testing machine.

The peak force at the point of extrusion of the post segment from root was taken as point of bond failure. The value was record in Newton (N). To get the bond strength in MPa, the load value recorded in Newton was divided by area of the bonded interface, which was calculated as followed

$$A = \pi(R + r) \sqrt{(R - r)^2 + h^2}$$

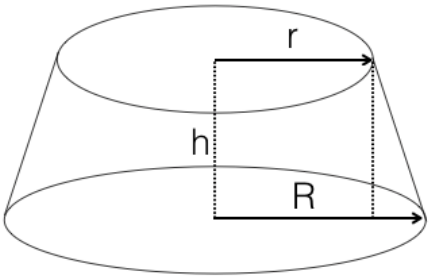


Figure 3. Bonded surface area was calculated using formula: $A = \pi(R + r) \sqrt{(R - r)^2 - h^2}$; where r is the apical side of post radius, R is the cervical side of post radius, and h is the thickness of the post in mm.

Stereomicroscope evaluation

After push-out testing, specimens were analyzed under Stereo Microscope (ML 9300, MEIJI) to determine failure mode at apical side of post radius at magnification of *45. The types of failure was classified into the following 5 categories :

1. adhesive failure between post and cement
2. adhesive failure between intra-radicular dentin and cement
3. cohesive failure of post
4. cohesive failure of cement
5. mixed failure

Five categories were examined by one operator with decision of more than 50% of that failure fall into that category. Mixed failure was determine by more than one failure has been shown in same amount.

Statistical analysis

Normal distribution is assumed, two-way ANOVA and Tukey's test are used.

Expected benefit from this study

The results of this study will be useful for dentists to archive better bond strength of fiber post and intra-radicular dentin by different final irrigation. They can decide from this study to use the method of irrigation such as syringe irrigation, ultrasonic irrigation or passive ultrasonic irrigation, and irrigation solution such as NaOCl, EDTA or NaOCl followed by Sodium ascorbate as well. In fact, if the result shows better push out bond strength in ultrasonic irrigation or passive ultrasonic irrigation, they can choose that method additional to the syringe irrigation. In addition, the result will illustrate mode of failure compared between cervical and apical section of root canal, which could be imply for the weak point of the bonding in this area and provide information for further future investigation.

Limitation

There is only one post system (D.T. Light-Post Illusion X-RO) and one resin cement product (Panavia SA cement) were used in this study. Moreover, according to sample preparation, teeth have to embed in a resin block which direction of the luted post has to perpendicular to the saw of low speed cutting machine to get the even height of specimen in precise direction. Due to Pilot study (study code HREC-DCU-P2016-003) has done, final protocol of sample preparation is adopted. Using surveyor to conduct direction of the post into the resin block was used to eliminate tilted direction of specimen.

Result

None of the prepared specimen failed prematurely. From two-way ANOVA model, Irrigant solution was found significantly effective on push-out bond strength ($p<0.05$; Table I) while irrigant method and irrigant method combined with irrigant solution were not found any statistically significant. The group that irrigated with NaOCl followed by Sodium ascorbate has been shown higher bond strength than NaOCl and EDTA group (Group 3,

6 and 9). Only in group 6 which is ultrasonic instrumentation with Sodium ascorbate group was found significantly difference between cervical region (mean 27.97, SD 12.48) and apical region of root (mean 43.18, SD 20.99) ($p<0.05$; Table II).

Failure mode at apical side of post radius at magnification of *45 was determined. The types of failure were classified into the following 5 categories but in this research we found only type 1 (Fig.4), type 2 (Fig.5), and type 5 (Fig.6). The failure modes of the groups and root levels are presented in Table 3. No cohesive failure in post and cement (type 3 and 4) was observed. A higher incidence of type1 failure was observed in group 2 (55%), group 3 (80%), group 6 (70%) and group 9 (80%). The other groups was shown high incidence in type 2 failure mode. Moreover, Gutta percha remnant has been shown in approximately 10% of all case (18 out of 200 samples)(Fig.7).

Noted that the result has been trasformed into Log10 before analysis.

Table I. ANOVA models

Source of variation	Sum of squares	*df*	Mean square	F	*P*
Irrigation method	.438	2	.219	1.189	.307
Irrigant solution	14.174	2	7.087	38.474	.000
Irrigation method*Irrigant solution	.418	4	.105	.568	.686
Error	31.498	171			
Total	267.782	180			

Table II. Mean bond strength values (SDs) of original data to different regions of the post in root canal

Group No.	Groups	Bond strength of cervical third (MPa)	Bond strength of apical third (MPa)
1	Syringe + NaOCl	12.18(10.56)^{Bb}	21.59(14.34)^{Bb}
2	Syringe + EDTA	11.27(8.23)^{Bb}	17.33(21.50)^{Bb}
3	Syringe + NaOCl + Sodium ascorbate	39.30(17.86)^{Ab}	35.96(18.90)^{Ab}
4	UI + NaOCl	13.47(13.18)^{Bb}	7.78(9.35)^{Bb}
5	UI + EDTA	15.25(10.54)^{Bb}	9.44(6.36)^{Bb}
6	UI + NaOCl + Sodium ascorbate	27.97(12.48)^{Aa}	43.18(20.99)^{Ab}
7	PUI + NaOCl	19.84(18.08)^{Bb}	6.49(4.71)^{Bb}
8	PUI + EDTA	12.89(14.13)^{Bb}	16.14(16.44)^{Bb}
9	PUI + NaOCl + Sodium ascorbate	39.30(21.49)^{Ab}	42.85(22.98)^{Ab}
10	Syringe + distilled water	18.68(19.81)^{Bb}	13.47(13.13)^{Bb}

*Within the same column, different capital letter means statistically significant different; within the same row, different lower case means statistically significant different (p<0.05).

Table III. Distribution of the failure mode following push-out bond strength test (Each group presented cervical (C) followed by apical part (A))

Failure mode	Group1		Group2		Group3		Group4		Group5		Group6		Group7		Group8		Group9		Group10	
	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
1.adhesive failure between post and cement	2	4	3	8	8	8	1	2	4	2	6	8	4	3	2	0	8	8	3	0
2.adhesive failure between intra-radicular dentin and cement	7	6	5	2	2	2	8	8	6	8	4	2	5	6	8	9	1	2	7	9
3.cohesive failure of post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.cohesive failure of cement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.mixed failure	1	-	2	-	-	-	1	-	-	-	-	-	1	1	-	1	1	-	-	1

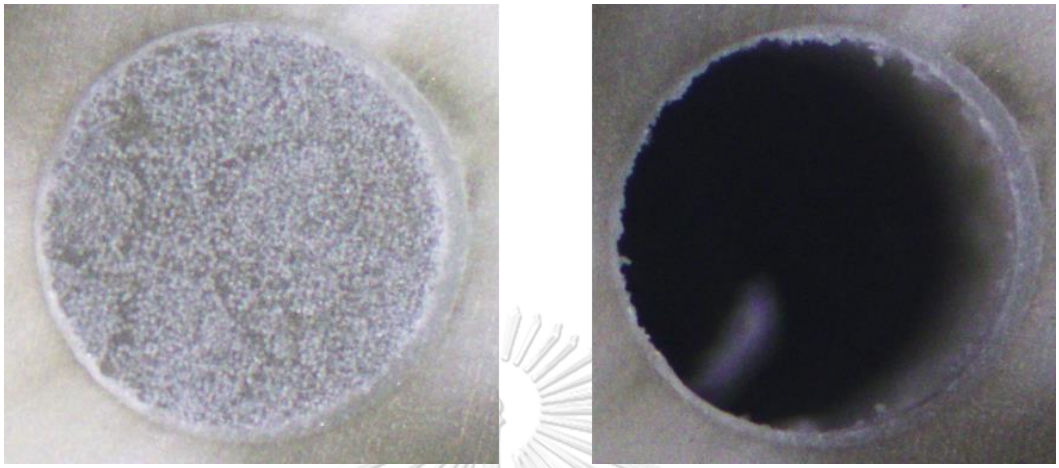


Figure 4. Example of type 1 adhesive failure between post and cement by stereomicroscope at magnification of 45 (before push out bond strength *(left)*, after push out bond strength test *(right))*

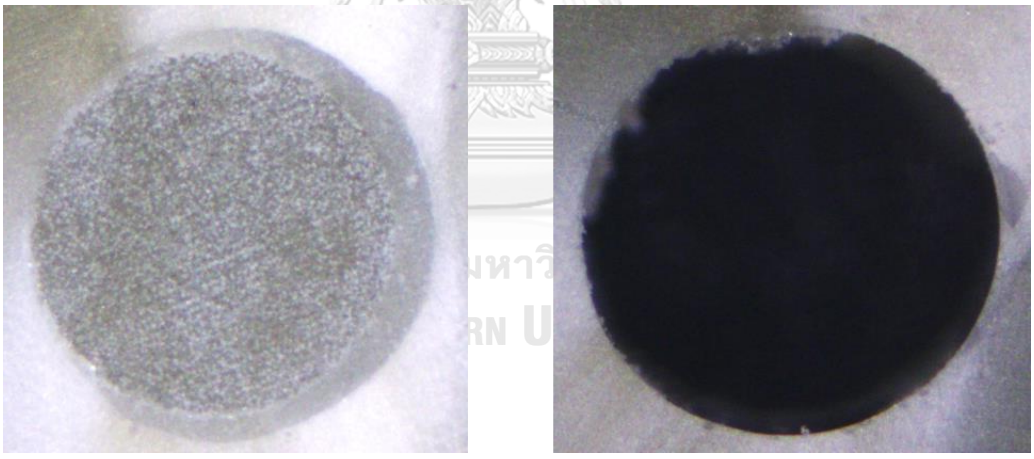


Figure 5. Example of type 2 adhesive failure between intra-radicular dentin and cement by stereomicroscope at magnification of 45 (before push out bond strength *(left)*, after push out bond strength test *(right))*

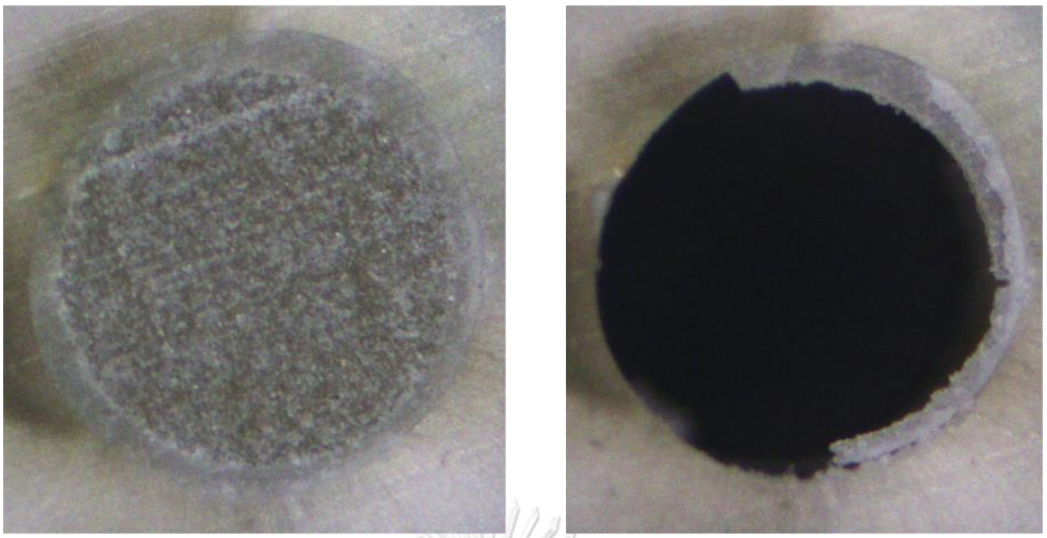


Figure 6. Example of type 5 mixed failure by stereomicroscope at magnification of 45 (before push out bond strength *(left)*, after push out bond strength test *(right))*

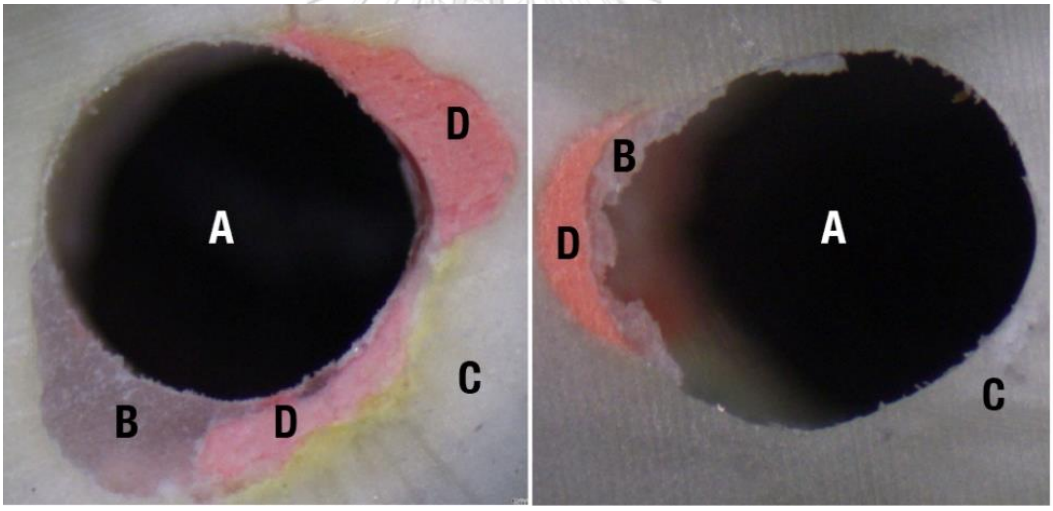


Figure 7. After push out bond strength test, Stereo Microscope was used with magnification of 45. Gutta percha remnant has been shown in approximately 10% of all case (18 out of 200 samples). (A: post space, B: resin cement, C: root, D: gutta percha)

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APPENDIX

Table of appendix

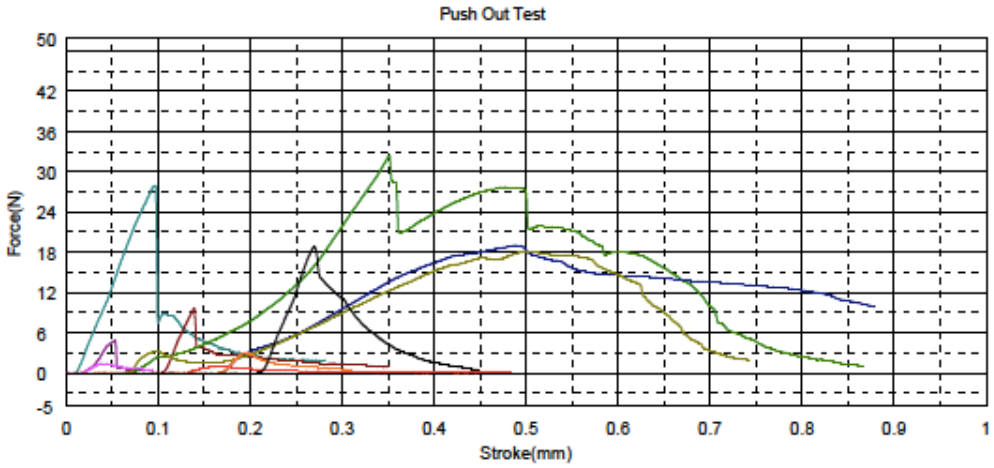
Graph

Figure

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	0.9420	0.9700
1 - 2	1.5030	1.4200
1 - 3	1.2360	1.0400
1 - 4	1.4530	1.4000
1 - 5	1.2820	1.1600
1 - 6	0.7940	0.8900
1 - 7	1.3230	1.1800
1 - 8	1.2030	1.2200
1 - 9	1.2040	1.1400
1 - 10	1.0740	1.0300

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	27.9375	.09650	29.6576	9.94845
1 - 2	9.62750	.13950	6.40552	9.82394
1 - 3	4.80500	.05317	3.88754	5.11218
1 - 4	32.4200	.35133	22.3125	25.0952
1 - 5	19.0175	.49250	14.8342	42.4569
1 - 6	18.0975	.49983	22.7928	56.1611
1 - 7	1.44500	.04133	1.09221	3.50283
1 - 8	.98500	.16500	.81879	13.5246
1 - 9	3.00500	.19600	2.49585	17.1930
1 - 10	18.7825	.26983	17.4884	26.1974
Mean	13.6122	.23050	12.1785	20.9016
Standard Deviation	11.2963	.16875	10.5615	17.0502

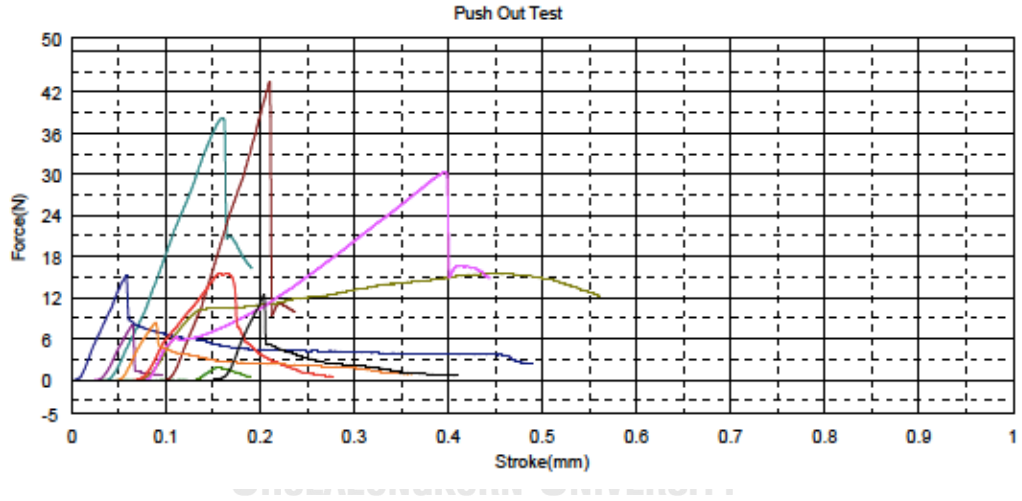


Graph 1 Comparison of Push out bond strength test of group1 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	0.8420	0.9900
1 - 2	1.0480	1.2000
1 - 3	0.7910	1.1200
1 - 4	1.0520	0.8400
1 - 5	1.0140	1.1700
1 - 6	0.7870	1.0800
1 - 7	0.9780	1.0700
1 - 8	0.5680	0.7900
1 - 9	0.7660	1.0000
1 - 10	0.9710	1.0700

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	38.2575	.15983	45.4365	16.1448
1 - 2	43.5300	.21017	41.5363	17.5139
1 - 3	8.07250	.06450	10.2054	5.75893
1 - 4	1.85000	.15533	1.75856	18.4921
1 - 5	15.1325	.05800	14.9236	4.95726
1 - 6	15.5450	.44267	19.7522	40.9877
1 - 7	30.3500	.39683	31.0327	37.0872
1 - 8	15.6100	.15733	27.4824	19.9156
1 - 9	8.39000	.08950	10.9530	8.95000
1 - 10	12.4550	.20417	12.8270	19.0810
Mean	18.9193	.19383	21.5908	18.8888
Standard Deviation	13.7786	.13061	14.3413	11.9976

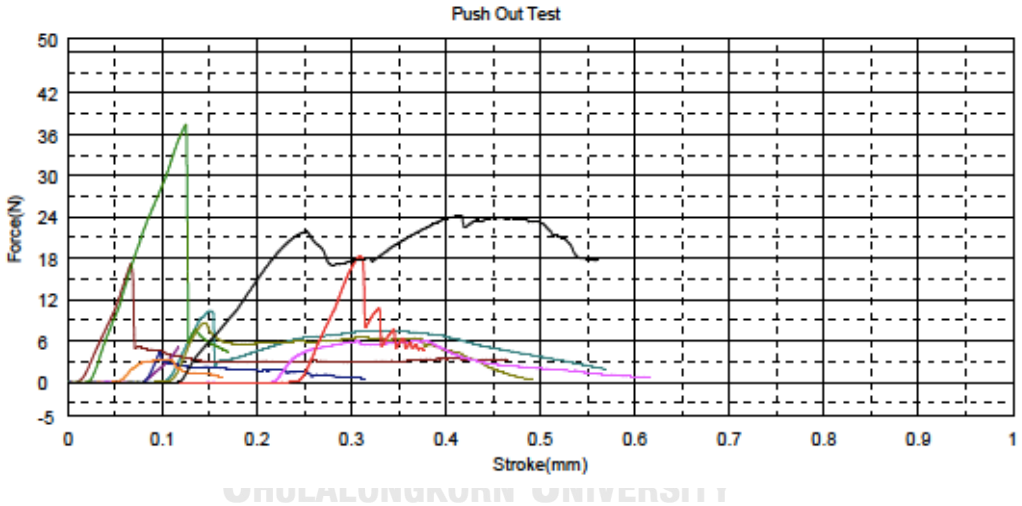


Graph 2 Comparison of Push out bond strength test of group1 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1- 1	1.2040	1.1800
1-2	1.4860	1.1400
1-3	1.4180	1.1400
1-4	1.3780	1.0700
1-5	1.0280	1.0100
1 - 6	1.2730	1.1200
1 - 7	1.2040	1.0800
1 - 8	1.0490	1.0000
1 - 9	0.5320	0.5500
1 - 10	1.0990	1.0000

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1- 1	10.3975	.15033	8.63580	12.7401
1-2	17.2900	.06700	11.6353	5.87719
1-3	5.09500	.11717	3.59309	10.2778
1-4	37.5175	.12500	27.2261	11.6822
1-5	4.25500	.09717	4.13911	9.62046
1 - 6	8.66250	.14517	6.80479	12.9613
1 - 7	6.03500	.37783	5.01246	34.9846
1 - 8	18.3150	.30883	17.4595	30.8833
1 - 9	3.30500	.10267	6.21241	18.6667
1 - 10	24.2050	.41433	22.0246	41.4333
Mean	13.5077	.19055	11.2743	18.9127
Standard Deviation	10.9432	.12658	8.23340	12.3174

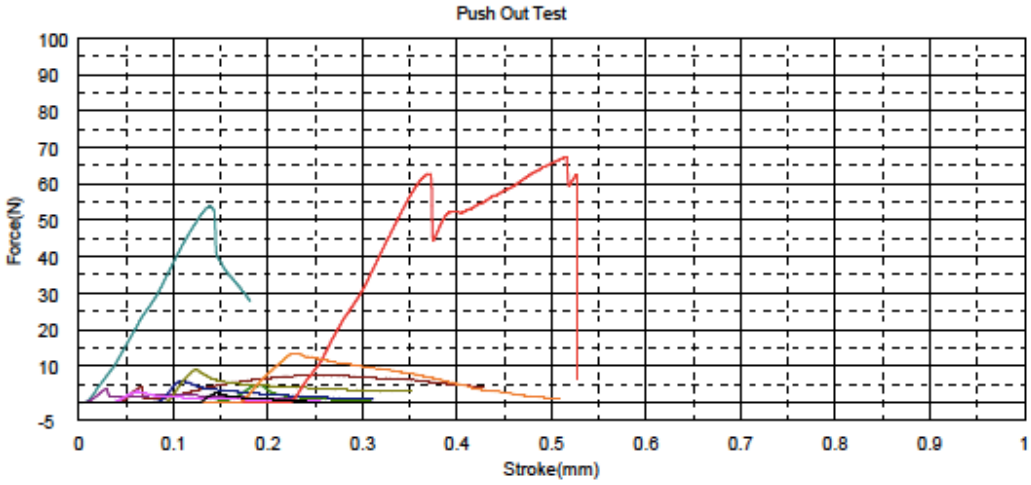


Graph 3 Comparison of Push out bond strength test of group2 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.0370	1.1800
1 - 2	1.0710	1.0400
1 - 3	0.7680	0.8100
1 - 4	0.8630	1.0000
1 - 5	0.9250	1.0300
1 - 6	0.9430	1.1000
1 - 7	0.9770	1.1400
1 - 8	1.0950	1.1900
1 - 9	0.6510	0.8900
1 - 10	1.0200	1.1400

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	53.7750	.13850	51.8563	11.7373
1 - 2	7.51750	.24783	7.01914	23.8301
1 - 3	3.63750	.02817	4.73633	3.47737
1 - 4	4.80000	.19267	5.56199	19.2667
1 - 5	5.94750	.10967	6.42973	10.6472
1 - 6	9.15750	.12383	9.71103	11.2576
1 - 7	3.02000	.06150	3.09110	5.39474
1 - 8	67.3750	.51583	61.5297	43.3473
1 - 9	13.5600	.22933	20.8295	25.7678
1 - 10	2.54750	.14650	2.49755	12.8509
Mean	17.1338	.17938	17.3262	16.7577
Standard Deviation	23.3500	.13663	21.5018	11.8230

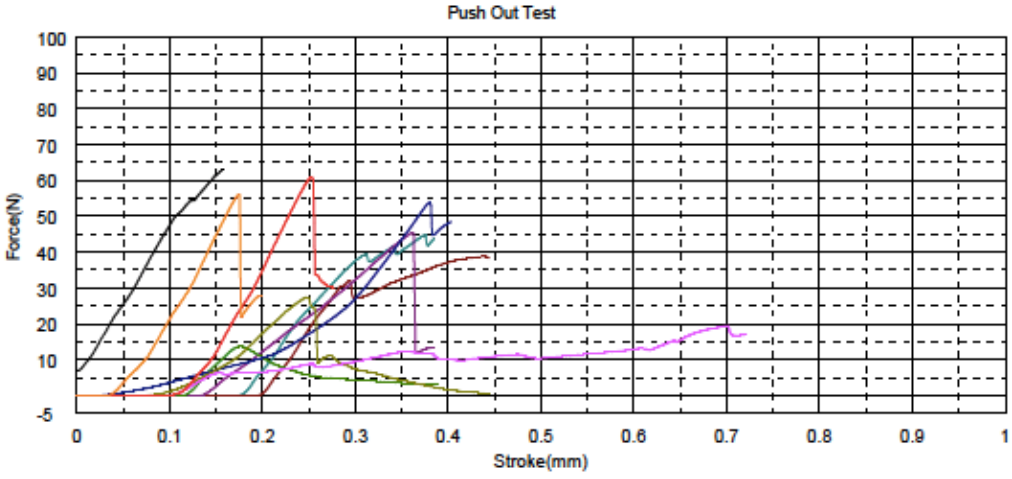


Graph 4 Comparison of Push out bond strength test of group2 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	0.9020	0.8300
1 - 2	1.1280	1.1300
1 - 3	1.3390	1.0200
1 - 4	1.2230	1.1000
1 - 5	1.2110	1.1900
1 - 6	0.9000	0.8100
1 - 7	1.3260	1.0100
1 - 8	1.0450	1.0300
1 - 9	1.1540	1.1700
1 - 10	0.9400	0.8700

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	44.7350	.37533	49.5953	45.2209
1 - 2	38.8400	.43933	34.4326	38.8791
1 - 3	45.3425	.36167	33.8630	35.4575
1 - 4	13.7550	.17650	11.2469	16.0455
1 - 5	53.8975	.37983	44.5066	31.9188
1 - 6	27.5275	.24883	30.5861	30.7202
1 - 7	19.5150	.70083	14.7172	69.3894
1 - 8	61.0000	.25233	58.3732	24.4984
1 - 9	56.2650	.17500	48.7565	14.9573
1 - 10	62.9500	.15700	66.9681	18.0460
Mean	42.3828	.32666	39.3045	32.5133
Standard Deviation	17.2721	.16500	17.8647	16.4216

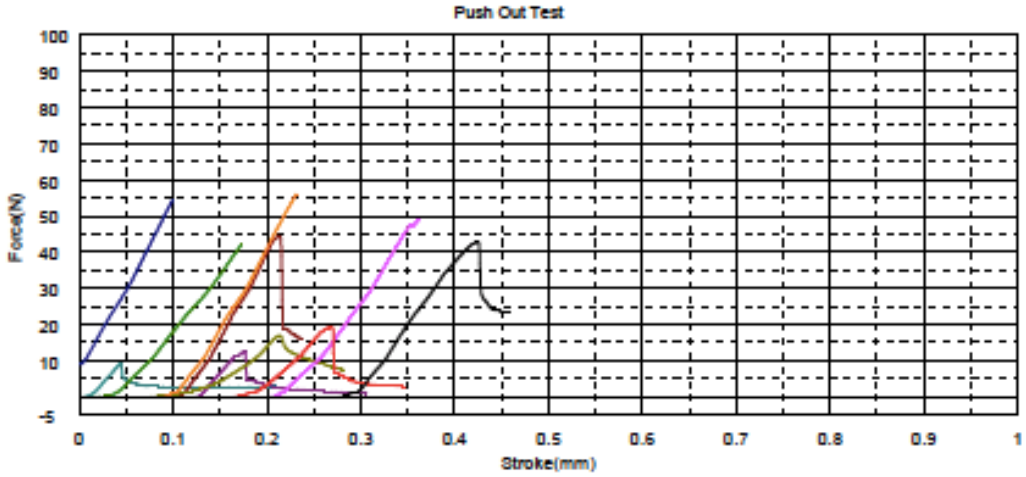


Graph 5 Comparison of Push out bond strength test of group3 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.0840	1.1700
1 - 2	1.1360	1.2300
1 - 3	0.8620	0.9800
1 - 4	0.9600	1.1200
1 - 5	0.9900	1.1300
1 - 6	0.9230	1.2400
1 - 7	0.8650	1.0400
1 - 8	1.0280	1.3000
1 - 9	1.0210	1.1200
1 - 10	0.8690	1.0800

Name	Max Force	Max Disp	Max Stress	Max Strain
Units	N	mm	MPa	%
1 - 1	9.35000	.04433	8.62546	3.78917
1 - 2	44.5750	.21317	39.2386	17.3306
1 - 3	12.6100	.17683	14.6288	18.0442
1 - 4	42.1400	.17317	43.8958	15.4613
1 - 5	54.2800	.09933	54.8283	8.79056
1 - 6	17.0275	.21383	18.4480	17.2446
1 - 7	49.2550	.36283	56.9422	34.8878
1 - 8	19.2550	.26900	18.7305	20.6923
1 - 9	56.1575	.23167	55.0024	20.6845
1 - 10	42.6275	.42367	49.2837	39.2284
Mean	34.7478	.22078	35.9624	19.6153
Standard Deviation	18.1231	.11253	18.9028	10.6376

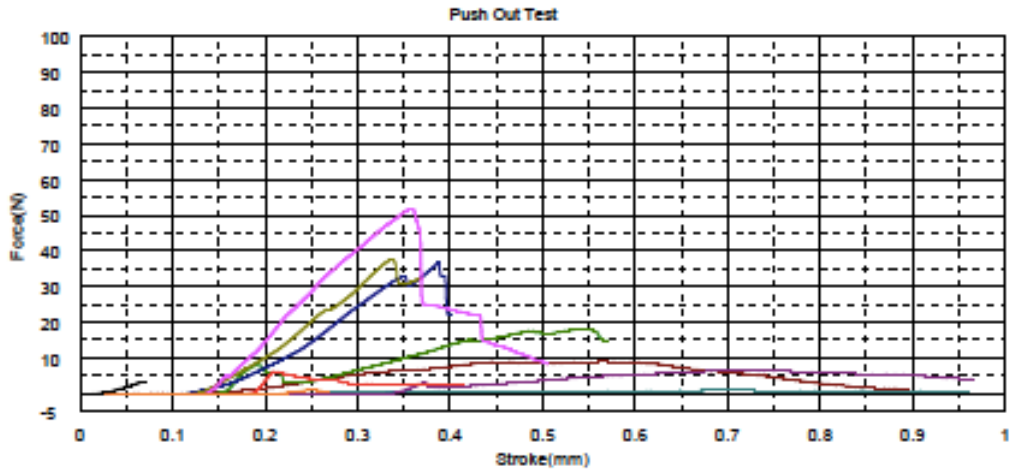


Graph 6 Comparison of Push out bond strength test of group3 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	0.1580	1.1700
1 - 2	1.3790	1.1900
1 - 3	1.1850	1.1000
1 - 4	1.1010	1.1200
1 - 5	1.7560	1.2100
1 - 6	1.1730	1.0800
1 - 7	1.3460	1.1100
1 - 8	1.2180	1.0400
1 - 9	1.4800	1.3700
1 - 10	1.4800	1.0800

Name	Max Force	Max Disp	Max Stress	Max Strain
Units	N	mm	MPa	%
1 - 1	.98000	.71833	6.20253	61.3960
1 - 2	9.06000	.56567	6.56998	47.5350
1 - 3	6.72750	.72967	5.67722	66.3333
1 - 4	18.1225	.54517	16.4600	48.6756
1 - 5	36.6975	.38733	20.8983	32.0110
1 - 6	37.6925	.33717	32.1334	31.2191
1 - 7	51.9675	.35833	38.6088	32.2823
1 - 8	6.24000	.21100	5.12315	20.2885
1 - 9	1.03000	.25167	.69595	18.3698
1 - 10	3.42250	.06900	2.31250	6.38889
Mean	17.1940	.41733	13.4682	36.4499
Standard Deviation	18.3186	.21824	13.1778	19.2753

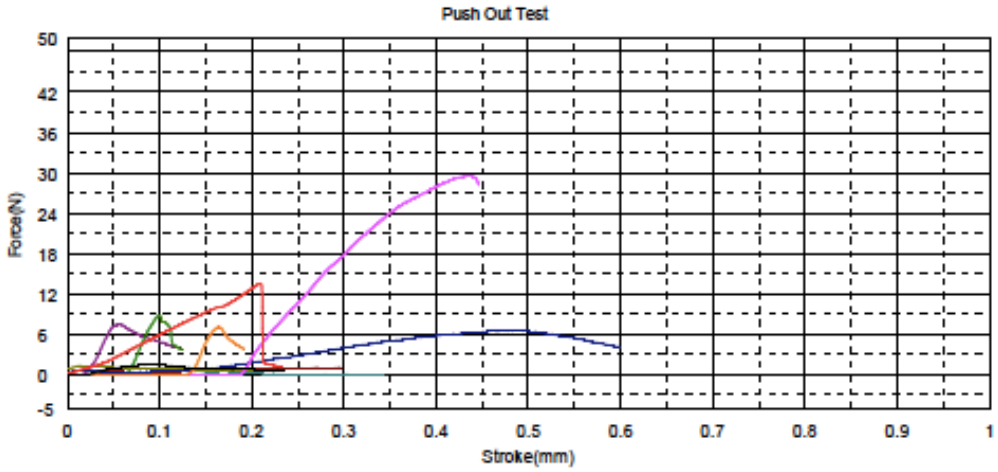


Graph 7 Comparison of Push out bond strength test of group4 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	0.8920	0.7700
1 - 2	1.1470	1.1600
1 - 3	1.0730	1.2200
1 - 4	0.9690	1.0900
1 - 5	1.6200	1.3400
1 - 6	1.0380	1.1400
1 - 7	0.9500	1.0800
1 - 8	0.9190	1.0200
1 - 9	0.9510	1.0800
1 - 10	0.9510	1.0900

Name	Max Force	Max Disp	Max Stress	Max Strain
Units	N	mm	MPa	%
1 - 1	.48250	.16700	.54092	21.6883
1 - 2	1.03250	.28283	.90017	24.3822
1 - 3	7.46750	.05617	6.95946	4.60383
1 - 4	8.83500	.10000	9.11765	9.17431
1 - 5	6.55000	.48833	4.04321	36.4428
1 - 6	1.37500	.02317	1.32466	2.03216
1 - 7	29.5175	.43633	31.0711	40.4012
1 - 8	13.5625	.20950	14.7579	20.5392
1 - 9	7.04750	.16450	7.41062	15.2315
1 - 10	1.55250	.09450	1.63249	8.66973
Mean	7.74225	.20223	7.77582	18.3165
Standard Deviation	8.74192	.15682	9.35075	12.9476

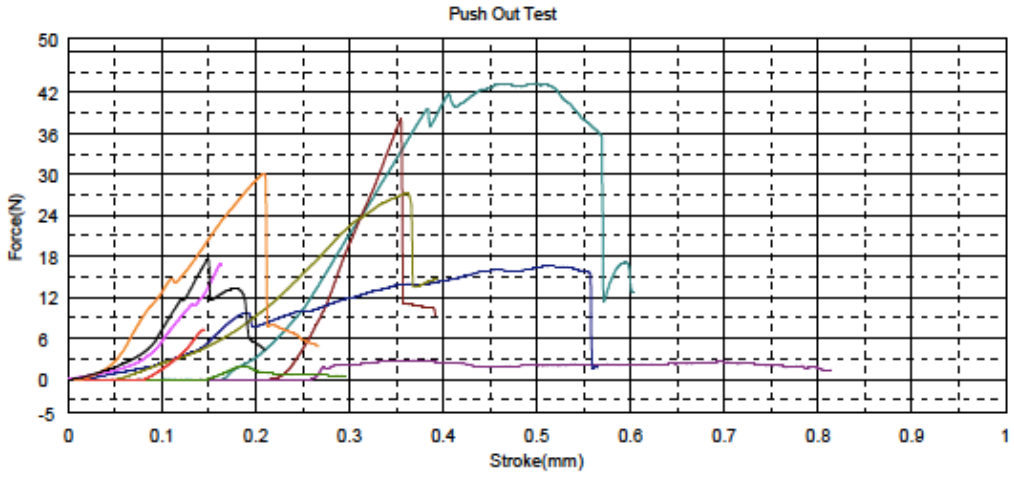


Graph 8 Comparison of Push out bond strength test of group4 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.3630	1.1100
1 - 2	1.3330	1.1500
1 - 3	1.5400	1.0900
1 - 4	1.3490	1.1800
1 - 5	1.2720	1.0100
1 - 6	1.4950	1.3600
1 - 7	1.3160	1.0500
1 - 8	1.0500	1.0100
1 - 9	1.2330	1.0700
1 - 10	1.3260	1.2600

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	43.3500	.49967	31.8048	45.0150
1 - 2	38.1650	.35483	28.6309	30.8551
1 - 3	2.81500	.37500	1.82792	34.4037
1 - 4	1.97000	.18767	1.46034	15.9040
1 - 5	16.5900	.51067	13.0425	50.5611
1 - 6	27.2675	.36150	18.2391	26.5809
1 - 7	16.9250	.16233	12.8609	15.4603
1 - 8	7.29000	.14450	6.94286	14.3069
1 - 9	30.0925	.20850	24.4059	19.4860
1 - 10	17.6075	.14917	13.2787	11.8386
Mean	20.2072	.29538	15.2494	26.4412
Standard Deviation	14.2914	.14272	10.5391	13.5406

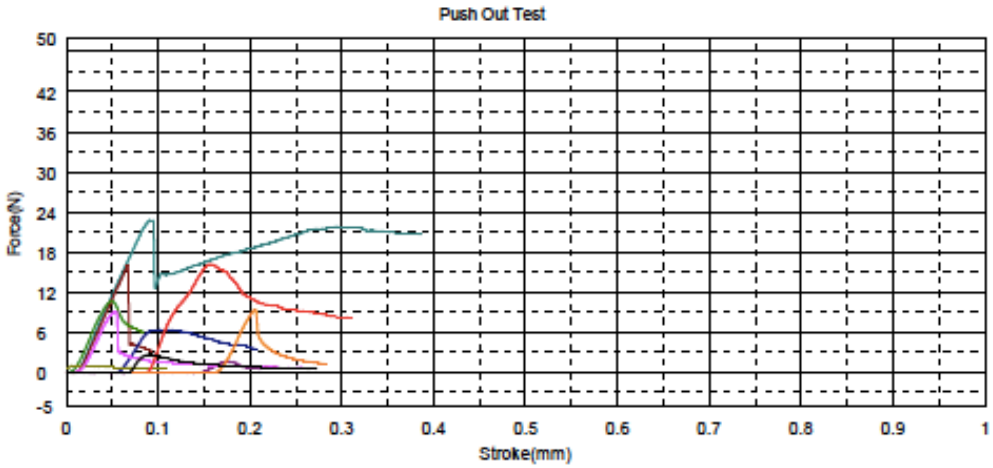


Graph 9 Comparison of Push out bond strength test of group5 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.3920	1.1600
1 - 2	0.9730	1.0300
1 - 3	0.9810	0.8700
1 - 4	0.9090	1.0300
1 - 5	0.8500	1.0100
1 - 6	1.0500	1.2400
1 - 7	0.9460	1.0500
1 - 8	0.8780	1.0100
1 - 9	1.0320	1.3100
1 - 10	1.0310	1.1600

Name	Max. Force	Max. Disp	Max. Stress	Max. Strain
Units	N	mm	MPa	%
1 - 1	22.8050	.09267	16.3829	7.98851
1 - 2	15.9050	.06667	16.3464	6.47249
1 - 3	1.65750	.17600	1.68960	20.2299
1 - 4	10.6775	.04933	11.7464	4.78964
1 - 5	6.42250	.10517	7.55588	10.4125
1 - 6	1.06750	.00750	1.01667	.60484
1 - 7	9.06250	.05400	9.57981	5.14286
1 - 8	16.1925	.15633	18.4425	15.4785
1 - 9	9.34750	.20550	9.05766	15.6870
1 - 10	2.69250	.09117	2.61154	7.85920
Mean	9.58300	.10043	9.44294	9.46654
Standard Deviation	7.09298	.06199	6.35637	6.00382

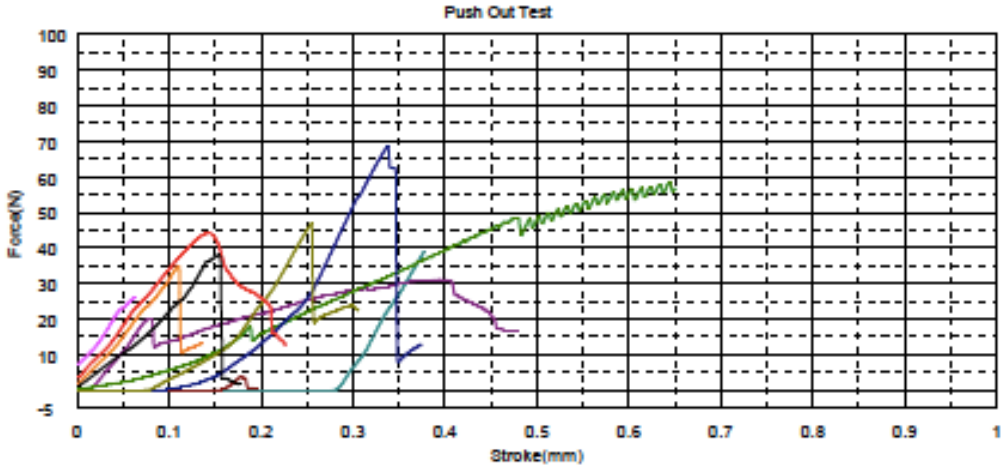


Graph 10 Comparison of Push out bond strength test of group5 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.3660	1.1300
1 - 2	1.2030	1.0300
1 - 3	1.3560	1.1800
1 - 4	1.4630	1.3200
1 - 5	1.7870	1.4700
1 - 6	1.4590	1.1700
1 - 7	1.3660	1.1600
1 - 8	0.9460	1.2000
1 - 9	1.7720	1.4000
1 - 10	1.3320	1.0900

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	38.9900	.37767	28.5432	33.4218
1 - 2	4.01000	.17800	3.33333	17.2816
1 - 3	31.1950	.39117	23.0052	33.1497
1 - 4	58.5575	.64467	40.0256	48.8384
1 - 5	68.8250	.33783	38.5143	22.9819
1 - 6	47.0350	.25517	32.2378	21.8091
1 - 7	25.9725	.06200	19.0135	5.34483
1 - 8	44.1225	.14200	46.6411	11.8333
1 - 9	35.1450	.11050	19.8335	7.89286
1 - 10	38.0225	.15383	28.5454	14.1131
Mean	39.1875	.26528	27.9693	21.6667
Standard Deviation	17.7427	.17585	12.4813	13.4957



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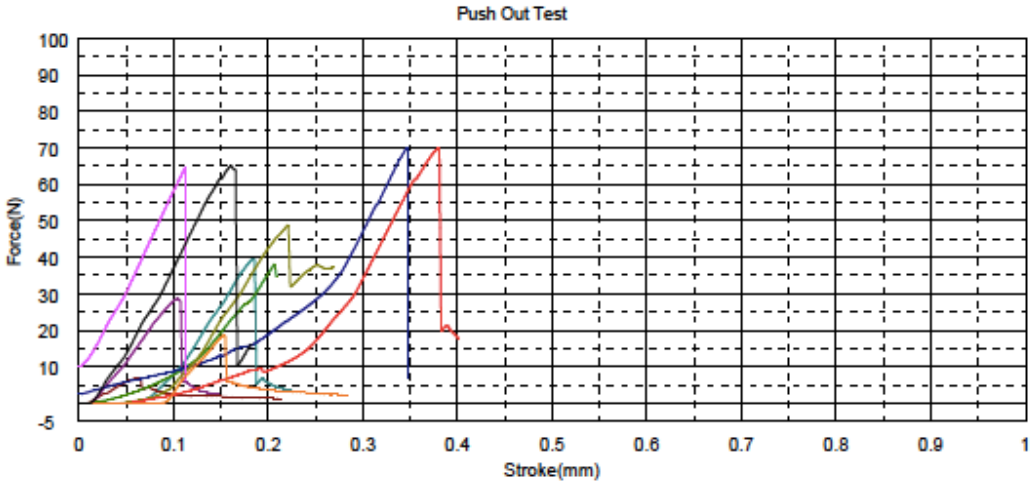
Graph 11 Comparison of Push out bond strength test of group6 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.0100	1.1300
1 - 2	0.9070	0.8300
1 - 3	1.0900	1.0600
1 - 4	0.9690	1.0600
1 - 5	1.1450	1.0300
1 - 6	0.7350	0.9400
1 - 7	1.0000	1.1100
1 - 8	1.0960	1.1300
1 - 9	1.0490	1.1400
1 - 10	1.4330	1.2400

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	39.5400	.18467	39.1485	16.3422
1 - 2	7.03000	.06350	7.75083	7.65060
1 - 3	28.6850	.10383	26.3165	9.79560
1 - 4	38.2300	.20683	39.4530	19.5126
1 - 5	69.9750	.34667	61.1135	33.6570
1 - 6	48.9675	.22117	66.6224	23.5284
1 - 7	64.4500	.11233	64.4500	10.1201
1 - 8	69.8250	.37983	63.7089	33.6136
1 - 9	18.6650	.15400	17.7931	13.5088
1 - 10	65.1000	.16050	45.4292	12.9435
Mean	45.0468	.19333	43.1786	18.0672
Standard Deviation	22.3983	.10186	20.9876	9.46769

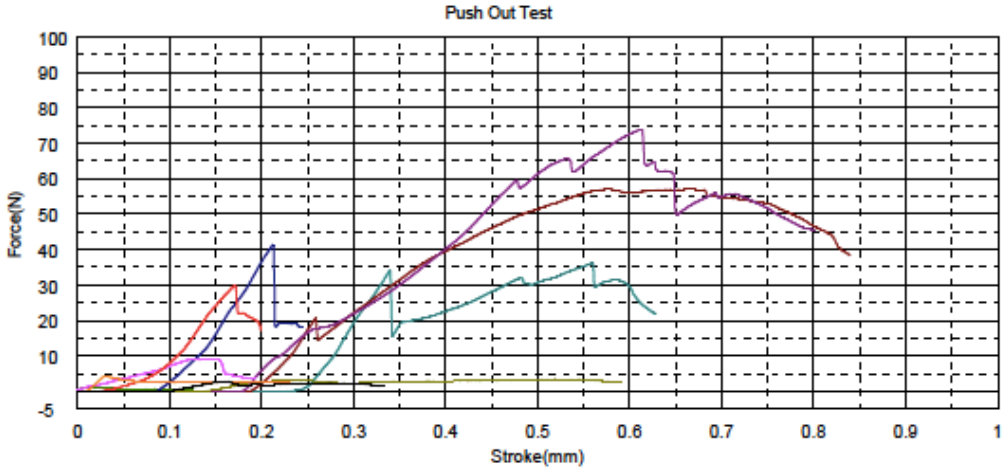


Graph 12 Comparison of Push out bond strength test of group6 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.0850	0.9900
1 - 2	1.3210	1.1100
1 - 3	2.0570	1.5300
1 - 4	1.0560	1.1800
1 - 5	0.9770	1.0100
1 - 6	1.3860	1.0900
1 - 7	1.5380	1.3600
1 - 8	1.0950	1.0500
1 - 9	1.0000	1.1200
1 - 10	1.2790	1.0500

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	36.1150	.55950	33.2857	56.5151
1 - 2	57.2350	.57783	43.3270	52.0571
1 - 3	73.8750	.61317	35.9140	40.0763
1 - 4	1.08500	.00700	1.02746	.59322
1 - 5	41.3925	.21250	42.3669	21.0396
1 - 6	3.58500	.52350	2.58658	48.0275
1 - 7	9.23250	.14700	6.00293	10.8088
1 - 8	29.8225	.17100	27.2352	16.2857
1 - 9	4.39750	.03067	4.39750	2.73810
1 - 10	2.89250	.16100	2.26153	15.3333
Mean	25.9633	.30032	19.8405	26.3475
Standard Deviation	25.8767	.23990	18.0846	20.9296

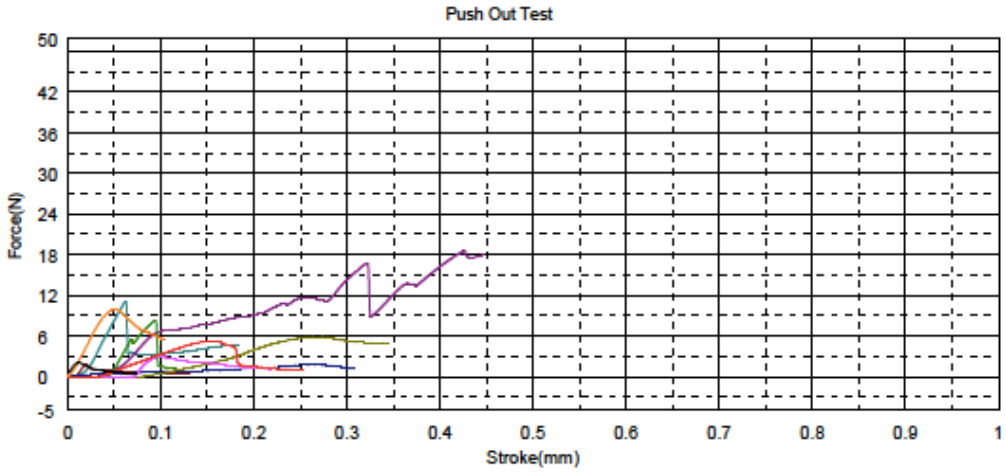


Graph 13 Comparison of Push out bond strength test of group7 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.1210	1.0500
1 - 2	1.0940	0.9600
1 - 3	1.2110	1.1900
1 - 4	0.8550	1.0600
1 - 5	0.9730	1.0400
1 - 6	0.9390	1.0600
1 - 7	1.1830	1.4000
1 - 8	1.1150	1.1200
1 - 9	0.9380	1.0900
1 - 10	0.9610	1.0700

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	11.1425	.06183	9.93979	5.88889
1 - 2	1.86750	.01950	1.70704	2.03125
1 - 3	18.5700	.42600	15.3344	35.7983
1 - 4	8.33750	.09483	9.75146	8.94654
1 - 5	1.76500	.27417	1.81398	26.3622
1 - 6	5.91000	.26767	6.29393	25.2516
1 - 7	2.98750	.09950	2.52536	7.10714
1 - 8	5.30250	.15567	4.75561	13.8988
1 - 9	9.92750	.05150	10.5837	4.72477
1 - 10	2.08500	.01183	2.16962	1.10592
Mean	6.78950	.14625	6.48749	13.1115
Standard Deviation	5.36466	.13520	4.71042	11.9307

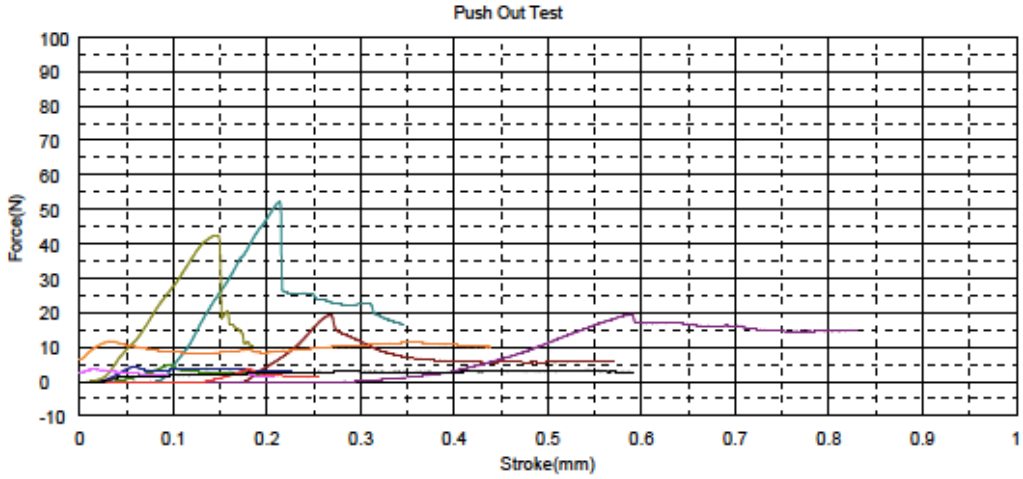


Graph 14 Comparison of Push out bond strength test of group7 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.2820	1.1400
1 - 2	1.3520	1.1600
1 - 3	1.4680	1.2600
1 - 4	1.2290	1.2500
1 - 5	1.2060	1.2000
1 - 6	1.1860	1.0700
1 - 7	1.3220	1.1600
1 - 8	1.4300	1.3200
1 - 9	1.2380	1.0800
1 - 10	1.3960	1.1000

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	52.1750	.21300	40.6981	18.6842
1 - 2	19.2275	.26683	14.2215	23.0029
1 - 3	19.5500	.58950	13.3174	46.7857
1 - 4	5.03750	.09683	4.09886	7.74667
1 - 5	4.42250	.05800	3.66708	4.83333
1 - 6	42.4725	.14500	35.8116	13.5514
1 - 7	3.57250	.01450	2.70234	1.25000
1 - 8	3.56000	.18150	2.48951	13.7500
1 - 9	11.7050	.03400	9.45477	3.14815
1 - 10	3.33000	.54267	2.38539	49.3333
Mean	16.5052	.21418	12.8847	18.2086
Standard Deviation	17.5508	.20218	14.1307	17.1689

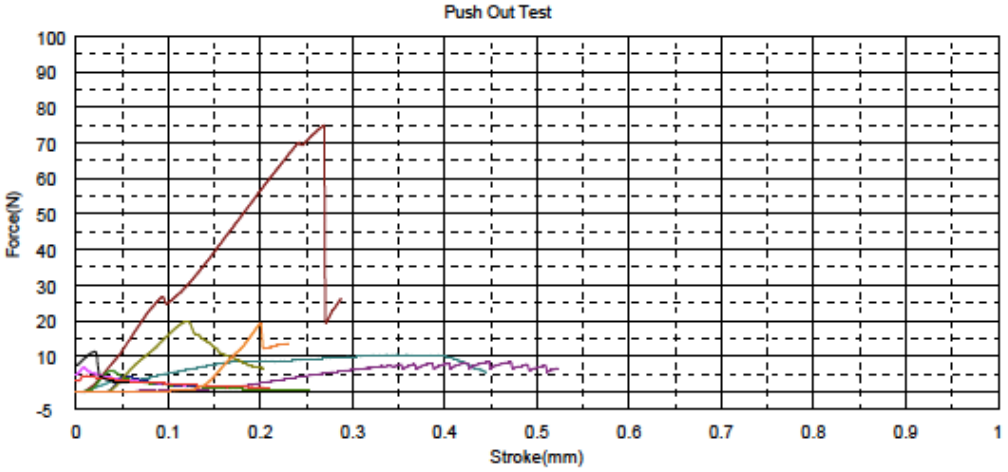


Graph 15 Comparison of Push out bond strength test of group8 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	0.6100	0.6000
1 - 2	1.2520	1.1800
1 - 3	0.9310	0.8500
1 - 4	0.8930	1.0900
1 - 5	0.9510	1.0900
1 - 6	0.9510	1.0000
1 - 7	0.9230	1.0500
1 - 8	0.9730	1.0900
1 - 9	1.0480	1.0300
1 - 10	0.9450	1.0600

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	10.4850	.35400	17.1885	59.0000
1 - 2	74.9900	.26900	59.8962	22.7966
1 - 3	8.48750	.47167	9.11654	55.4902
1 - 4	6.07750	.03900	6.80571	3.57798
1 - 5	4.54750	.05467	4.78181	5.01529
1 - 6	19.8375	.11983	20.8596	11.9833
1 - 7	6.80250	.00817	7.36999	.77778
1 - 8	4.60000	.00917	4.72765	.84098
1 - 9	19.4825	.20050	18.5902	19.4660
1 - 10	11.3850	.02033	12.0476	1.91824
Mean	16.6695	.15463	16.1384	18.0866
Standard Deviation	21.2250	.16353	16.4430	22.0455

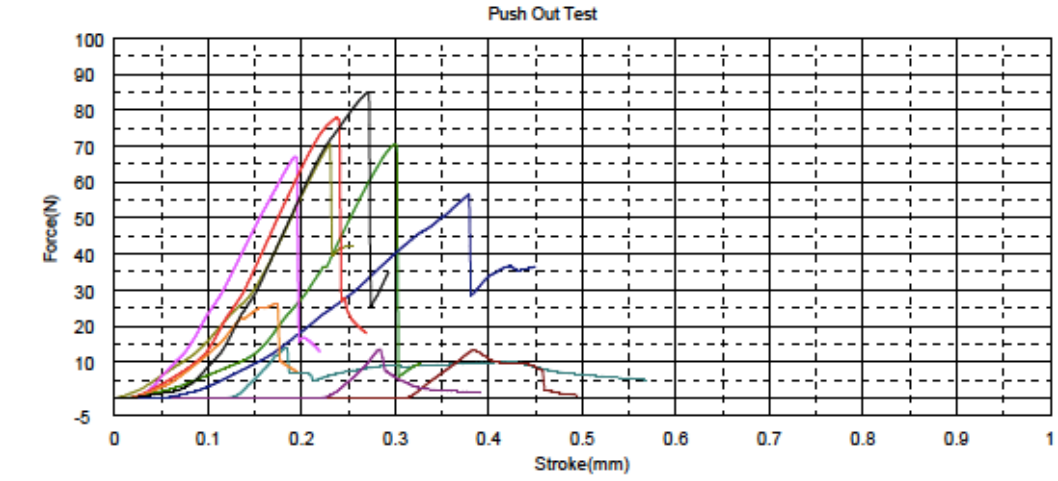


Graph 16 Comparison of Push out bond strength test of group8 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.2430	1.0200
1 - 2	0.6420	0.5300
1 - 3	1.1520	1.0600
1 - 4	1.2460	1.0200
1 - 5	1.2480	1.0600
1 - 6	1.7250	1.2600
1 - 7	1.1370	1.0400
1 - 8	1.3000	1.0700
1 - 9	1.3040	1.1600
1 - 10	1.2680	1.0600

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	14.0050	.18400	11.2671	18.0392
1 - 2	13.4750	.38417	20.9891	72.4843
1 - 3	13.6375	.28350	11.8381	26.7453
1 - 4	70.5750	.30000	56.6412	29.4118
1 - 5	56.4525	.37833	45.2344	35.6918
1 - 6	70.7175	.23067	40.9957	18.3069
1 - 7	67.0500	.19317	58.9710	18.5737
1 - 8	77.8250	.23717	59.8654	22.1651
1 - 9	26.3700	.17383	20.2224	14.9856
1 - 10	84.9750	.27100	67.0150	25.5660
Mean	49.5082	.26358	39.3039	28.1970
Standard Deviation	29.2314	.07499	21.4892	16.7749

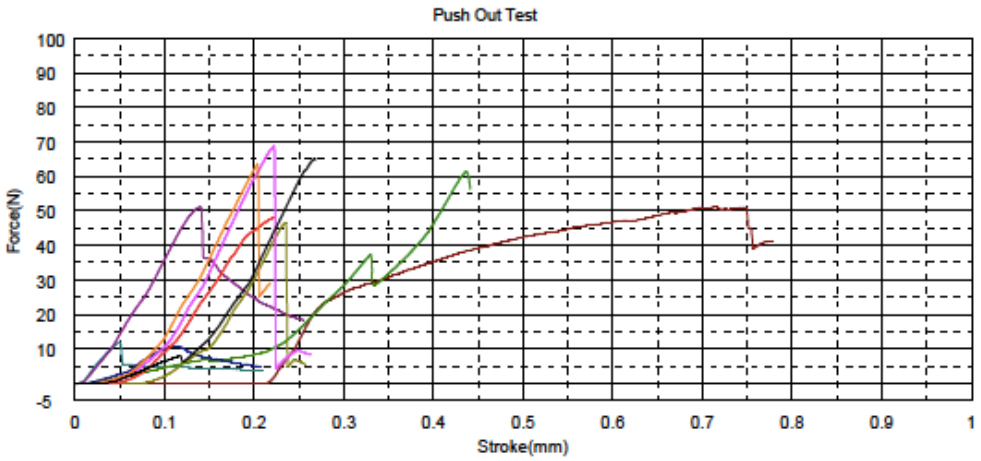


Graph 17 Comparison of Push out bond strength test of group9 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.1560	0.9900
1 - 2	1.9890	1.5300
1 - 3	1.2000	1.3000
1 - 4	0.9770	1.0200
1 - 5	1.2410	1.5200
1 - 6	1.4160	1.3500
1 - 7	1.0250	1.1700
1 - 8	1.0590	0.9500
1 - 9	0.9080	0.9700
1 - 10	1.0320	1.0500

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	11.9625	.04950	10.3482	5.00000
1 - 2	51.1625	.71317	25.7227	46.6122
1 - 3	51.1025	.13933	42.5854	10.7179
1 - 4	61.3500	.43633	62.7943	42.7778
1 - 5	10.8575	.11183	8.74899	7.35746
1 - 6	46.4300	.23433	32.7895	17.3580
1 - 7	68.7500	.22167	67.0732	18.9459
1 - 8	47.9875	.22100	45.3140	23.2632
1 - 9	63.5750	.20350	70.0165	20.9794
1 - 10	65.1000	.26733	63.0814	25.4603
Mean	47.8278	.25980	42.8474	21.8472
Standard Deviation	20.6662	.18979	22.9778	13.7978

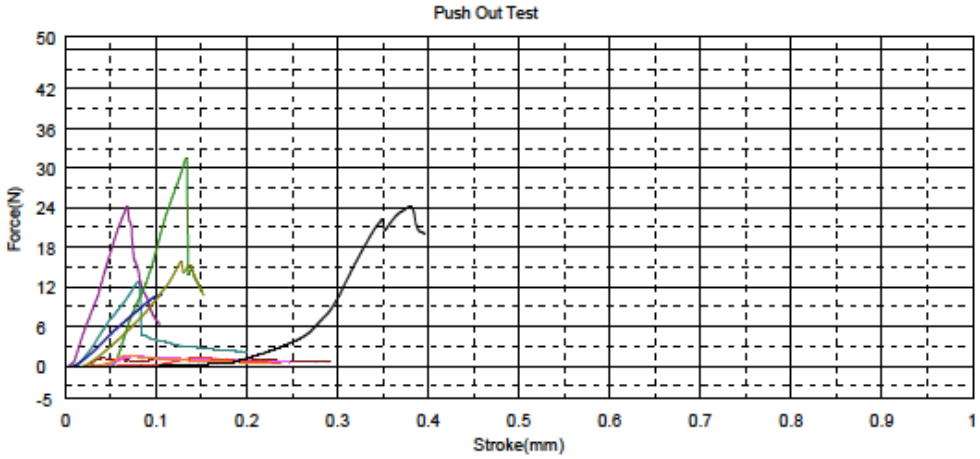


Graph 18 Comparison of Push out bond strength test of group9 at apical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.3290	1.0200
1 - 2	0.9960	1.0900
1 - 3	1.1100	1.1700
1 - 4	0.9810	1.2300
1 - 5	1.2660	1.3300
1 - 6	0.5900	0.7200
1 - 7	1.4550	1.4000
1 - 8	1.2070	1.0800
1 - 9	1.3420	1.4100
1 - 10	0.7810	0.8100

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	12.8900	.08150	9.69902	7.99020
1 - 2	1.20500	.04150	1.20984	3.80734
1 - 3	24.2800	.06817	21.8739	5.82621
1 - 4	31.5725	.13333	32.1840	10.8401
1 - 5	10.8475	.10550	8.56833	7.93233
1 - 6	15.8250	.12783	26.8220	17.7546
1 - 7	1.49500	.07717	1.02749	5.51190
1 - 8	1.38500	.14917	1.14747	13.8117
1 - 9	1.58750	.07033	1.18294	4.98818
1 - 10	24.1975	.38017	30.9827	46.9342
Mean	12.5285	.12347	13.4698	12.5397
Standard Deviation	11.2773	.09632	13.1318	12.8424

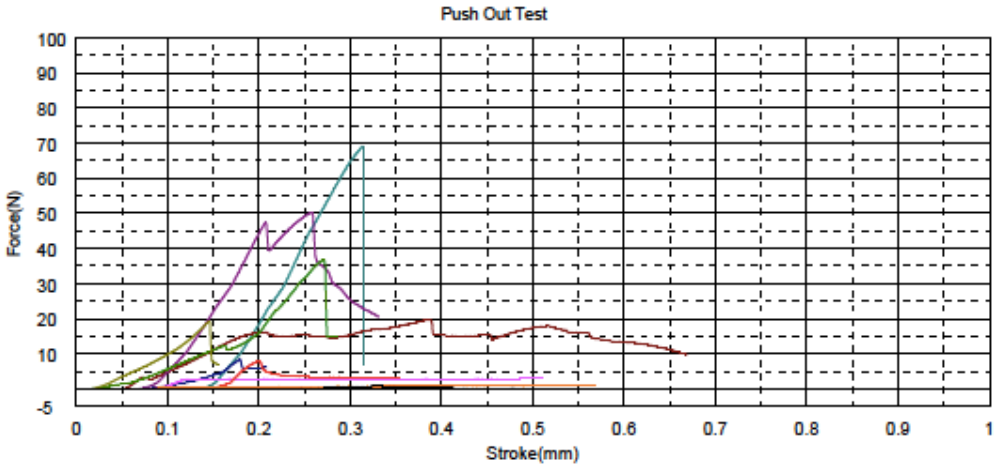


Graph 19 Comparison of Push out bond strength test of group10 at cervical region (n=10)

Shape: Area

	Area	Height
Units	mm2	mm
1 - 1	1.1880	1.1000
1 - 2	1.2030	1.1100
1 - 3	1.2570	1.1000
1 - 4	1.0030	1.0400
1 - 5	1.0030	0.9000
1 - 6	1.1100	1.3600
1 - 7	1.6900	1.3000
1 - 8	1.2300	1.0000
1 - 9	1.4200	1.3900
1 - 10	1.1850	1.1100

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain
Units	N	mm	MPa	%
1 - 1	69.1500	.31400	58.2071	28.5455
1 - 2	19.7600	.38633	16.4256	34.8048
1 - 3	50.2325	.25750	39.9622	23.4091
1 - 4	36.7825	.27083	36.6725	26.0417
1 - 5	8.50500	.17950	8.47956	19.9444
1 - 6	19.3575	.14550	17.4392	10.6985
1 - 7	3.06500	.49533	1.81361	38.1026
1 - 8	7.90250	.19933	6.42480	19.9333
1 - 9	.95250	.46533	.67077	33.4772
1 - 10	.88250	.32733	.74473	29.4895
Mean	21.6590	.30410	18.6840	26.4447
Standard Deviation	23.2806	.11780	19.8057	8.23887



Graph 20 Comparison of Push out bond strength test of group10 at apical region (n=10)

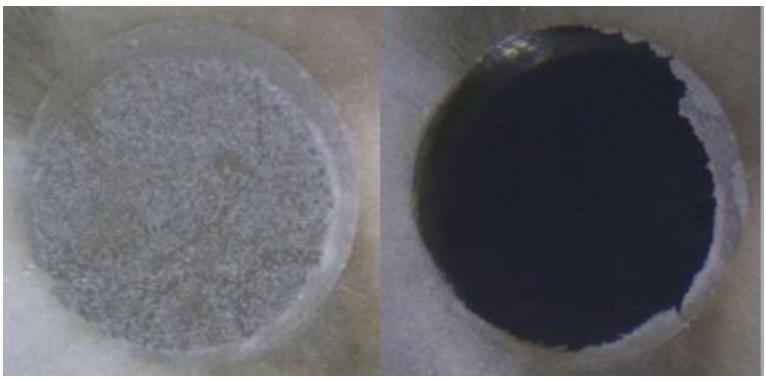


Figure1. Cervical side of group1 sample1 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

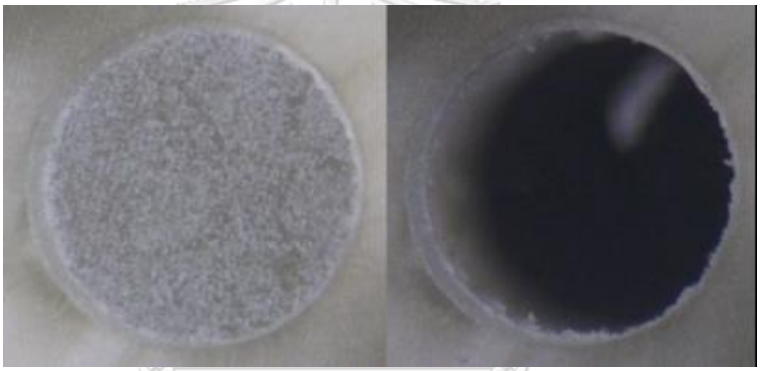


Figure2. Apical side of group1 sample1 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

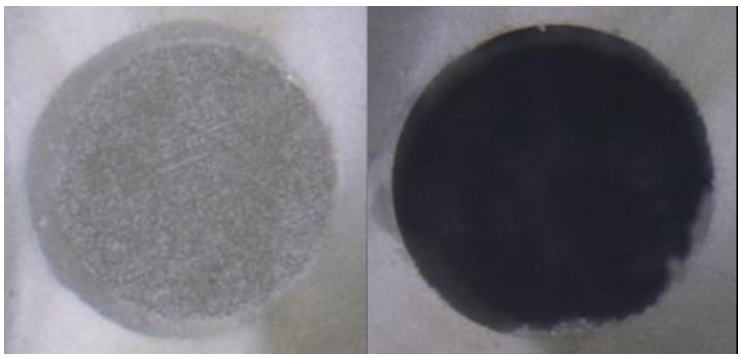


Figure3. Cervical side of group1 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

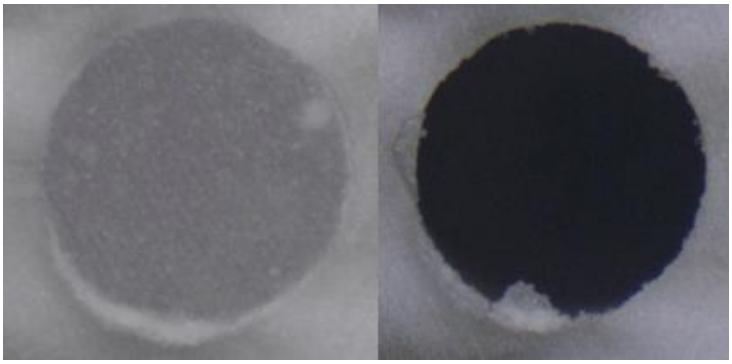


Figure4. Apical side of group1 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

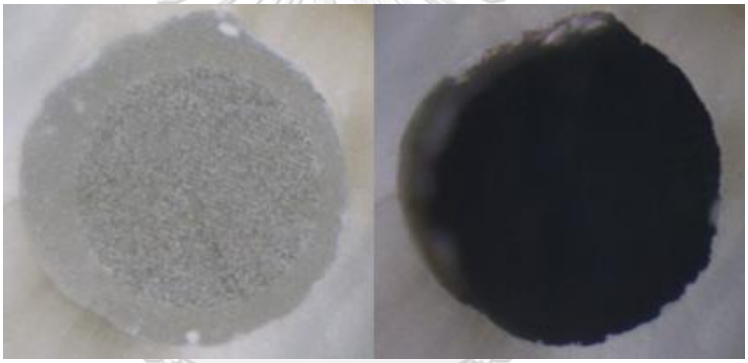


Figure5. Cervical side of group1 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

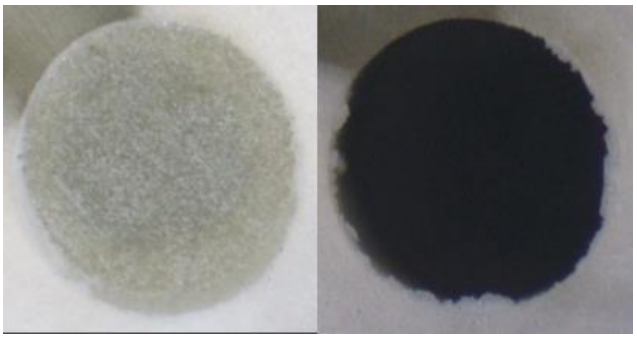


Figure6. Apical side of group1 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

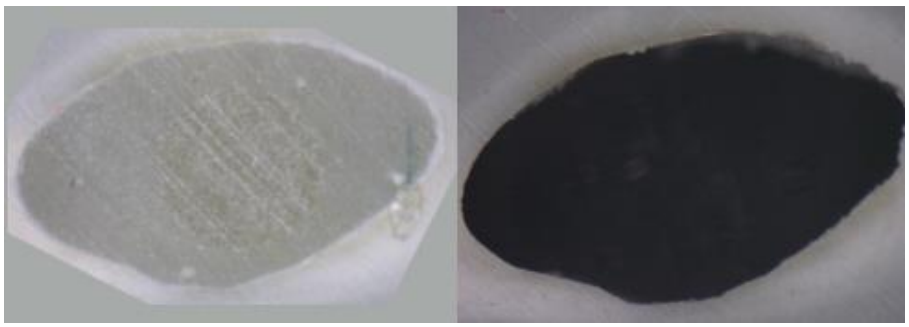


Figure7. Cervical side of group1 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

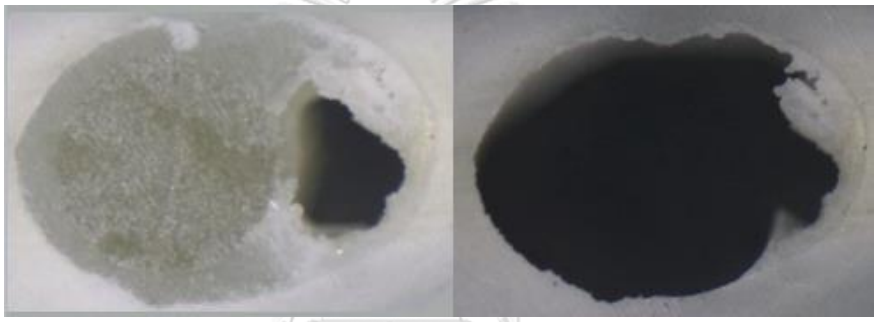


Figure8. Apical side of group1 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

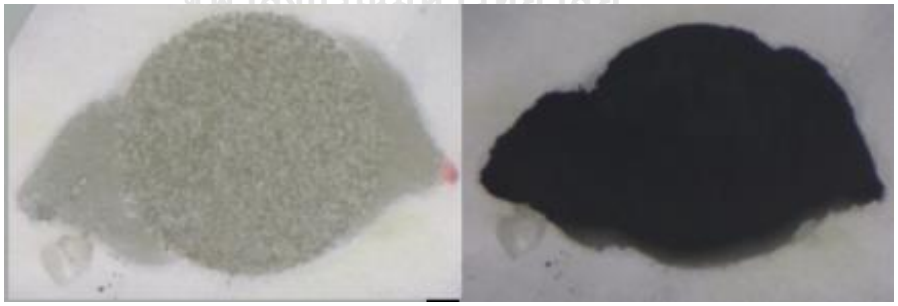


Figure9. Cervical side of group1 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

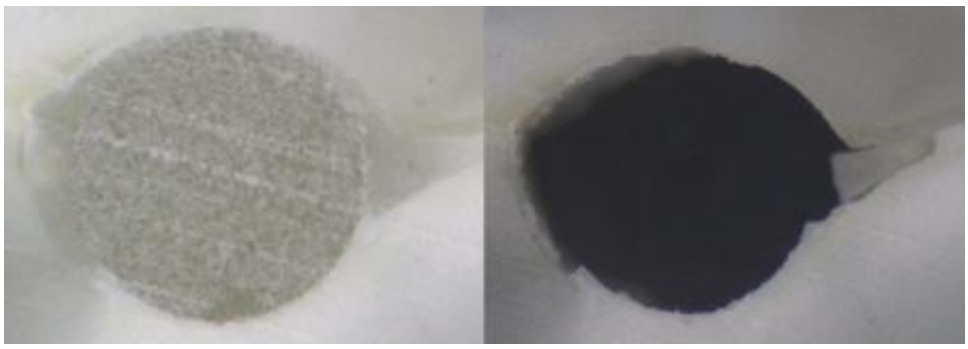


Figure10. Apical side of group1 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

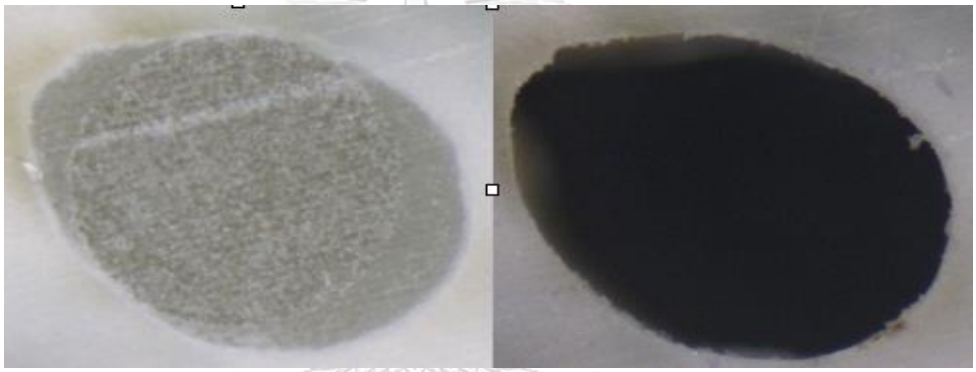


Figure11. Cervical side of group1 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

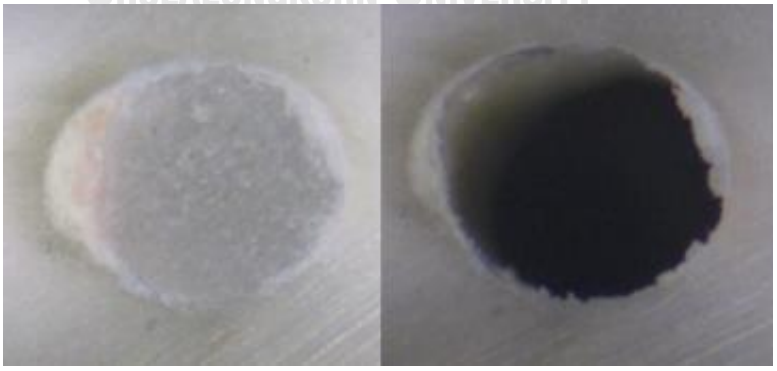


Figure12. Apical side of group1 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

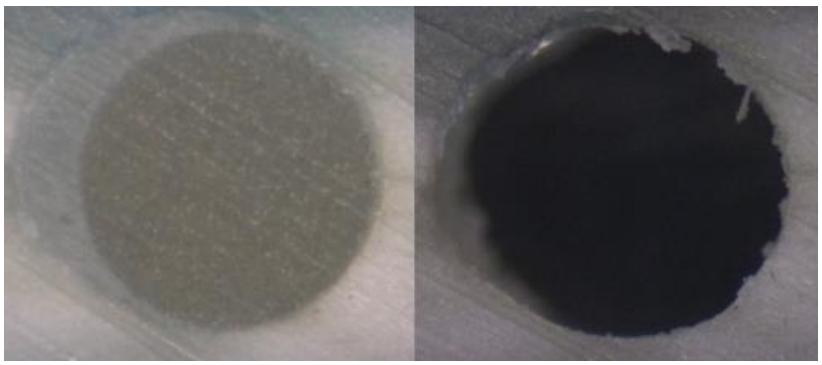


Figure13. Cervical side of group1 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

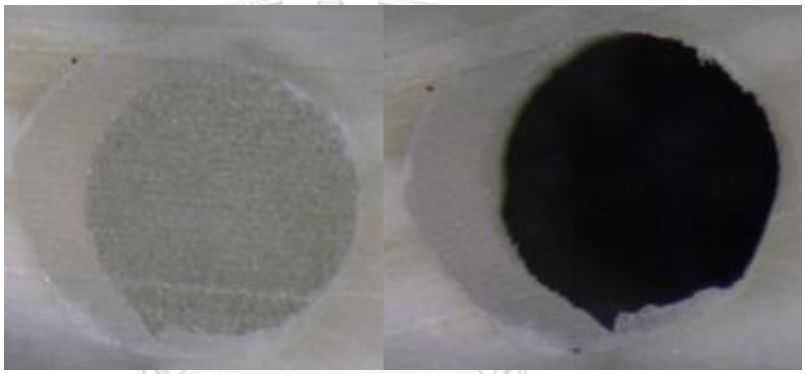


Figure14. Apical side of group1 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

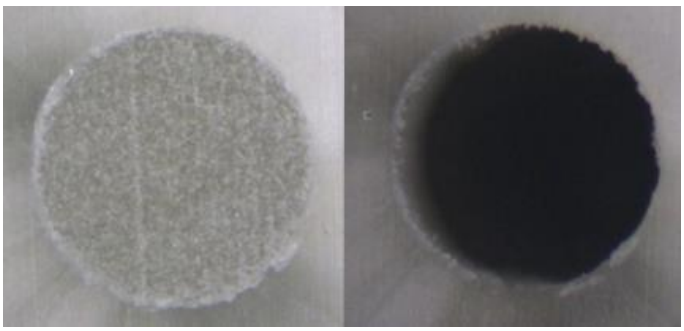


Figure15. Cervical side of group1 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

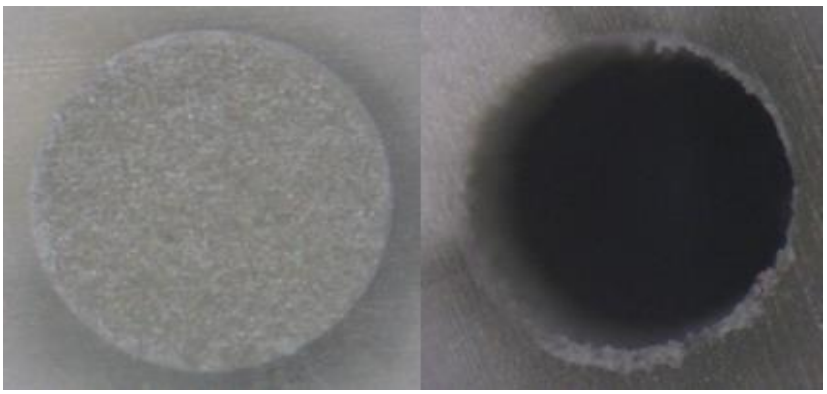


Figure16. Apical side of group1 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

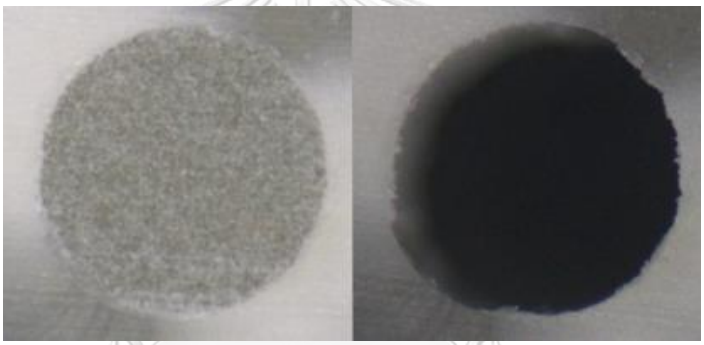


Figure17. Cervical side of group1 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

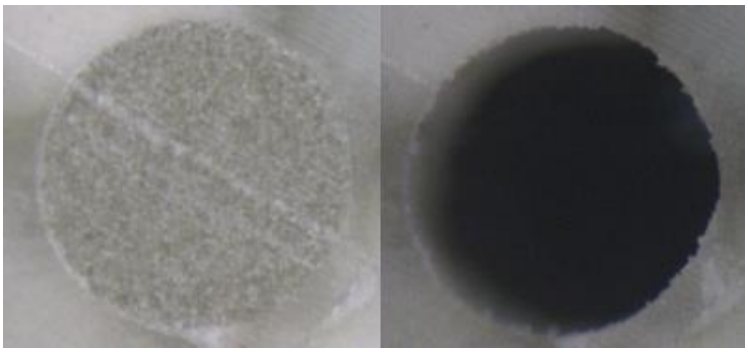


Figure18. Apical side of group1 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

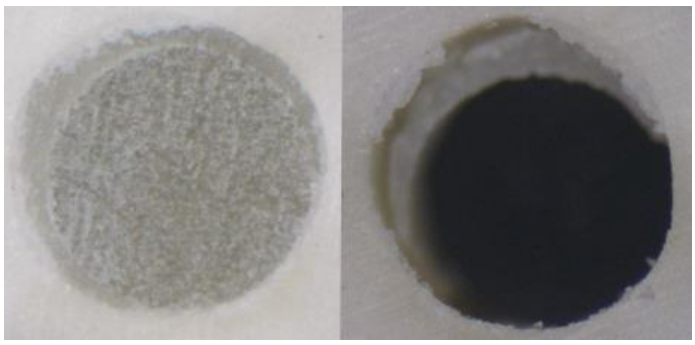


Figure19. Cervical side of group1 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

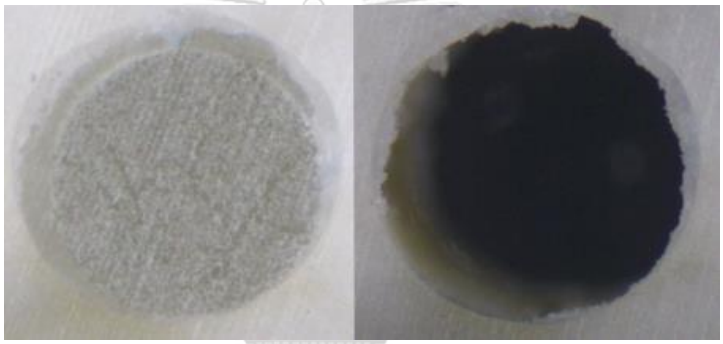


Figure20. Apical side of group1 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

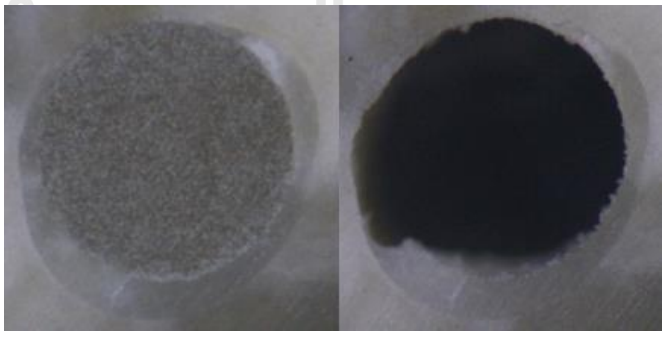


Figure21. Cervical side of group2 sample1 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

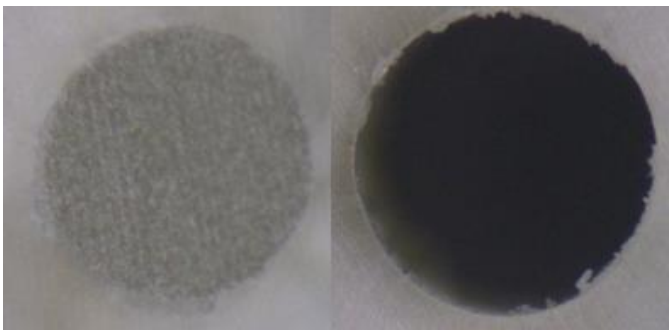


Figure22. Apical side of group2 sample1 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

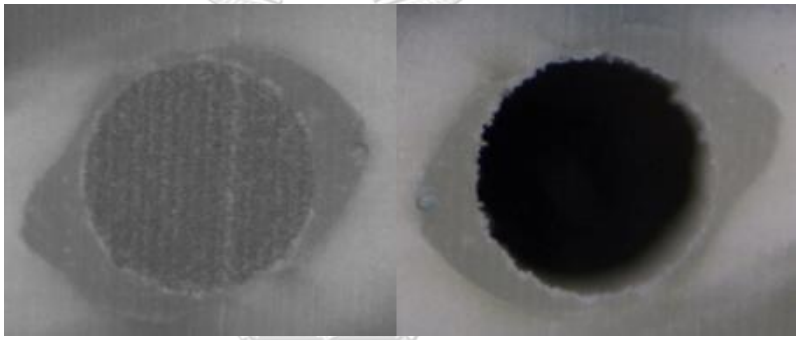


Figure23. Cervical side of group2 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

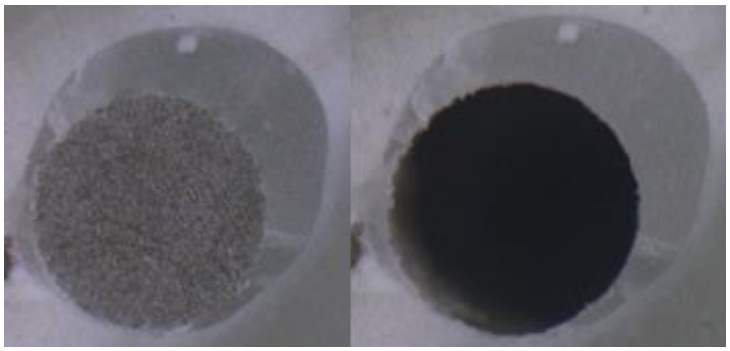


Figure24. Apical side of group2 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

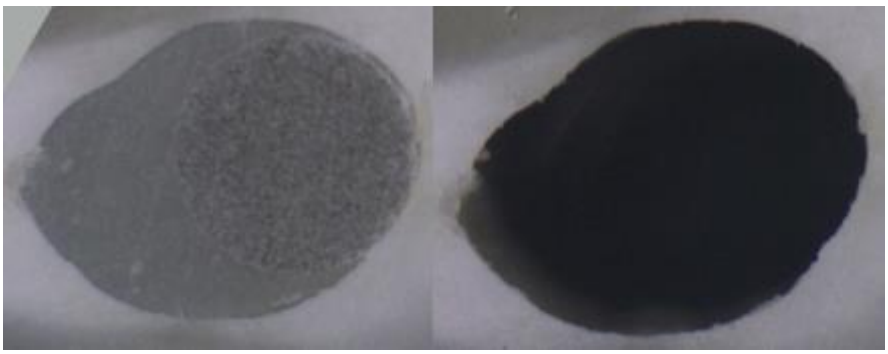


Figure25. Cervical side of group2 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

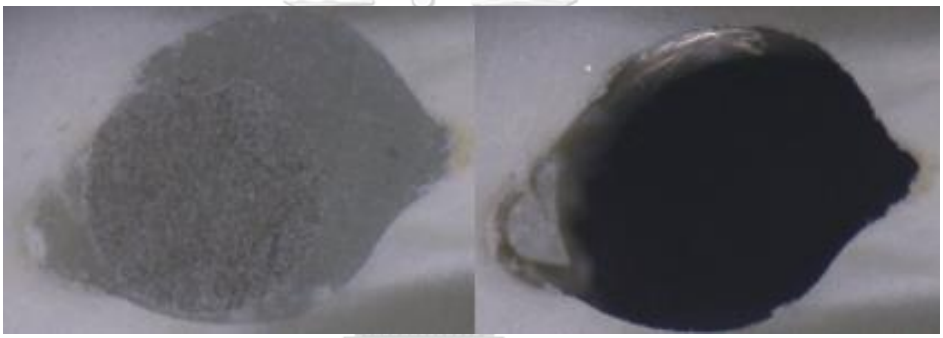


Figure26. Apical side of group2 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

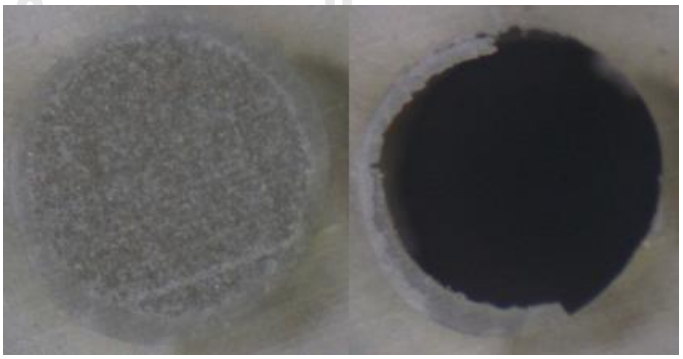


Figure27. Cervical side of group2 sample4 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

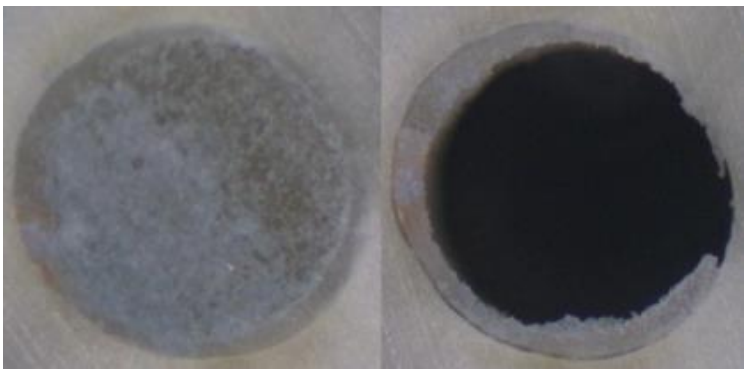


Figure28. Apical side of group2 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

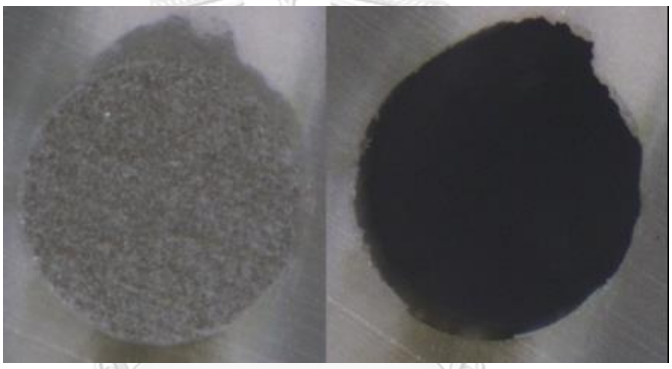


Figure29. Cervical side of group2 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

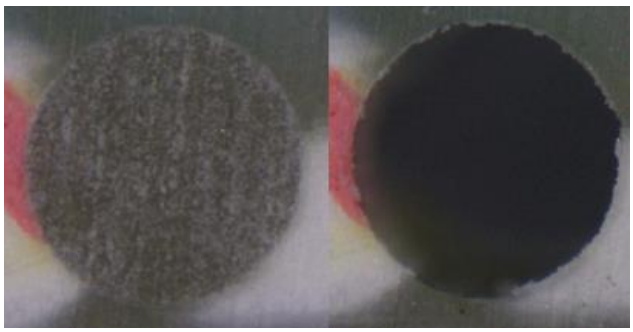


Figure30. Apical side of group2 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

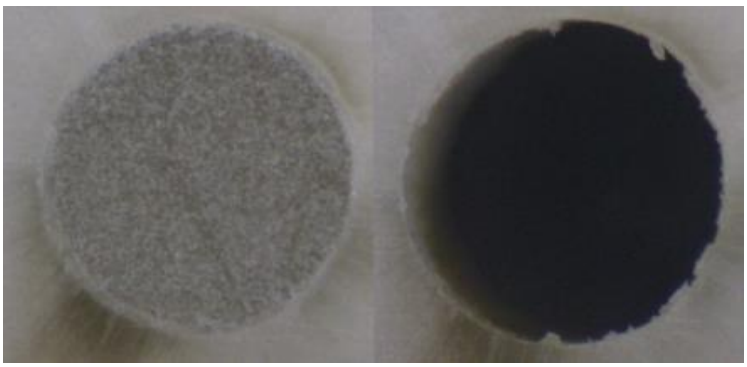


Figure31. Cervical side of group2 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

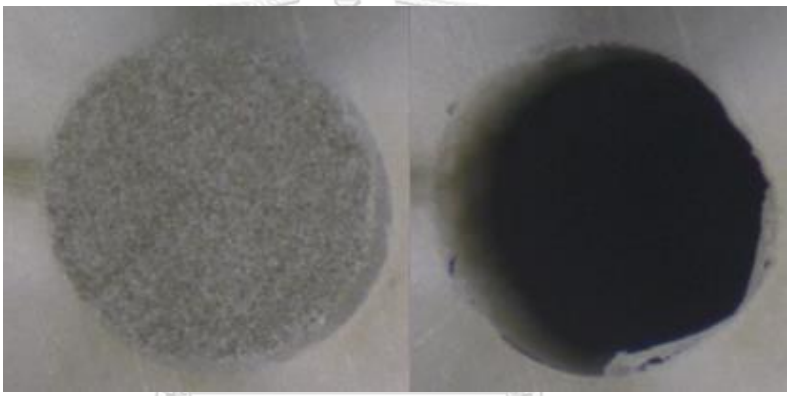


Figure32. Apical side of group2 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

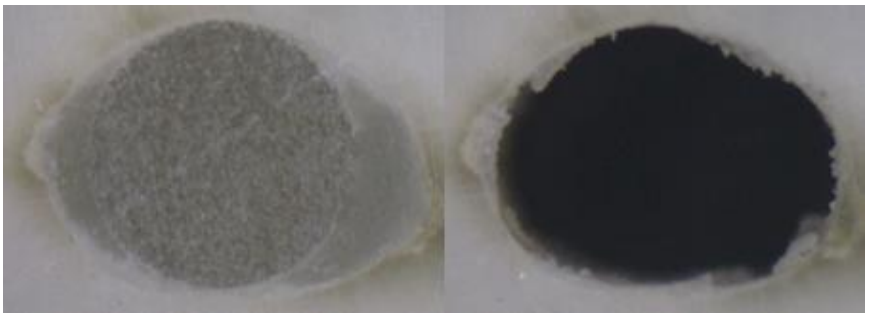


Figure33. Cervical side of group2 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

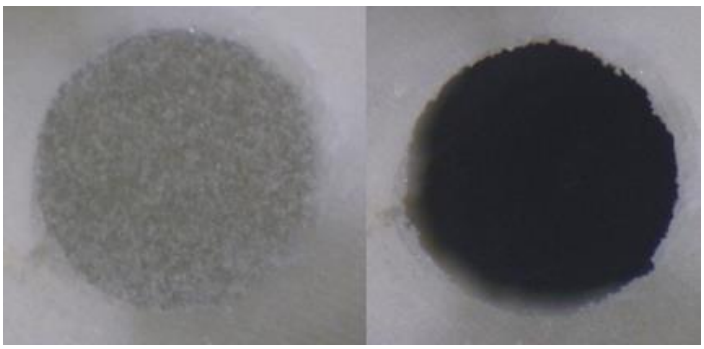


Figure34. Apical side of group2 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

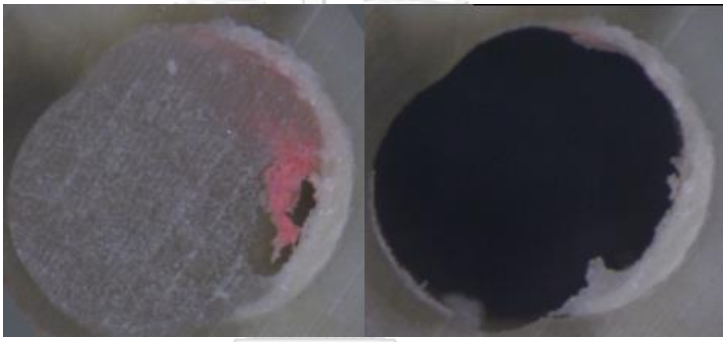


Figure35. Cervical side of group2 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

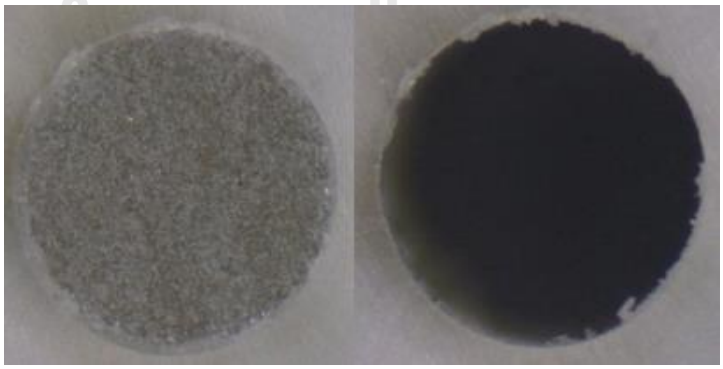


Figure36. Apical side of group2 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

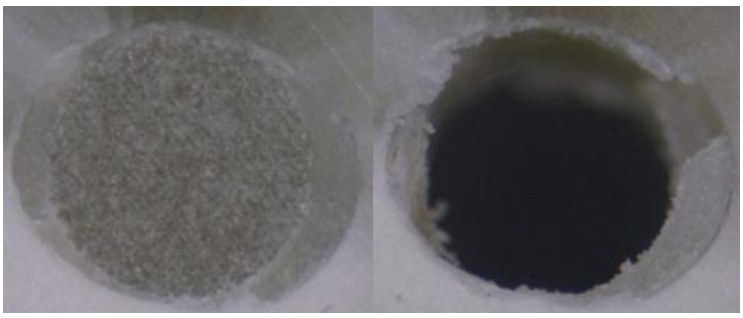


Figure37. Cervical side of group2 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

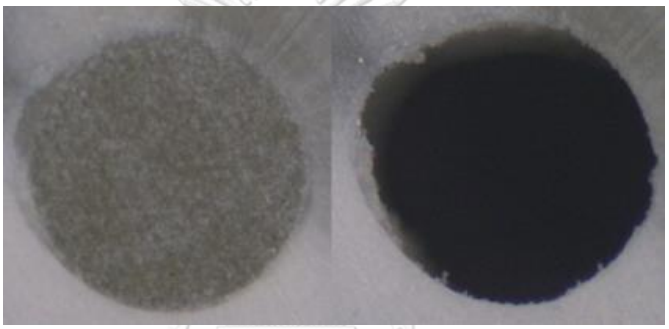


Figure38. Apical side of group2 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

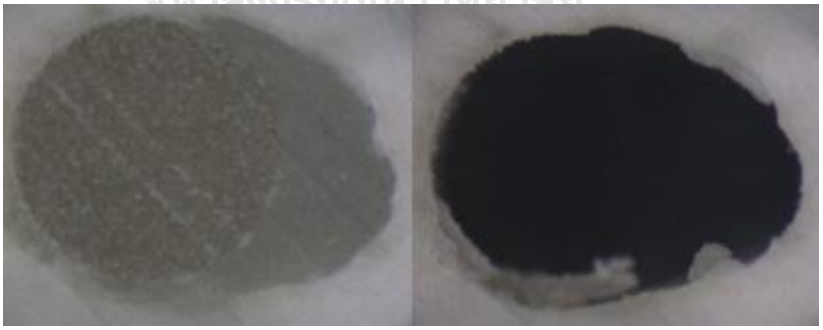


Figure39. Cervical side of group2 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

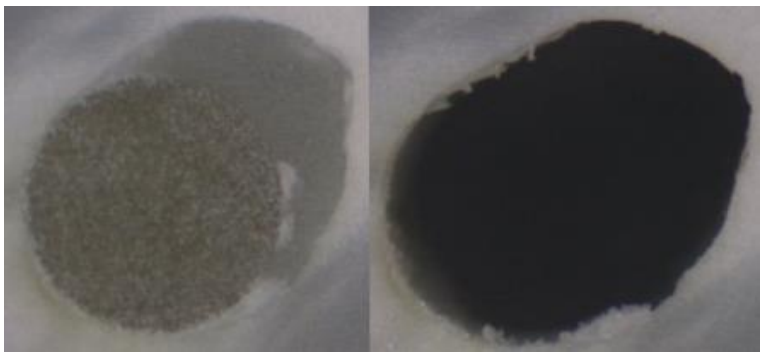


Figure40. Apical side of group2 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

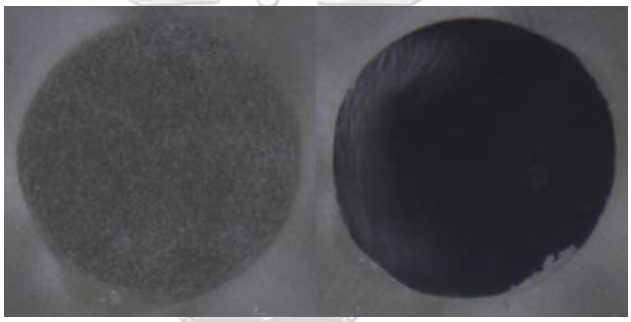


Figure41. Cervical side of group3 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

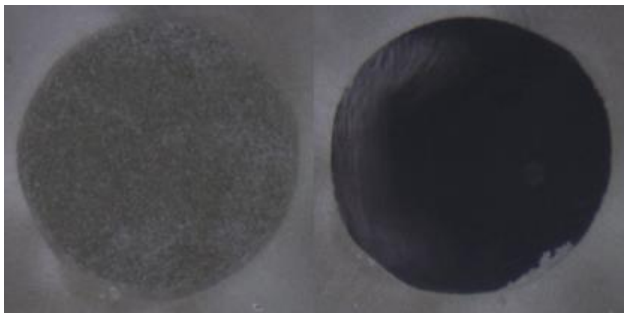


Figure42. Apical side of group3 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

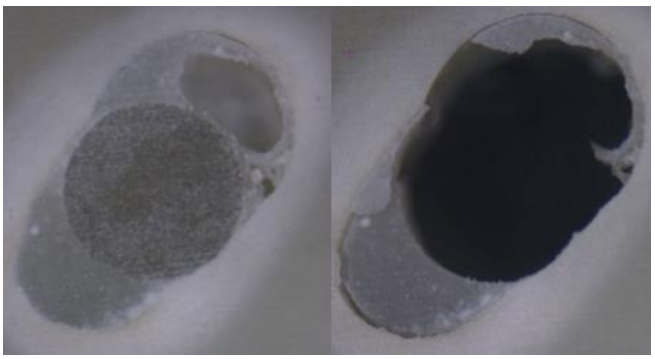


Figure43. Cervical side of group3 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

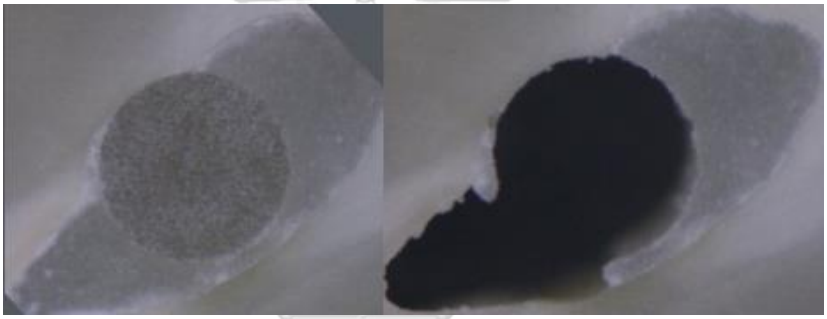


Figure44. Apical side of group3 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

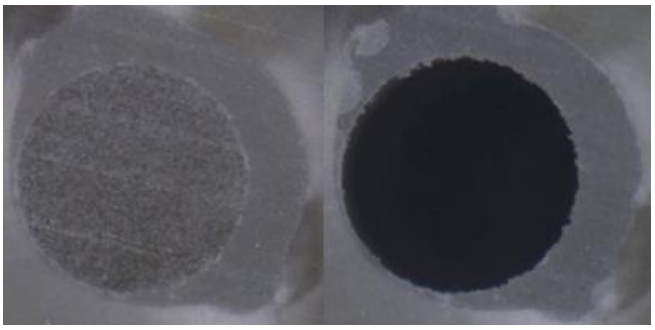


Figure45. Cervical side of group3 sample3 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

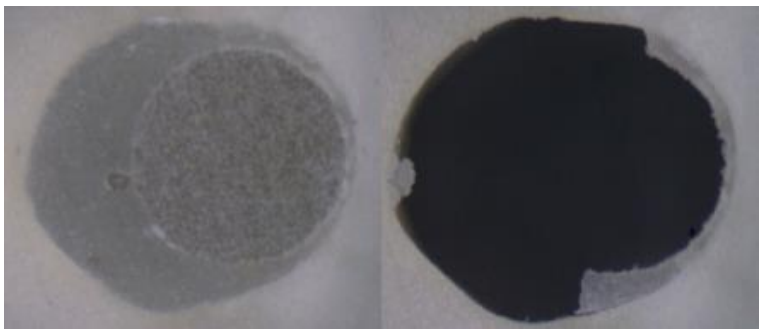


Figure46. Apical side of group3 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

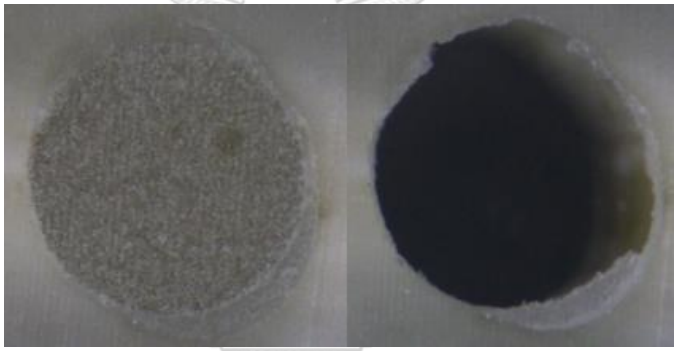


Figure47. Cervical side of group3 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

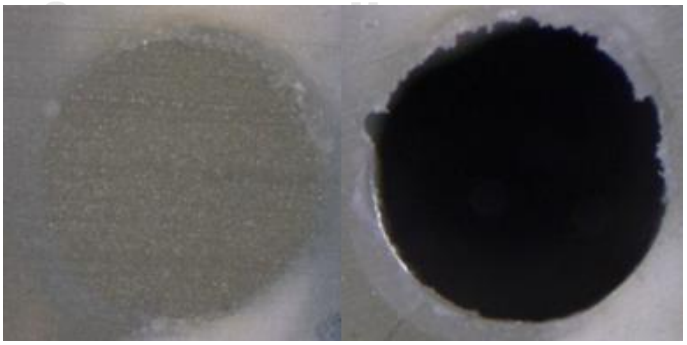


Figure48. Apical side of group3 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

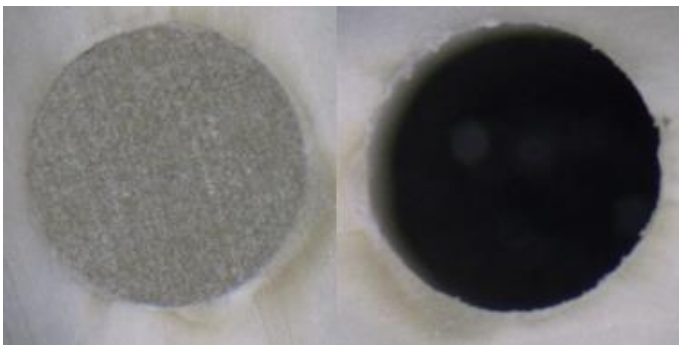


Figure49. Cervical side of group3 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

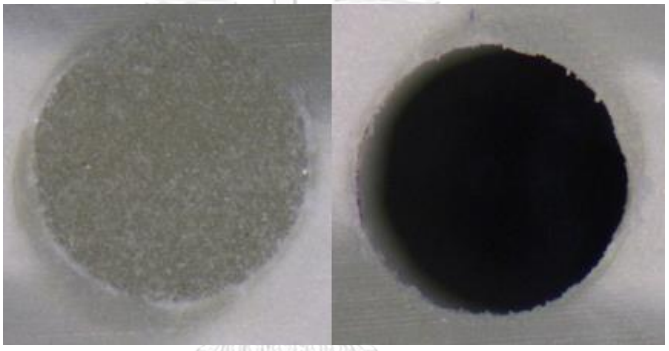


Figure50. Apical side of group3 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

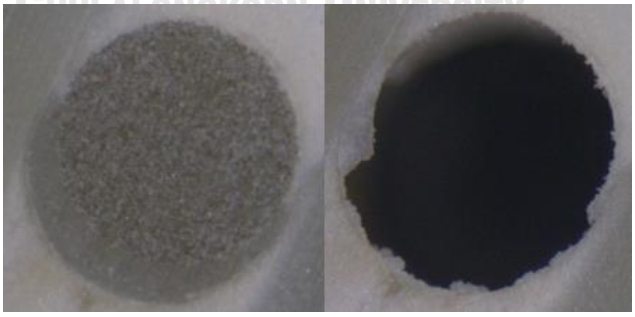


Figure51. Cervical side of group3 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

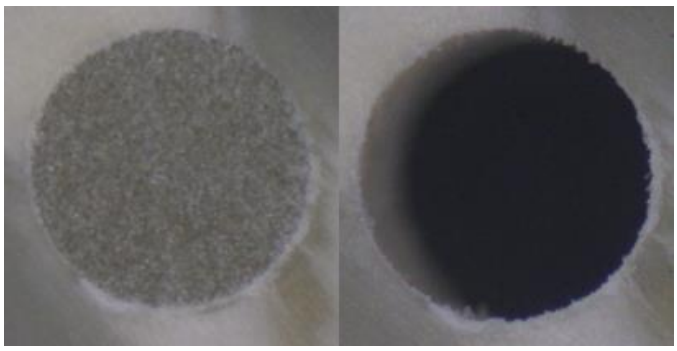


Figure52. Apical side of group3 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

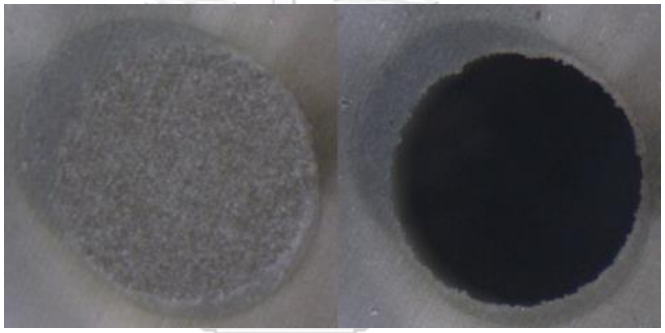


Figure53. Cervical side of group3 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

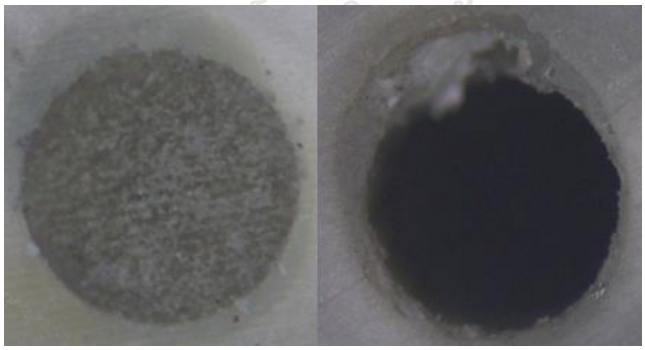


Figure54. Apical side of group3 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

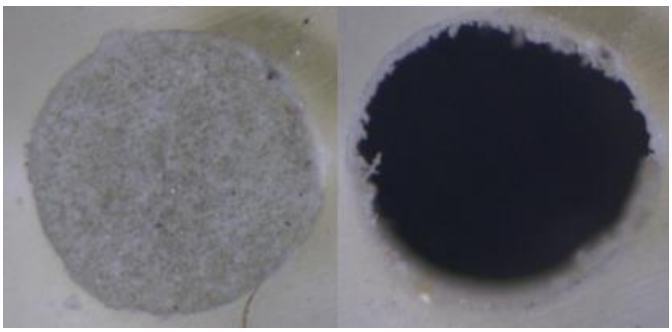


Figure55. Cervical side of group3 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

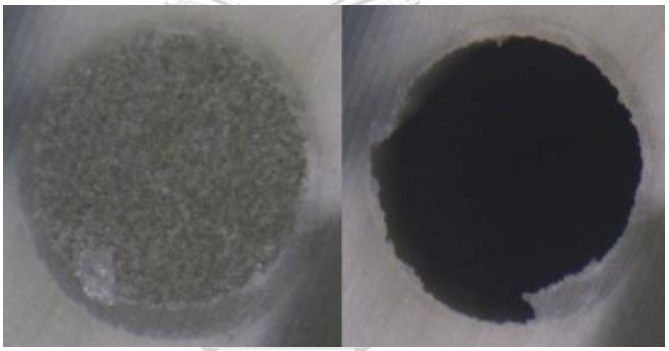


Figure56. Apical side of group3 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

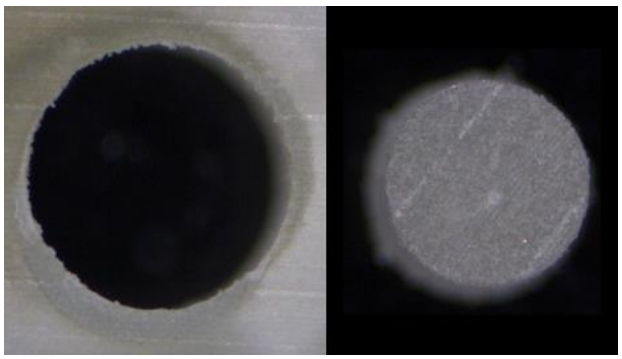


Figure57. Cervical side of group3 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

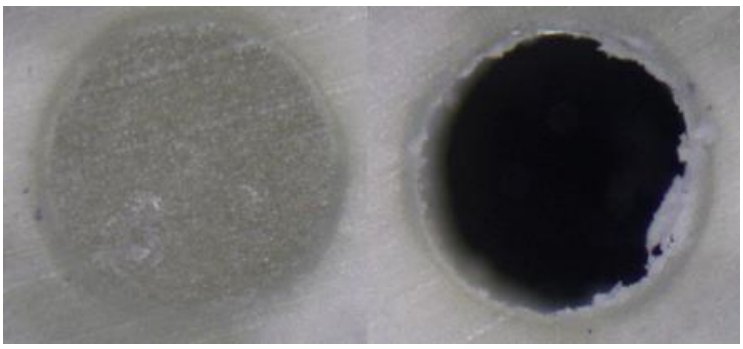


Figure58. Apical side of group3 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

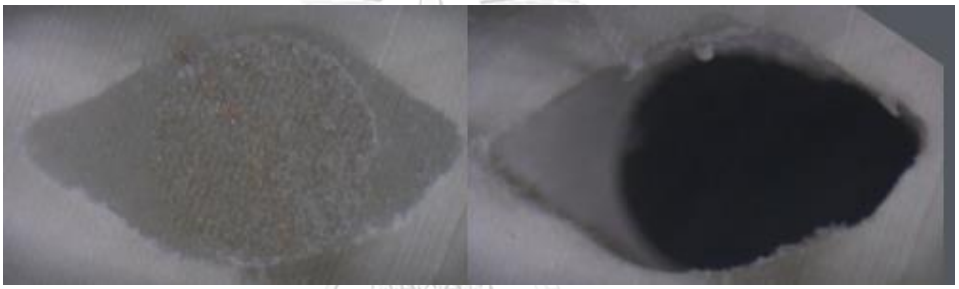


Figure59. Cervical side of group3 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

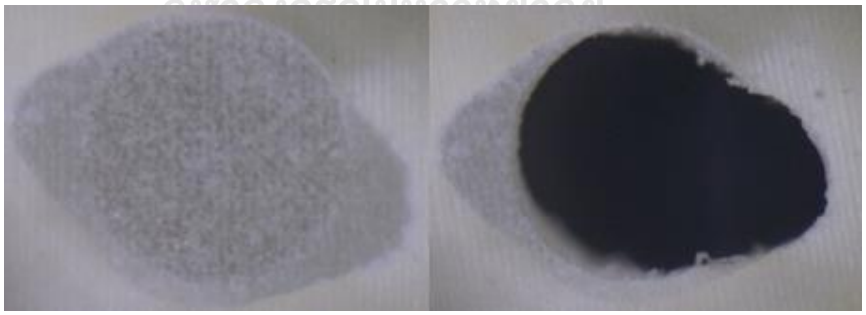


Figure60. Apical side of group3 sample10 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

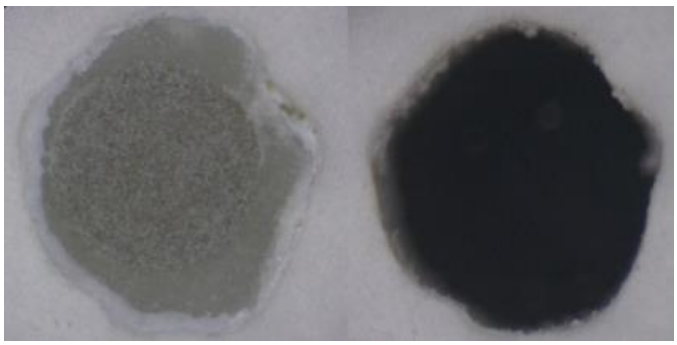


Figure61. Cervical side of group4 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

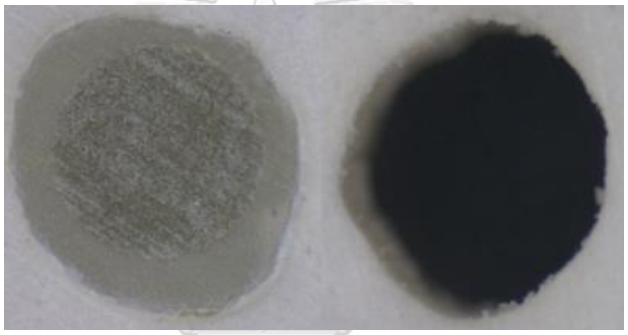


Figure62. Apical side of group4 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

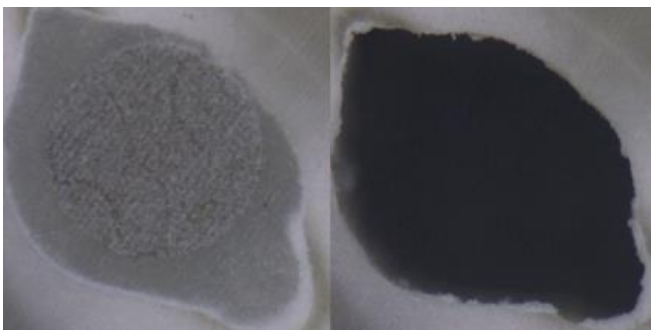


Figure63. Cervical side of group4 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

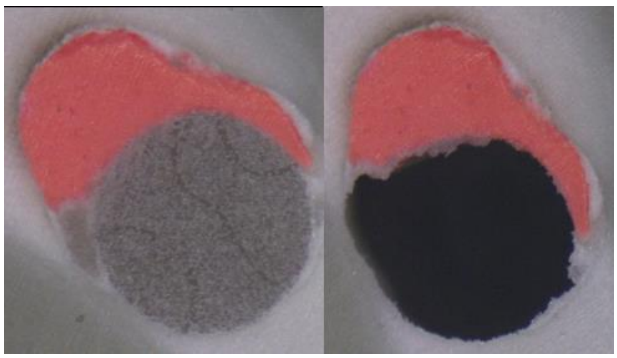


Figure64. Apical side of group4 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

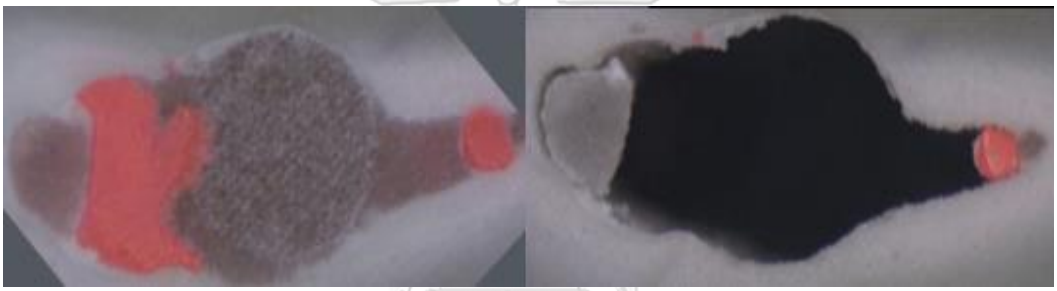


Figure65. Cervical side of group4 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

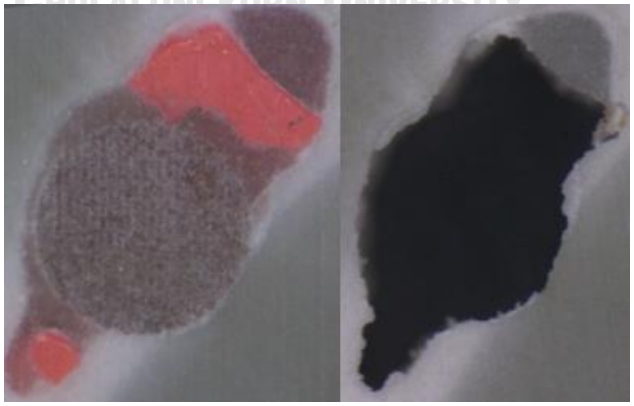


Figure66. Apical side of group4 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

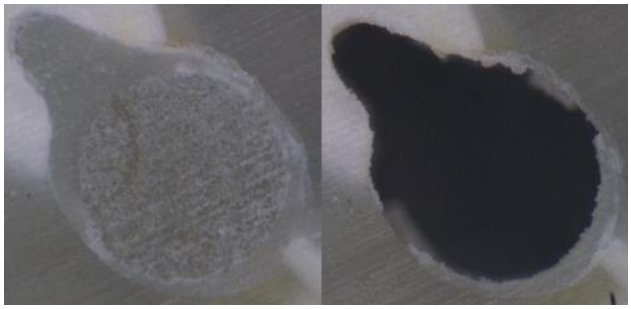


Figure67. Cervical side of group4 sample4 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

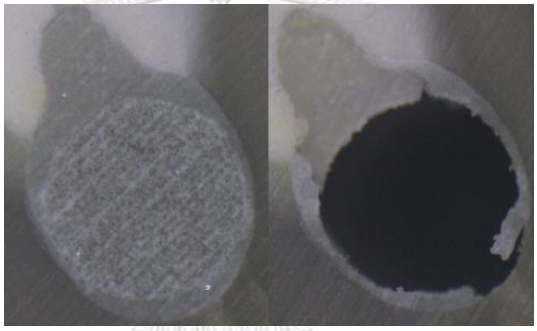


Figure68. Apical side of group4 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

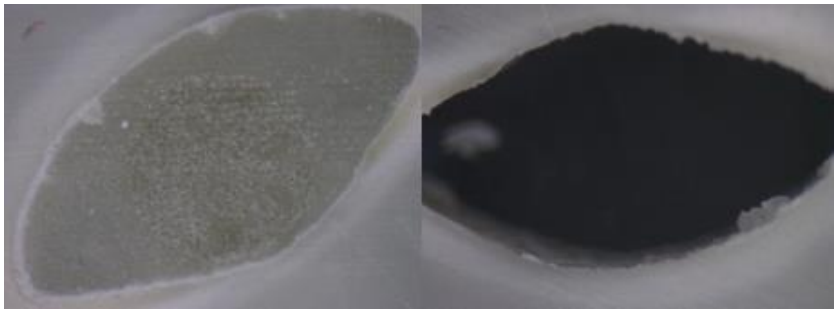


Figure69. Cervical side of group4 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

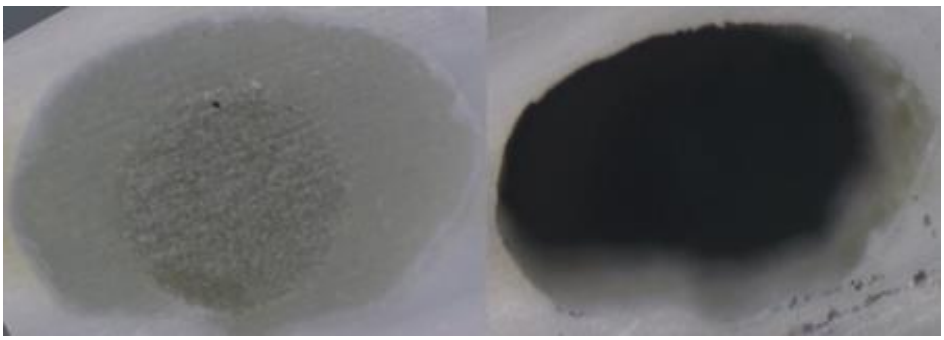


Figure70. Apical side of group4 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

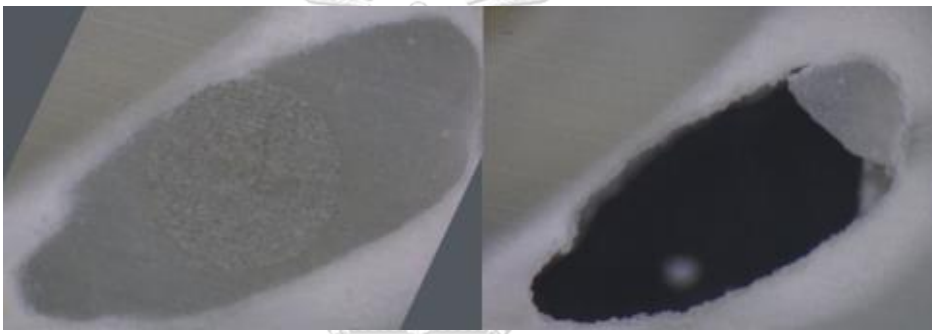


Figure71. Cervical side of group4 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

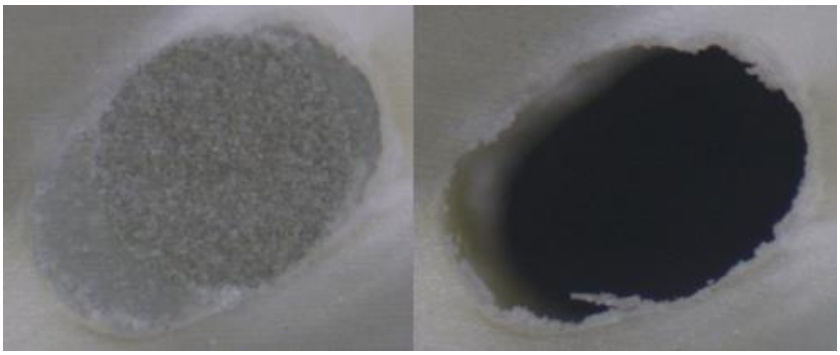


Figure72. Apical side of group4 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

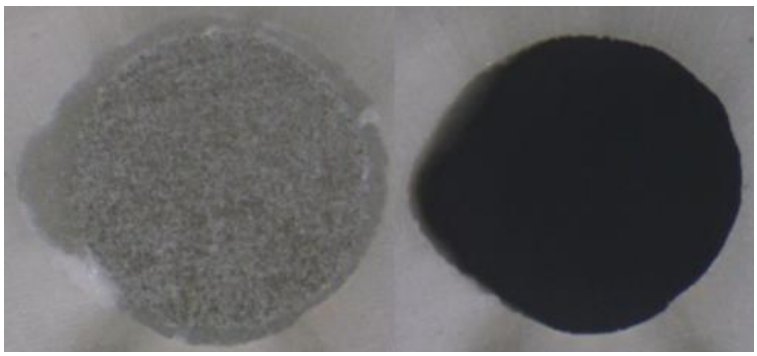


Figure73. Cervical side of group4 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

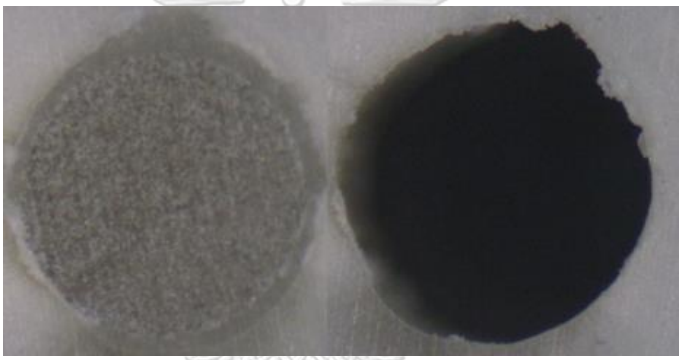


Figure74. Apical side of group4 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

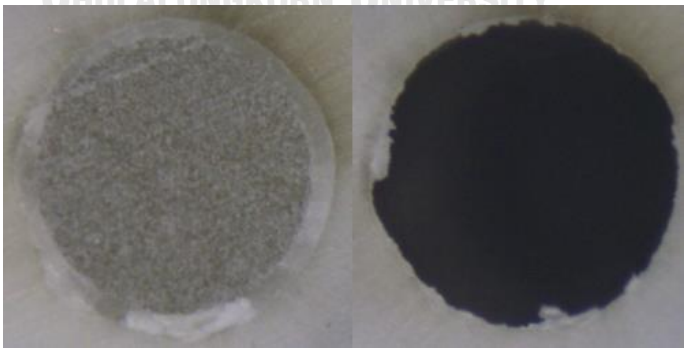


Figure75. Cervical side of group4 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

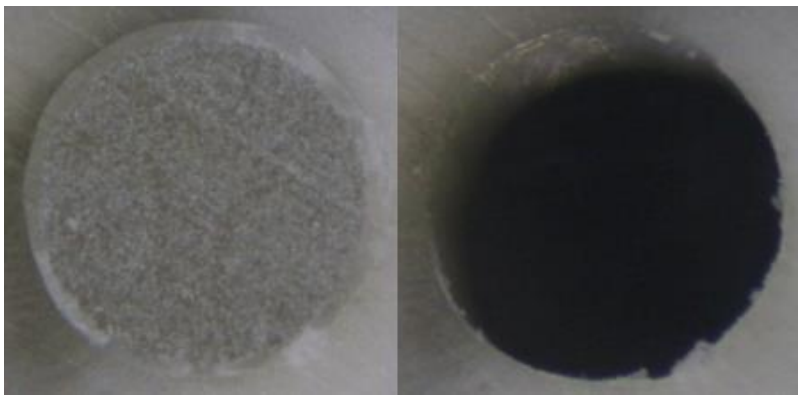


Figure76. Apical side of group4 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

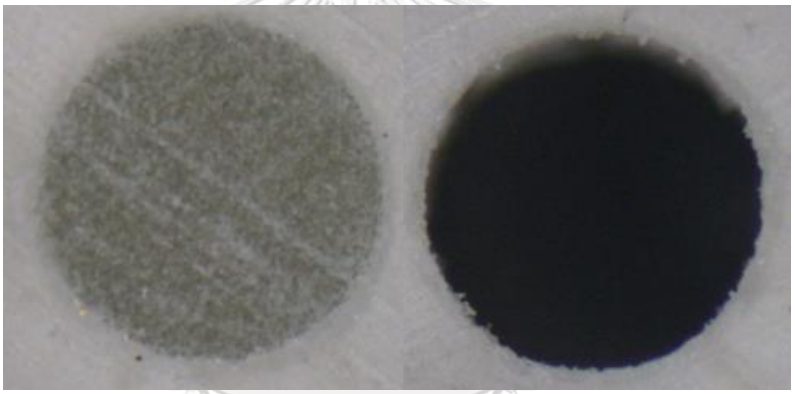


Figure77. Cervical side of group4 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

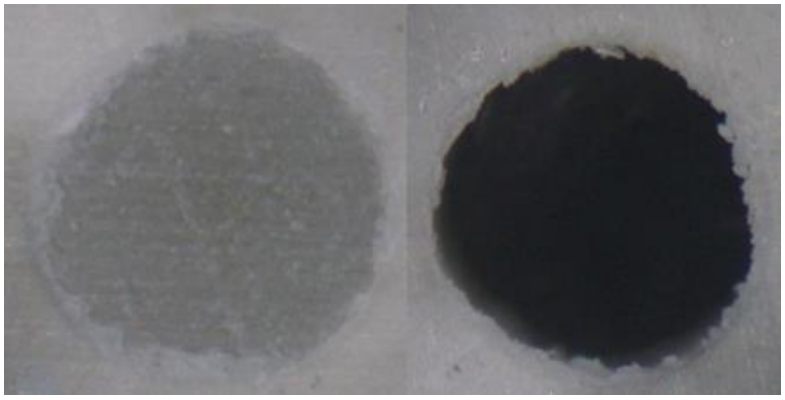


Figure78. Apical side of group4 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

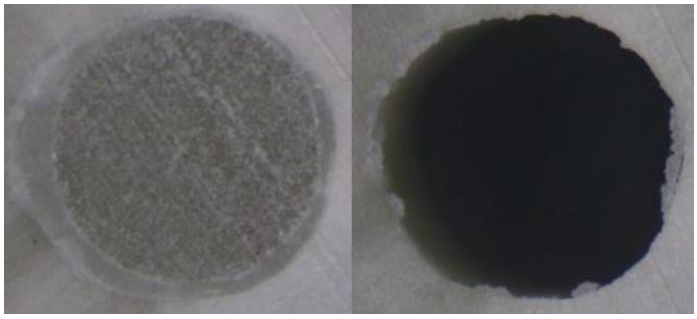


Figure79. Cervical side of group4 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

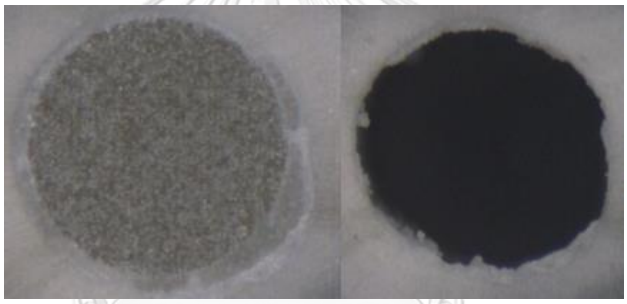


Figure80. Apical side of group4 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

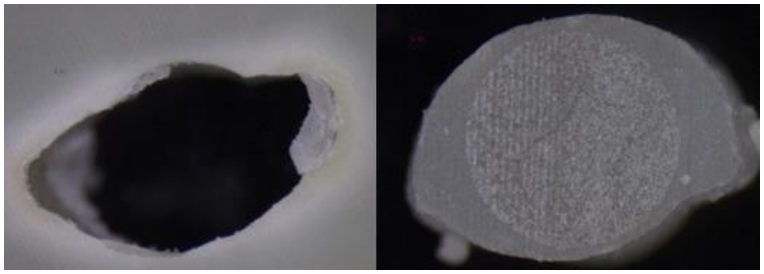


Figure81. Cervical side of group5 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

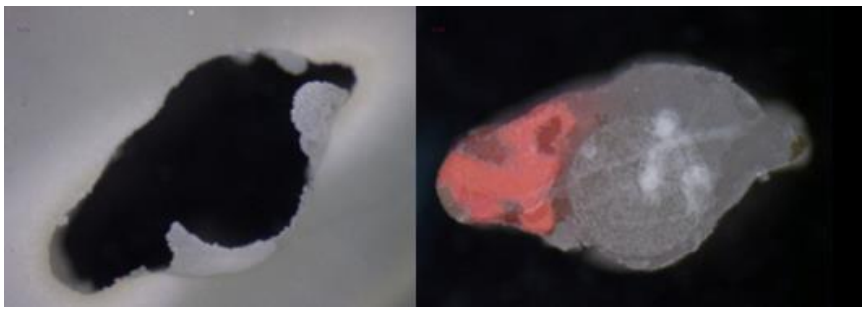


Figure82. Apical side of group5 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

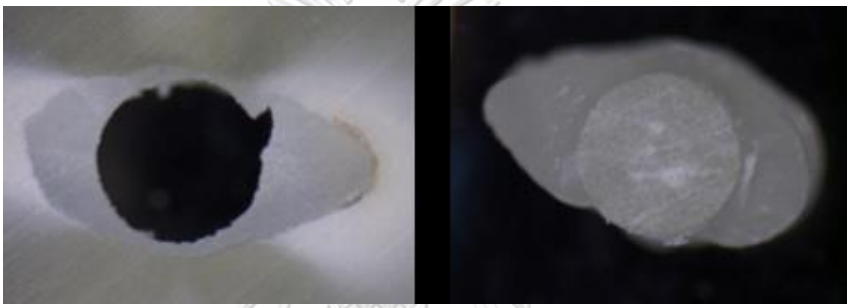


Figure83. Cervical side of group5 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

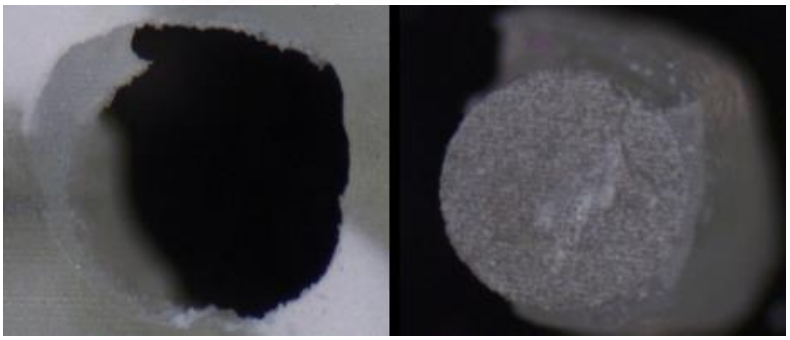


Figure84. Apical side of group5 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

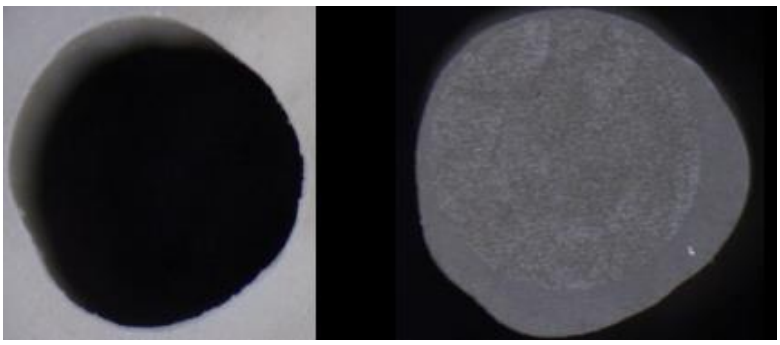


Figure85. Cervical side of group5 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

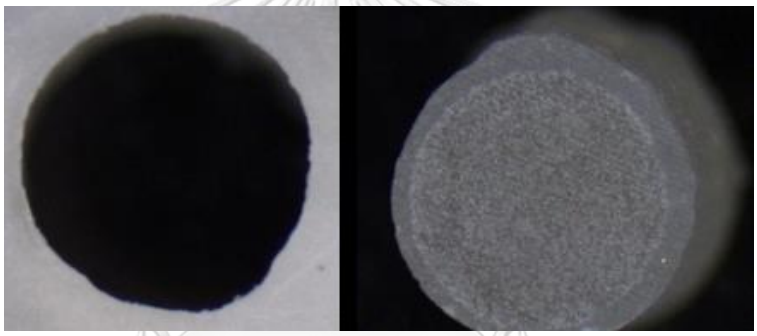


Figure86. Apical side of group5 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

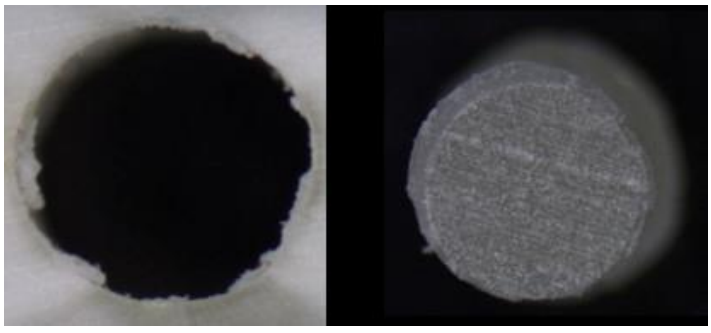


Figure87. Cervical side of group5 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

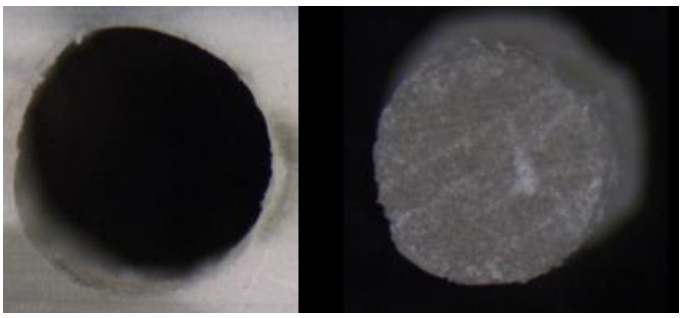


Figure88. Apical side of group5 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

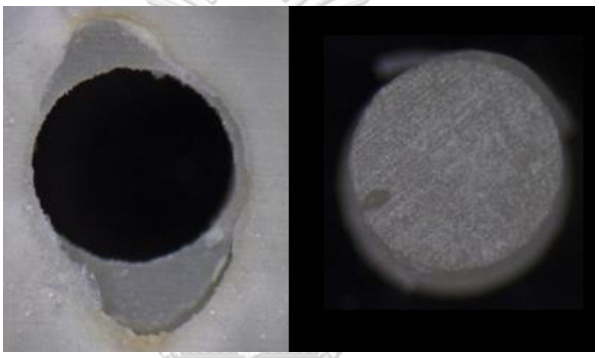


Figure89. Cervical side of group5 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

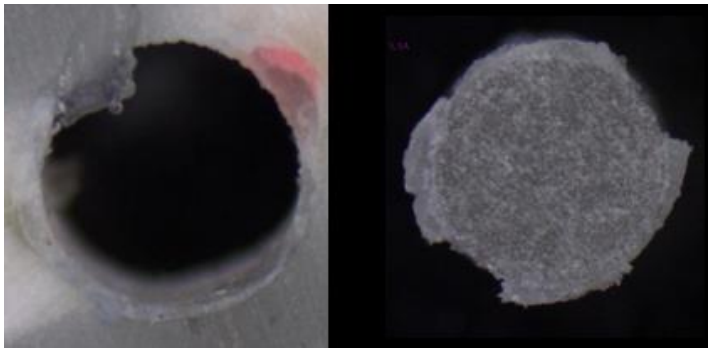


Figure90. Apical side of group5 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

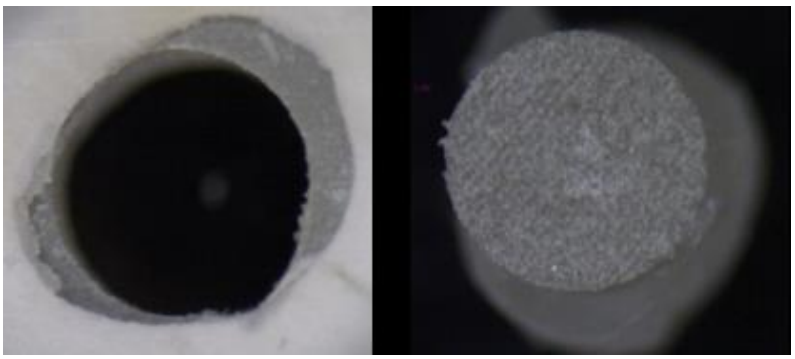


Figure91. Cervical side of group5 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

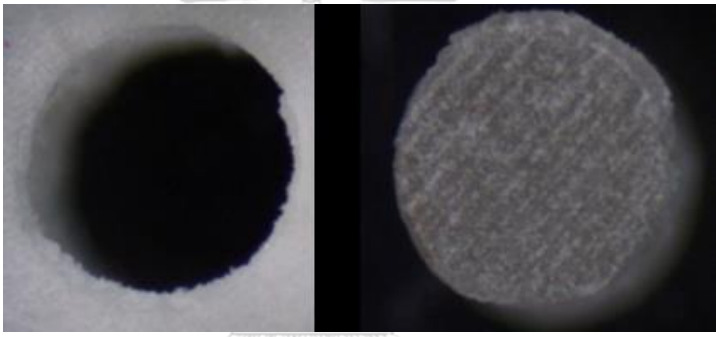


Figure92. Apical side of group5 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

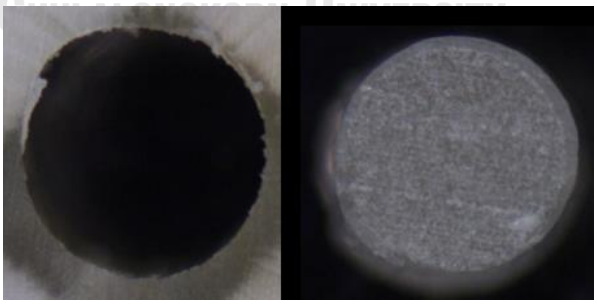


Figure93. Cervical side of group5 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

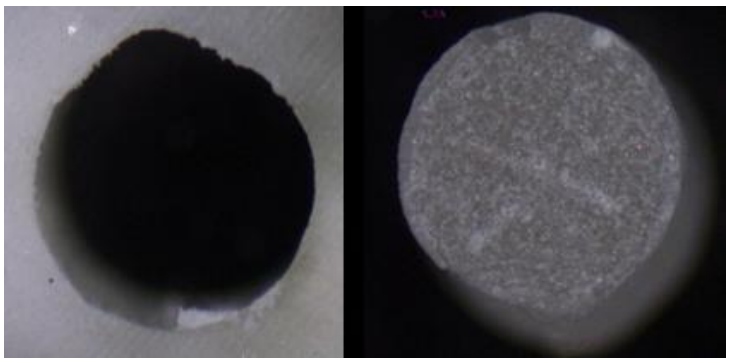


Figure94. Apical side of group5 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

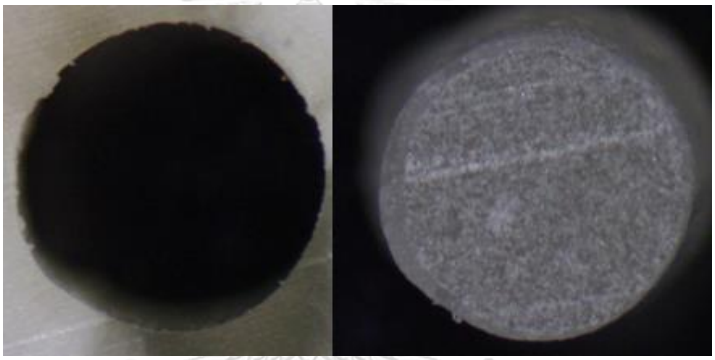


Figure95. Cervical side of group5 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

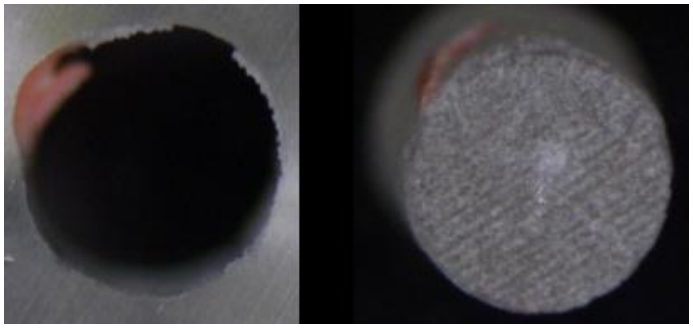


Figure96. Apical side of group5 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

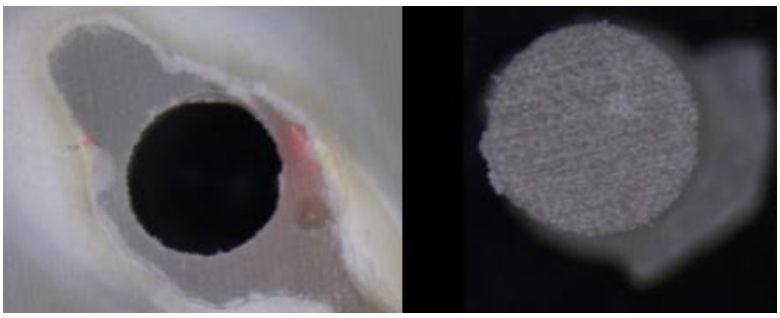


Figure97. Cervical side of group5 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

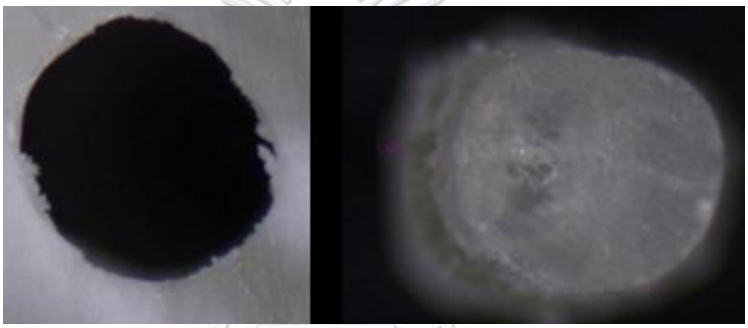


Figure98. Apical side of group5 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

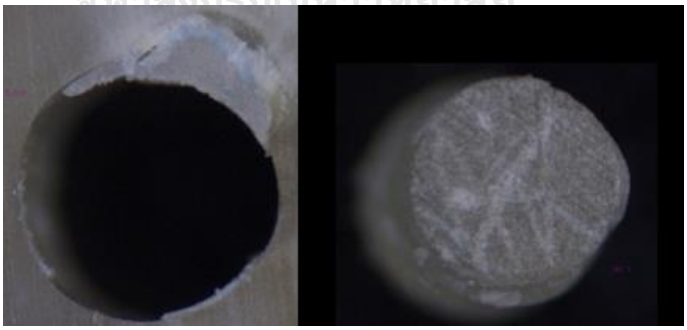


Figure99. Cervical side of group5 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

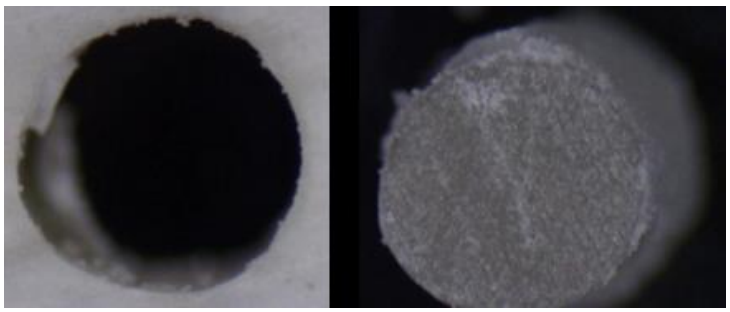


Figure100. Apical side of group5 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

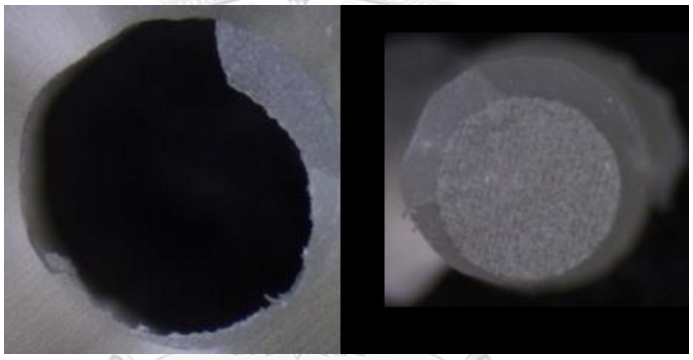


Figure101. Cervical side of group6 sample1 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

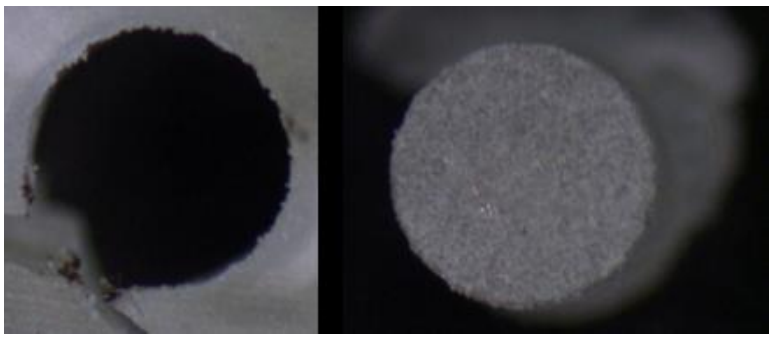


Figure102. Apical side of group6 sample1 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

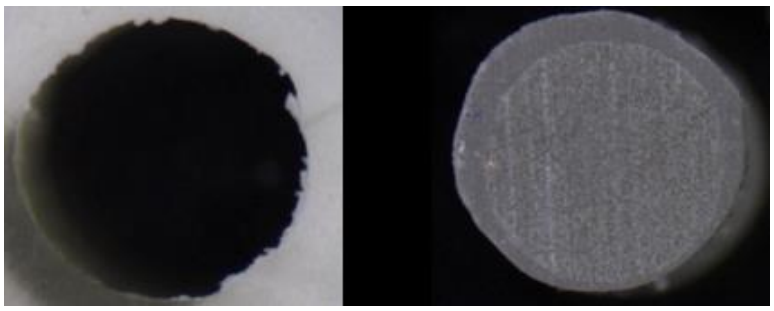


Figure103. Cervical side of group6 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

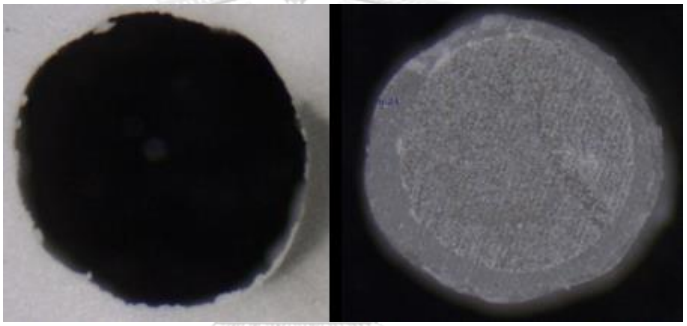


Figure104. Apical side of group6 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

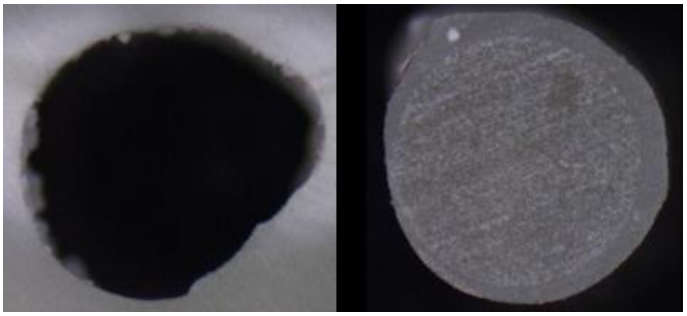


Figure105. Cervical side of group6 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

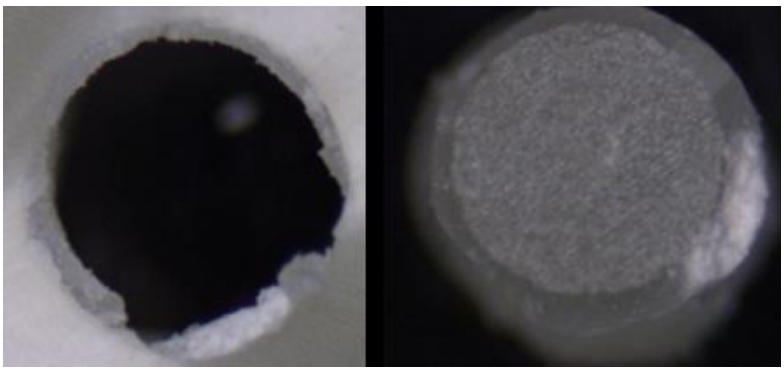


Figure106. Apical side of group6 sample3 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

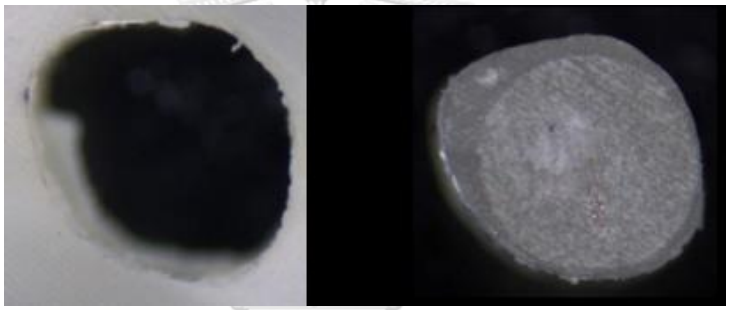


Figure107. Cervical side of group6 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

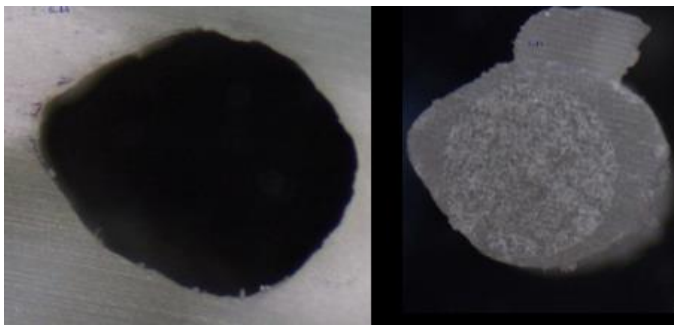


Figure108. Apical side of group6 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

Figure109. Cervical side of group6 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

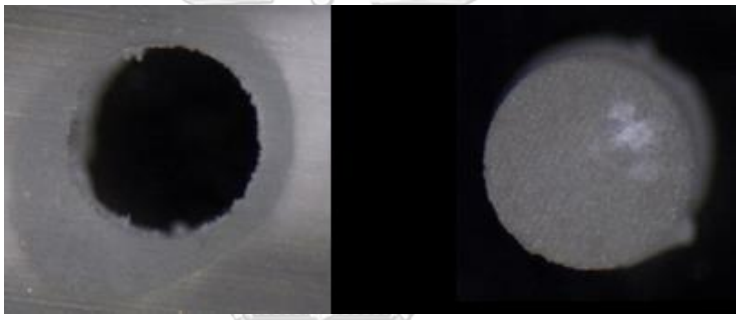


Figure110. Apical side of group6 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

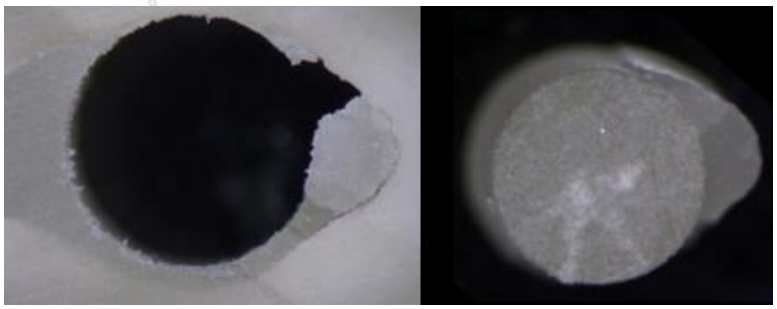


Figure111. Cervical side of group6 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

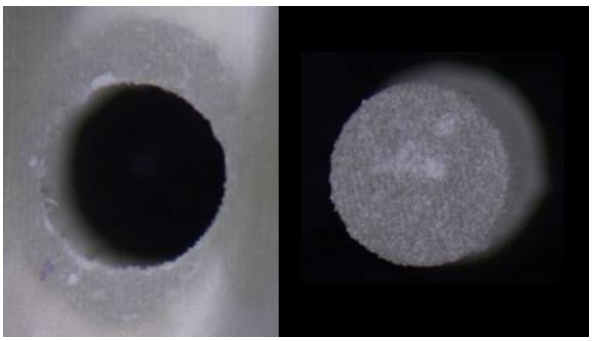


Figure112. Apical side of group6 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

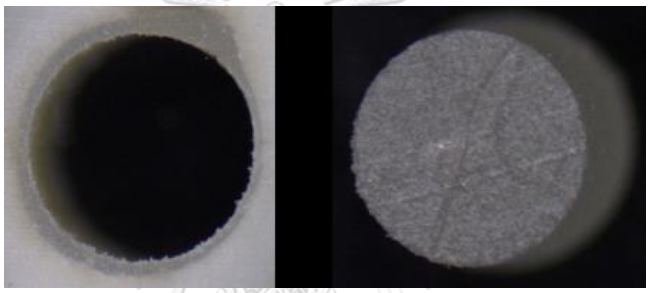


Figure113. Cervical side of group6 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

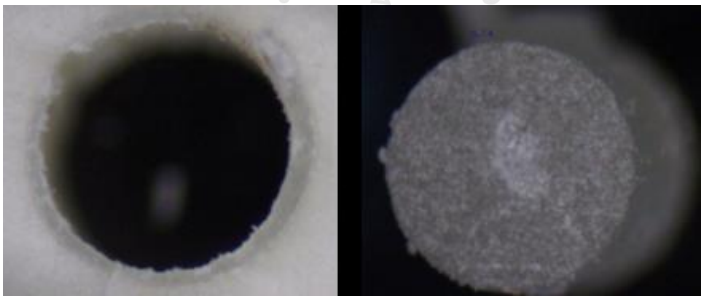


Figure114. Apical side of group6 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

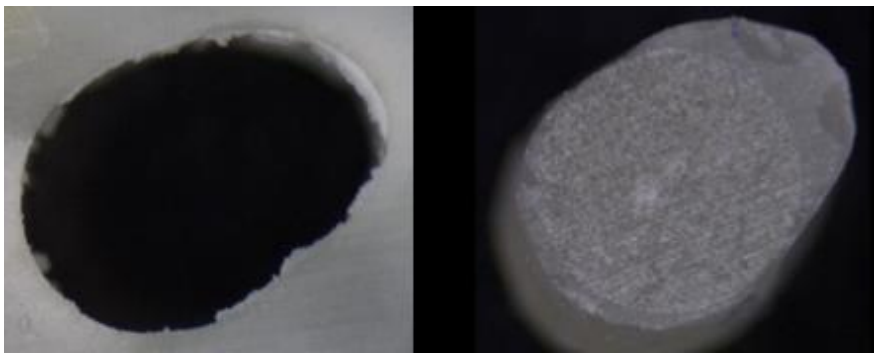


Figure115. Cervical side of group6 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

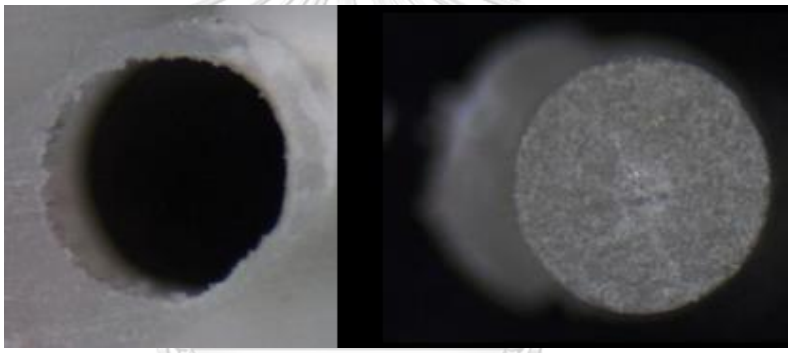


Figure116. Apical side of group6 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

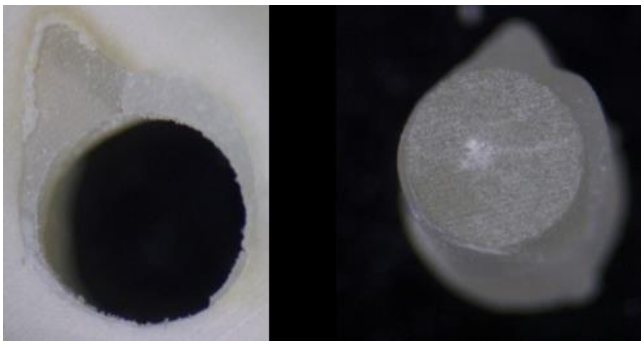


Figure117. Cervical side of group6 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

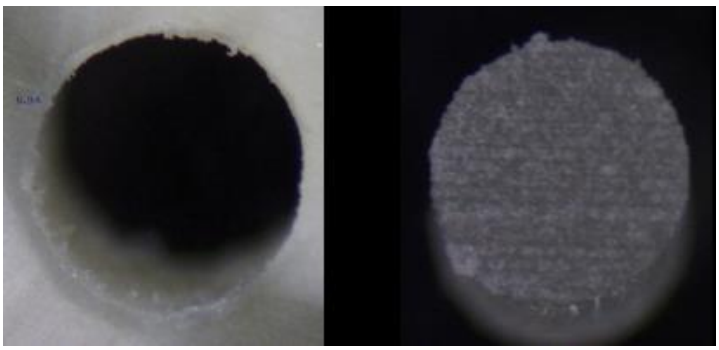


Figure118. Apical side of group6 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

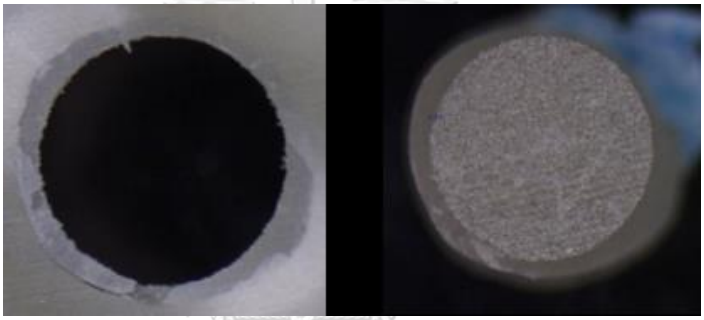


Figure119. Cervical side of group6 sample10 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

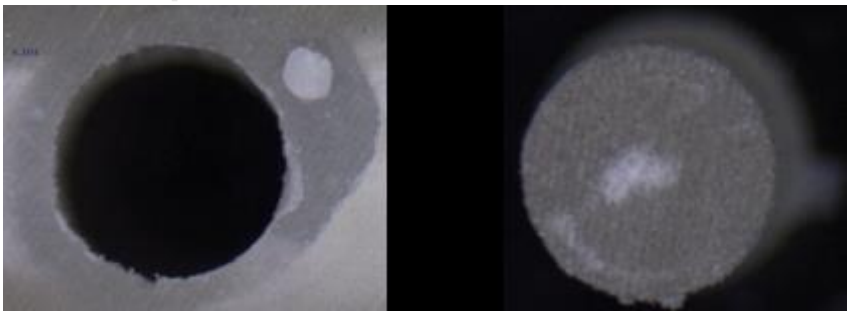


Figure120. Apical side of group6 sample10 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

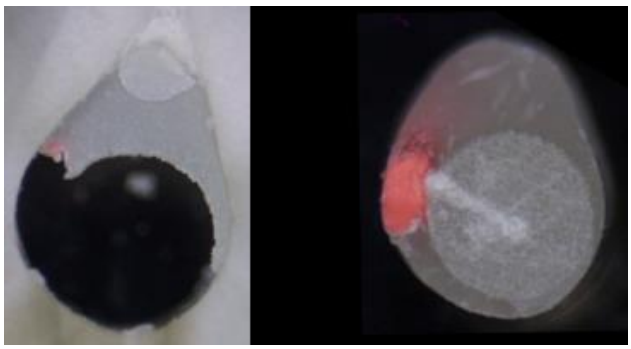


Figure121. Cervical side of group7 sample1 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

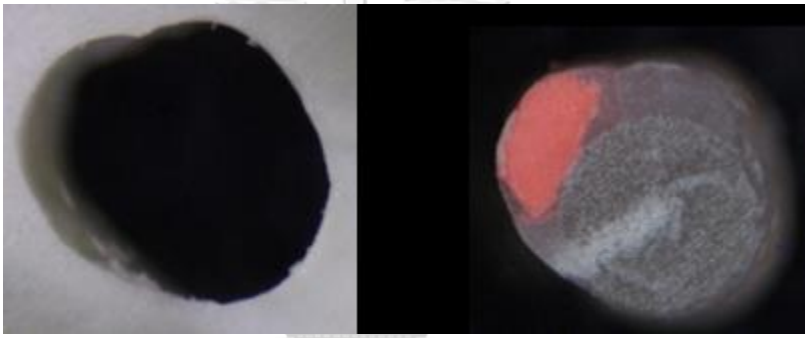


Figure122. Apical side of group7 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

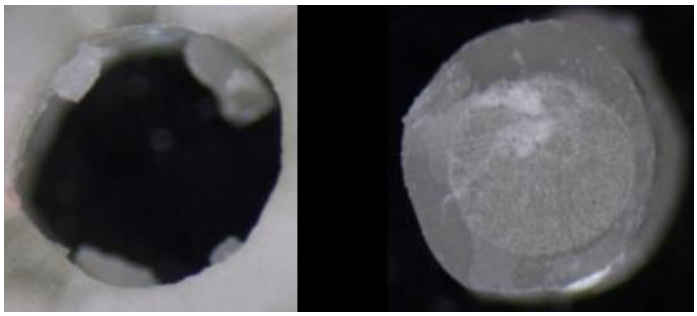


Figure123. Cervical side of group7 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

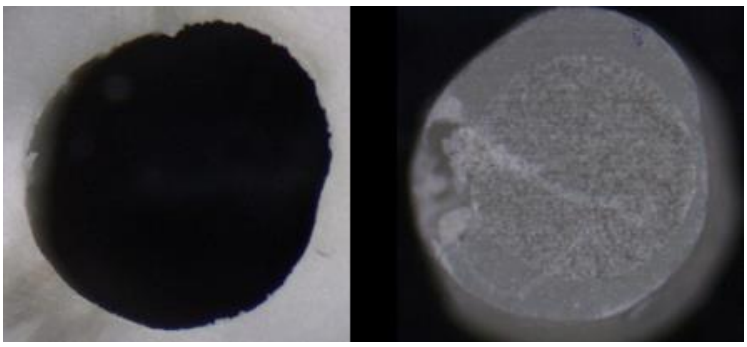


Figure124. Apical side of group7 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

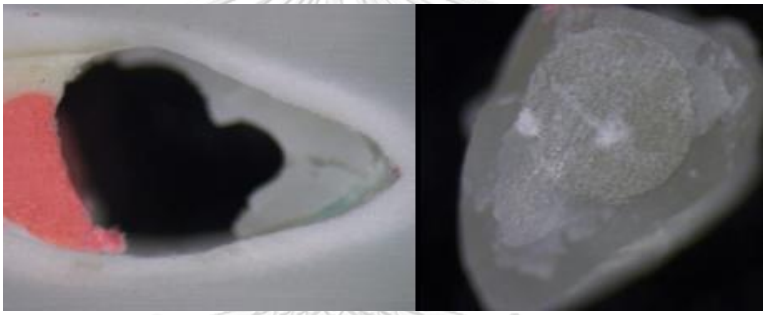


Figure125. Cervical side of group7 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

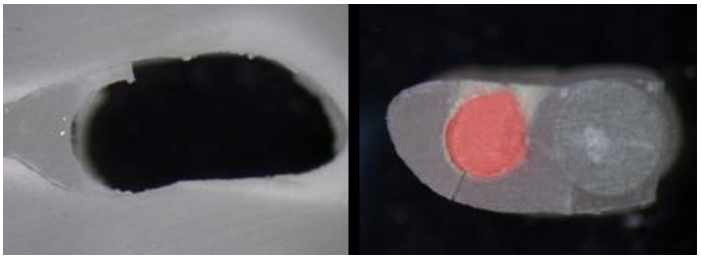


Figure126. Apical side of group7 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

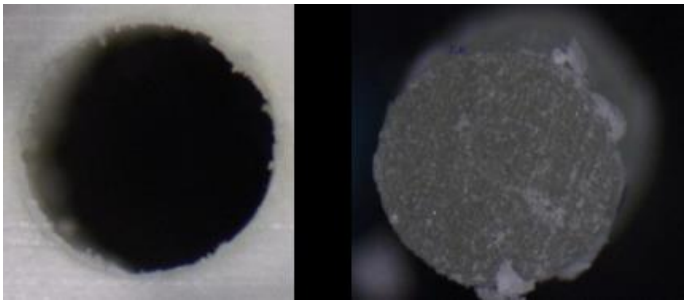


Figure127. Cervical side of group7 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

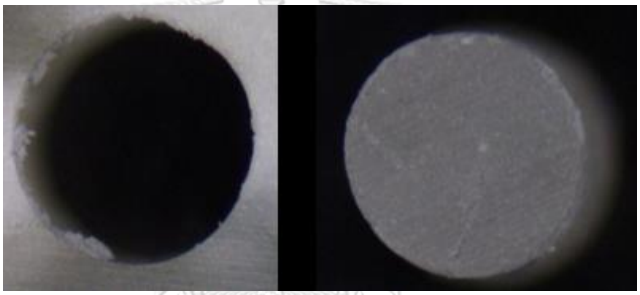


Figure128. Cervical side of group7 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

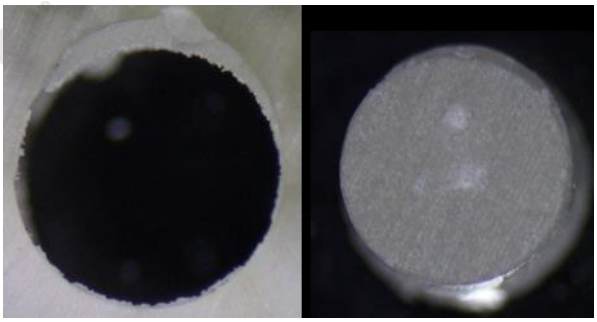


Figure129. Cervical side of group7 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*)

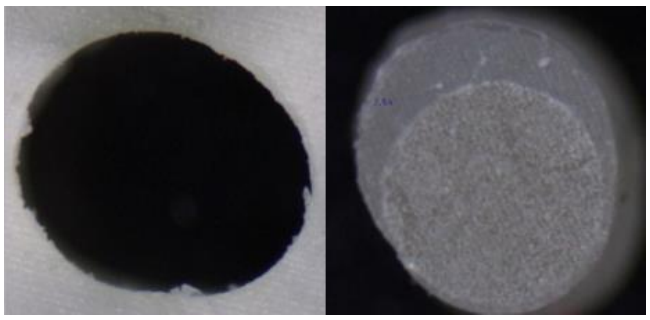


Figure130. Apical side of group7 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

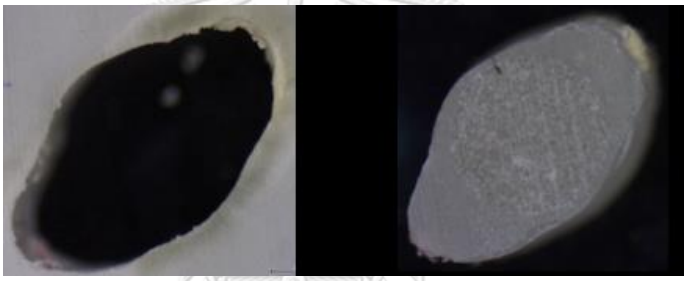


Figure131. Cervical side of group7 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

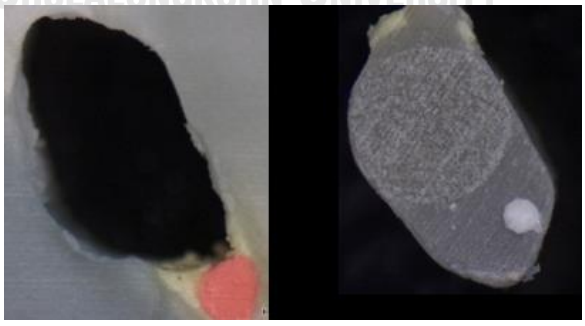


Figure132. Apical side of group7 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

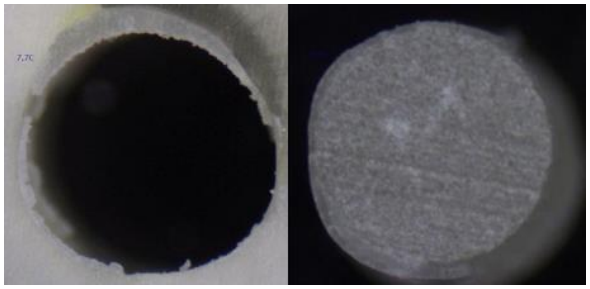


Figure133. Cervical side of group7 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

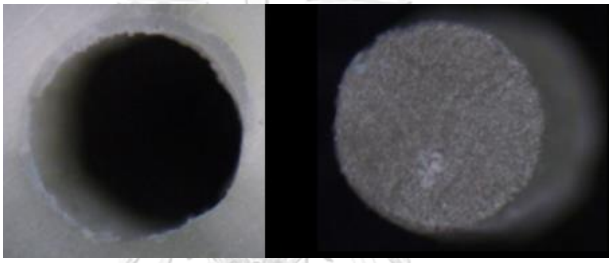


Figure134. Apical side of group7 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

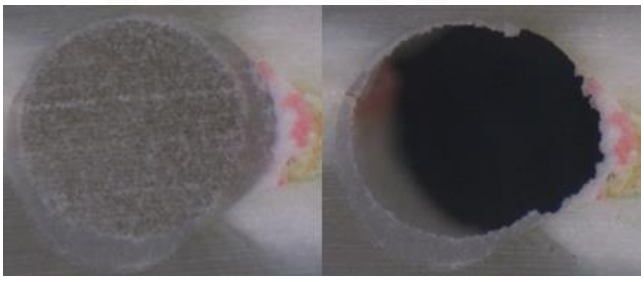


Figure135. Cervical side of group7 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

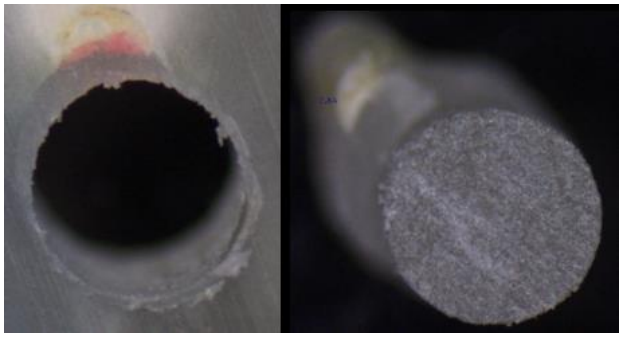


Figure136. Apical side of group7 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

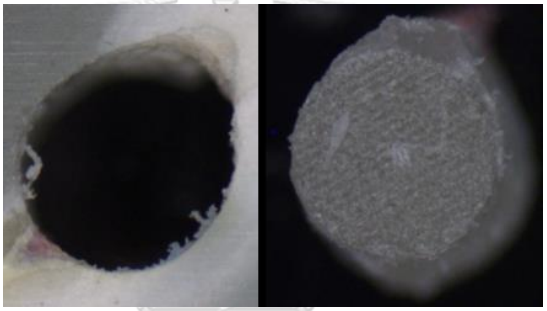


Figure137. Cervical side of group7 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

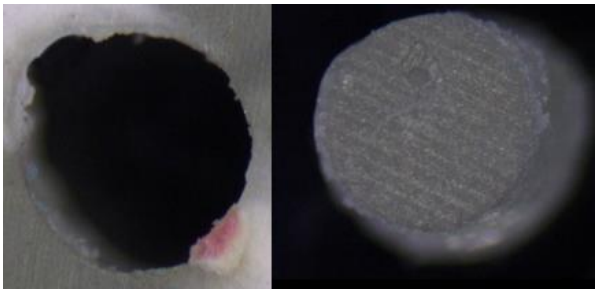


Figure138. Apical side of group7 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

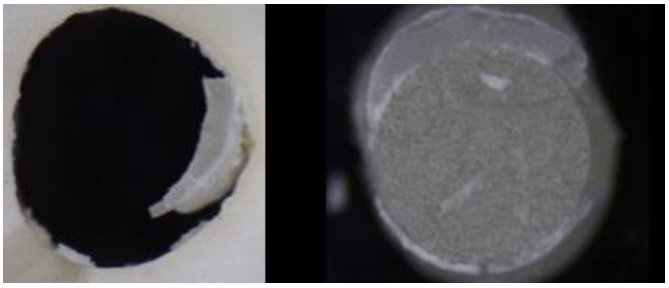


Figure139. Cervical side of group7 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

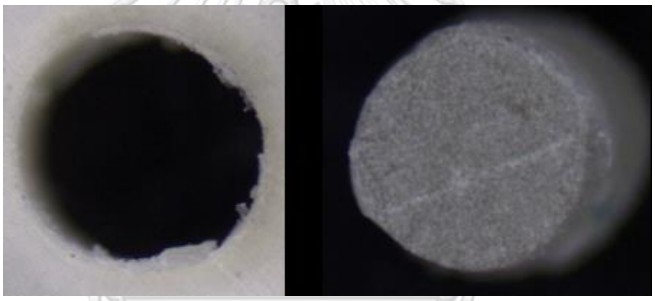


Figure140. Apical side of group7 sample10 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

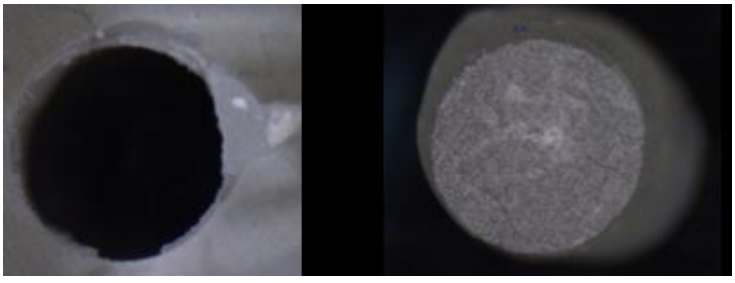


Figure141. Cervical side of group8 sample1 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

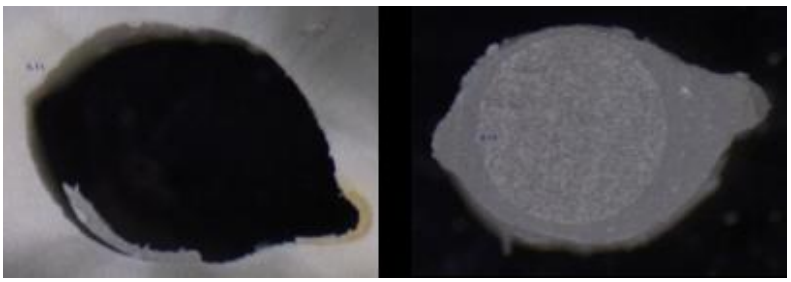


Figure142. Apical side of group8 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

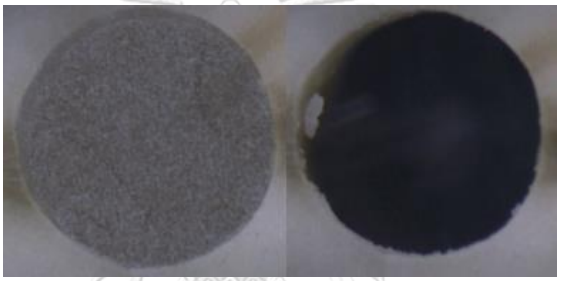


Figure143. Cervical side of group8 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

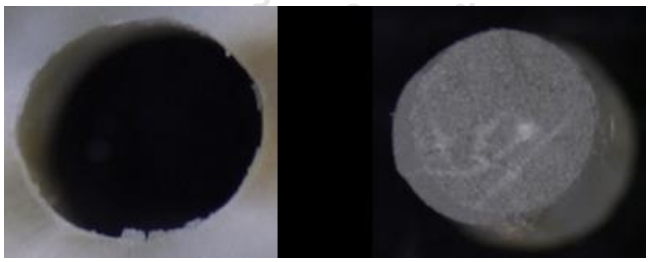


Figure144. Apical side of group8 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

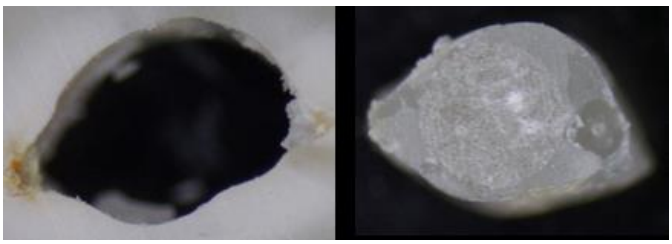


Figure145. Cervical side of group8 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

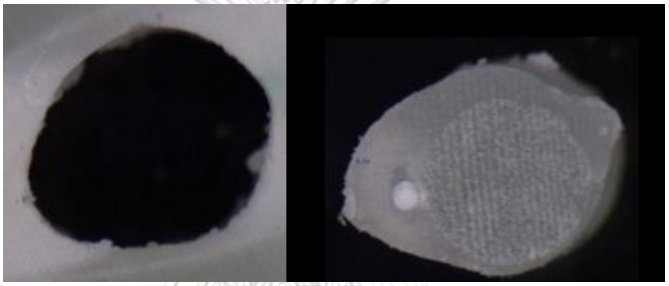


Figure146. Apical side of group8 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

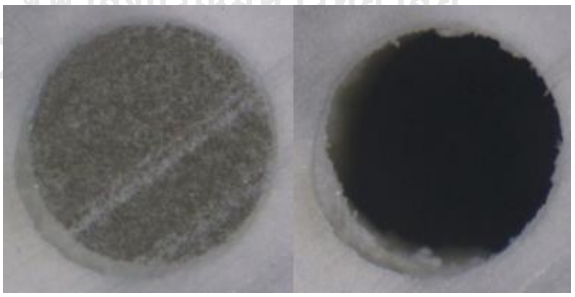


Figure147. Cervical side of group8 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

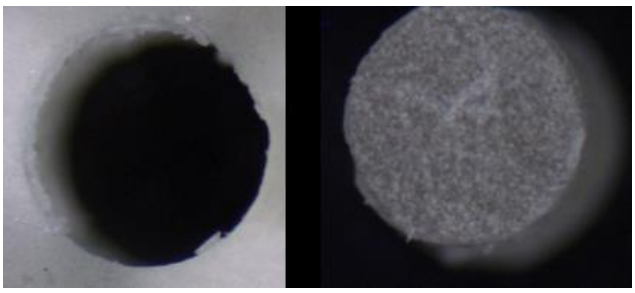


Figure148. Apical side of group8 sample4 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

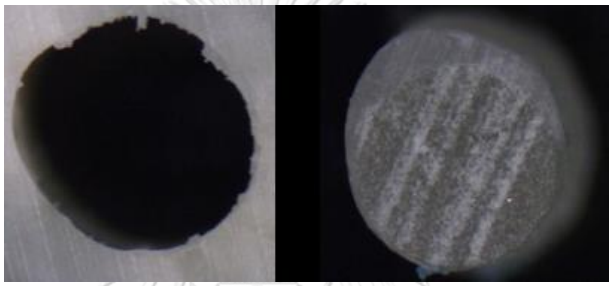


Figure149. Cervical side of group8 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

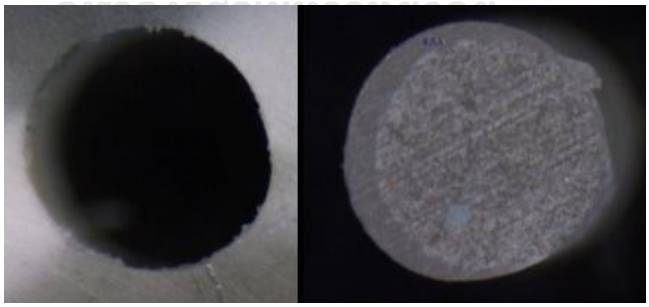


Figure150. Apical side of group8 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

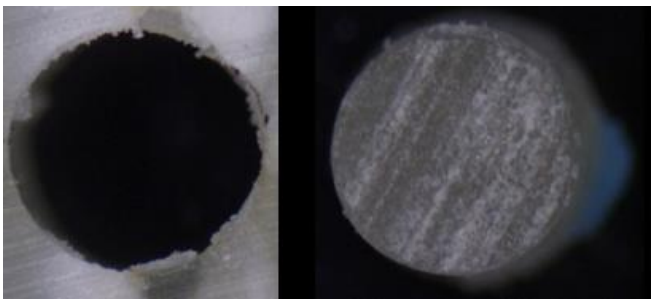


Figure151. Cervical side of group8 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

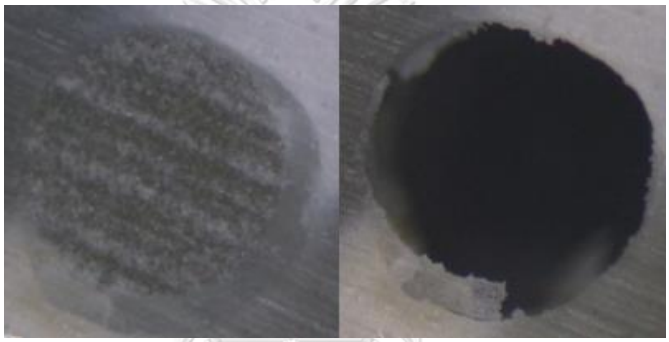


Figure152. Apical side of group8 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (before push out bond strength test (left), after push out bond strength test (*right*))

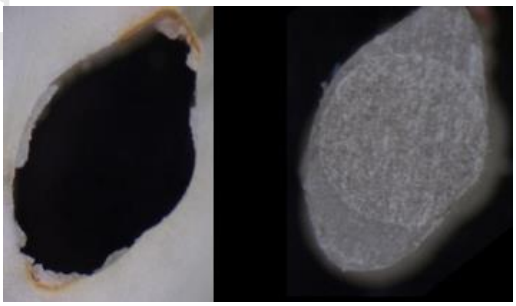


Figure153. Cervical side of group8 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

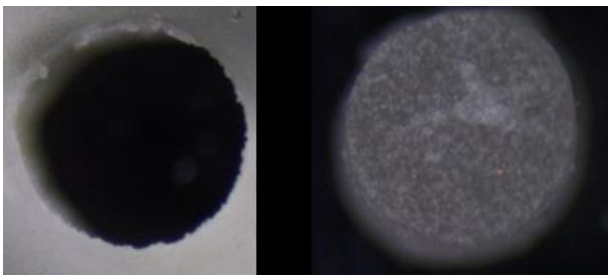


Figure154. Apical side of group8 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

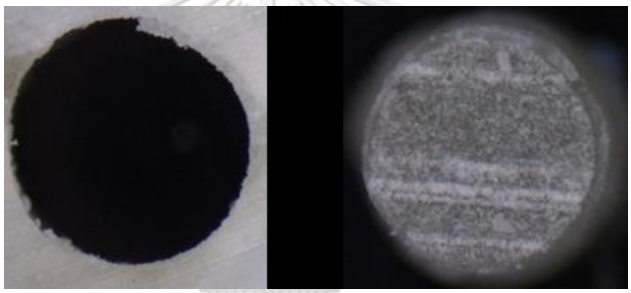


Figure155. Cervical side of group8 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

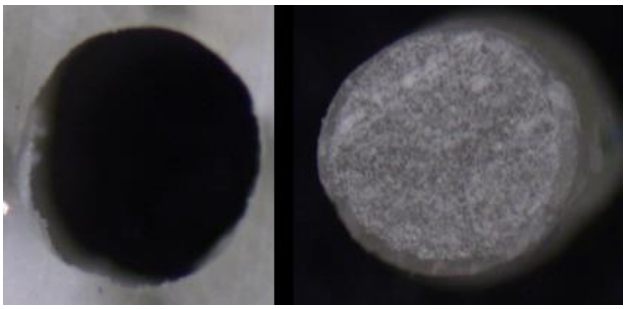


Figure156. Apical side of group8 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

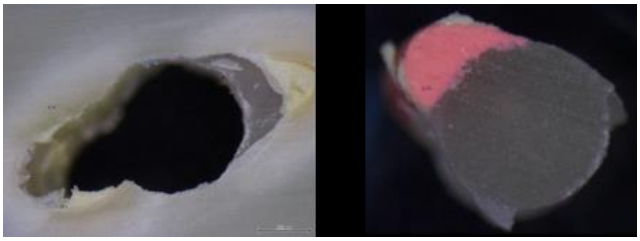


Figure157. Cervical side of group8 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

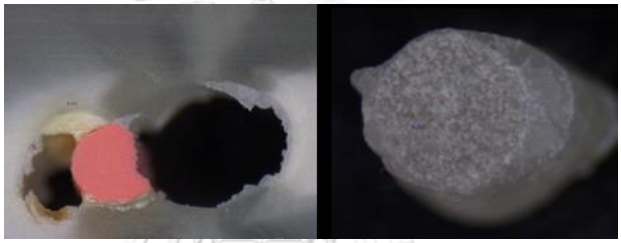


Figure158. Apical side of group8 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

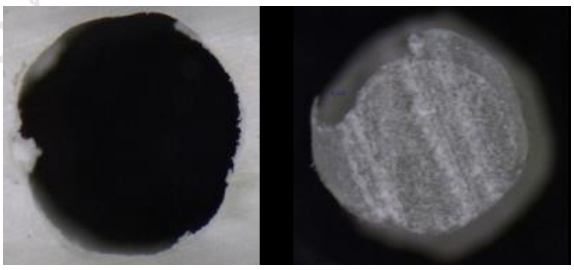


Figure159. Cervical side of group8 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

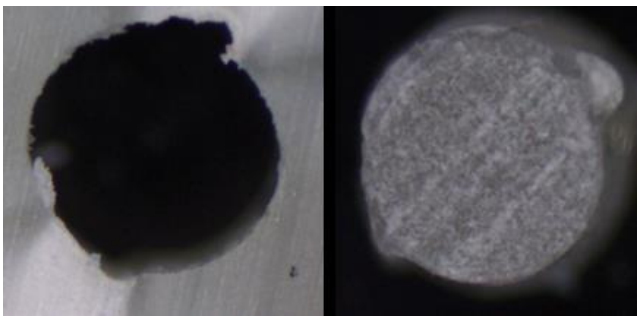


Figure160. Apical side of group8 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

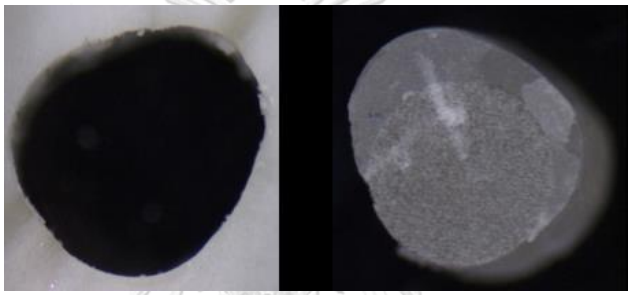


Figure161. Cervical side of group9 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

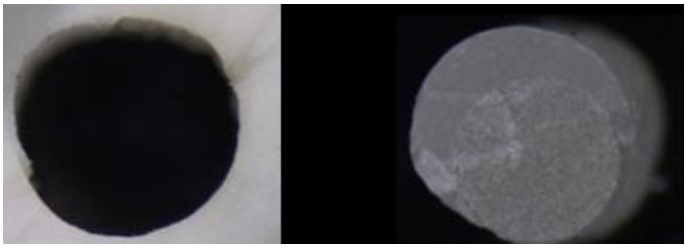


Figure162. Apical side of group9 sample1 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

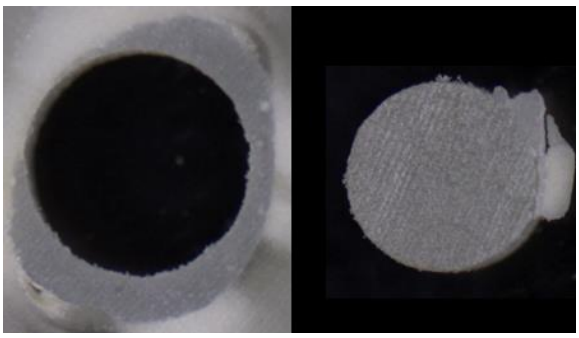


Figure163. Cervical side of group9 sample2 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

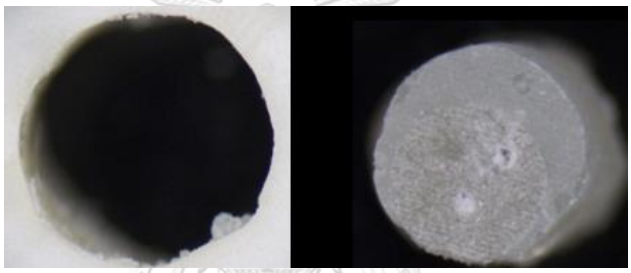


Figure164. Apical side of group9 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

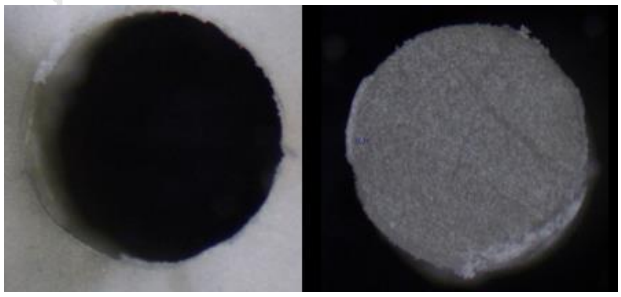


Figure165. Cervical side of group9 sample3 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

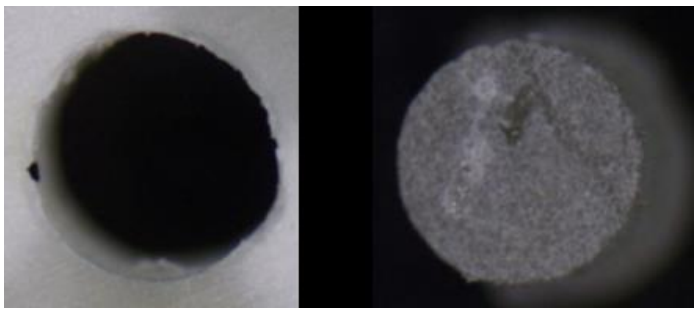


Figure166. Apical side of group9 sample3 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

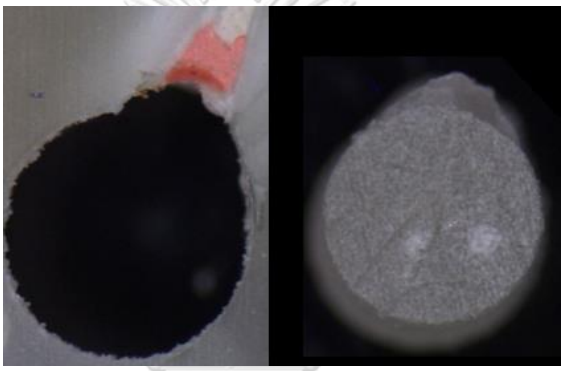


Figure167. Cervical side of group9 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

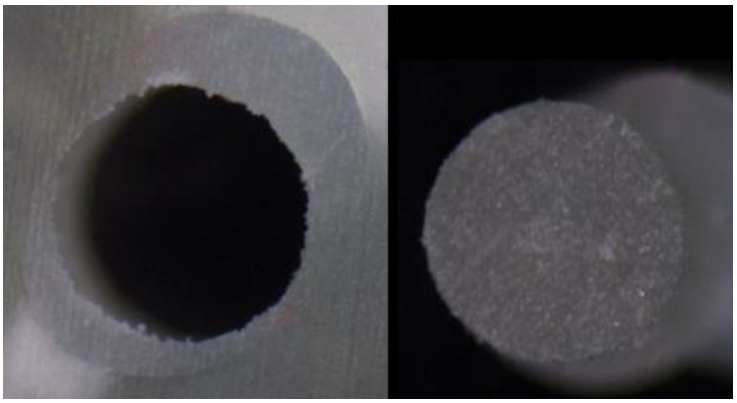


Figure168. Apical side of group9 sample4 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

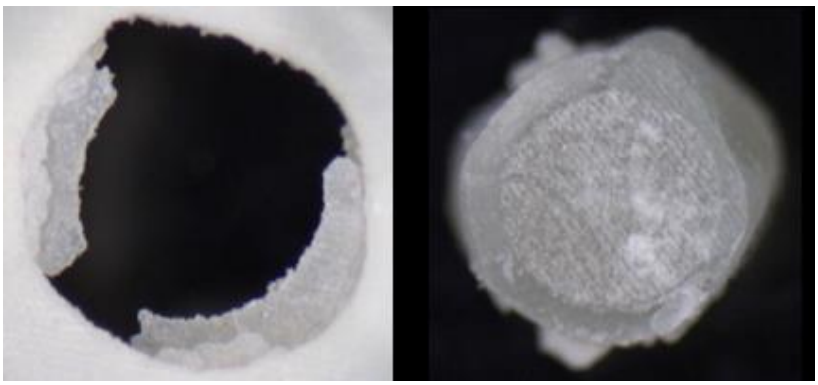


Figure169. Cervical side of group9 sample5 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

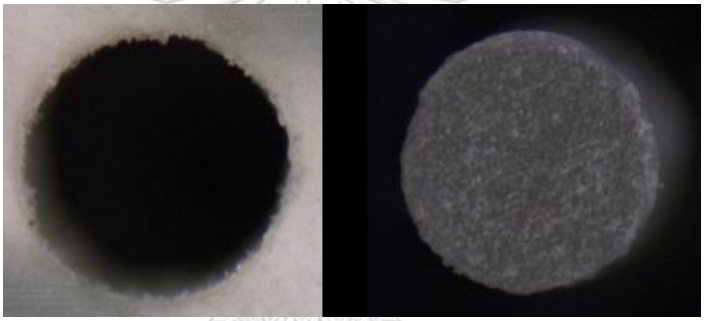


Figure170. Apical side of group9 sample5 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

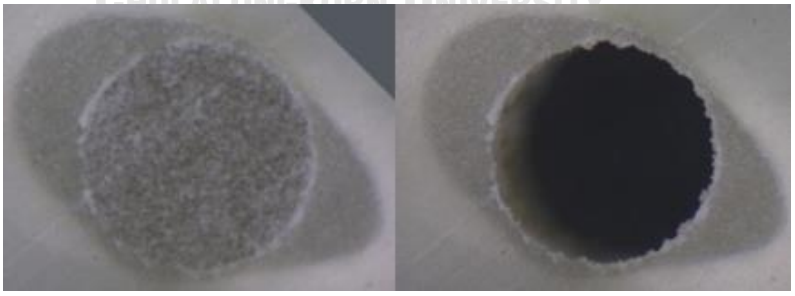


Figure171. Cervical side of group9 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

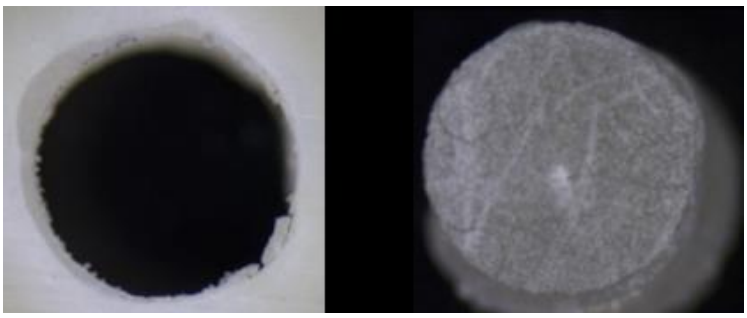


Figure172. Apical side of group9 sample6 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

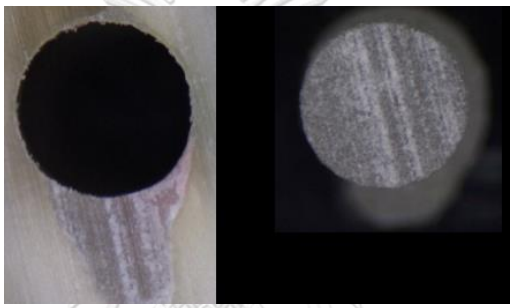


Figure173. Cervical side of group9 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

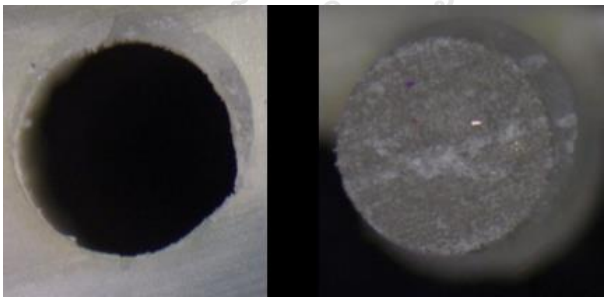


Figure174. Apical side of group9 sample7 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

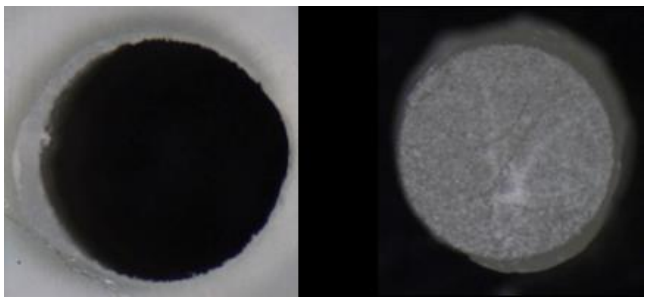


Figure175. Cervical side of group9 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

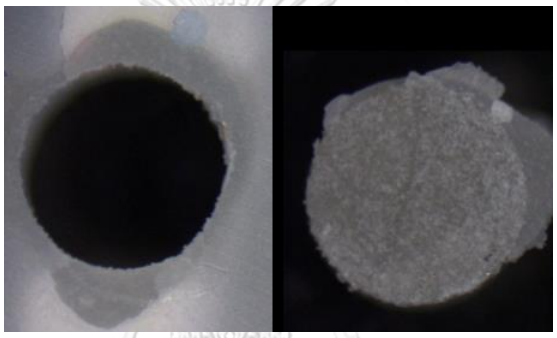


Figure176. Apical side of group9 sample8 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

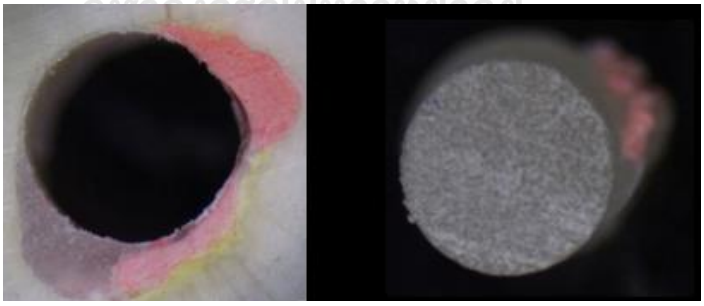


Figure177. Cervical side of group9 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

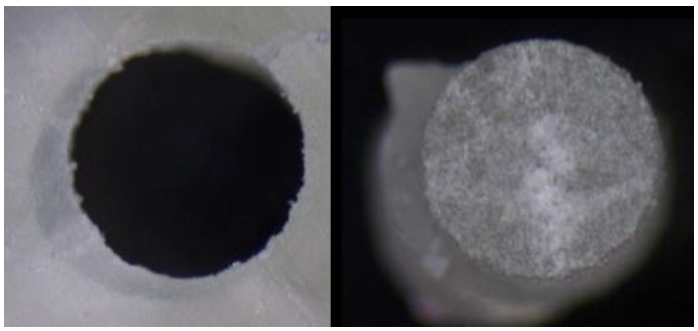


Figure178. Apical side of group9 sample9 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

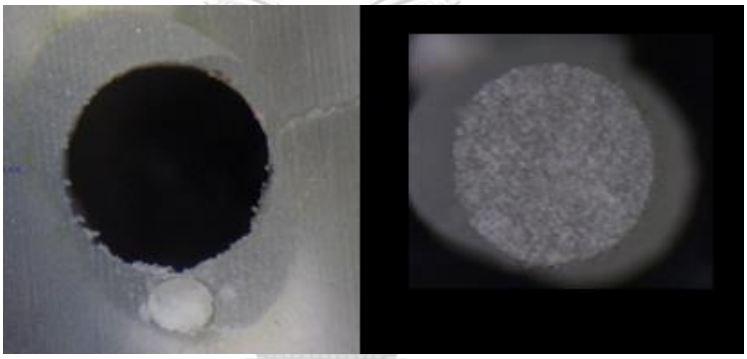


Figure179. Cervical side of group9 sample10 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

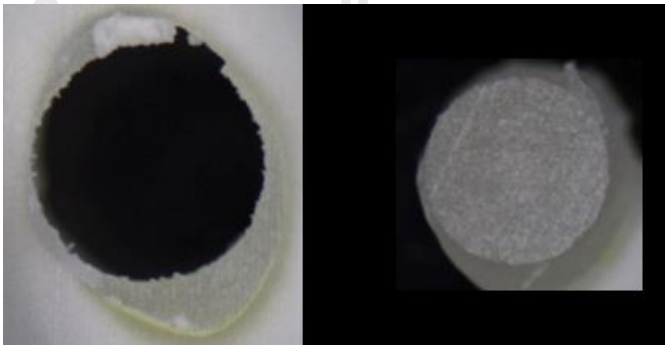


Figure180. Apical side of group9 sample10 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

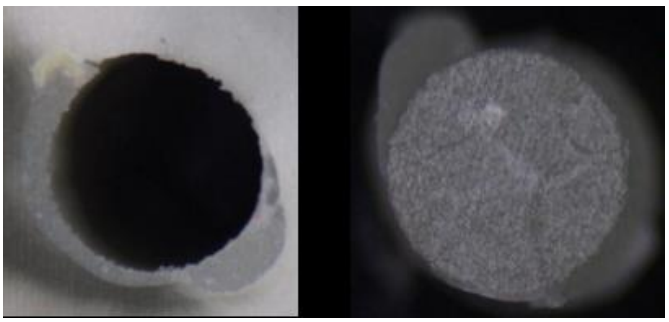


Figure181. Cervical side of group10 sample1 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

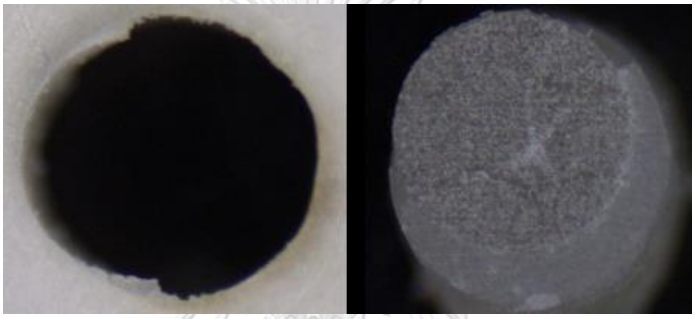


Figure182. Apical side of group10 sample1 shown mixed failure analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

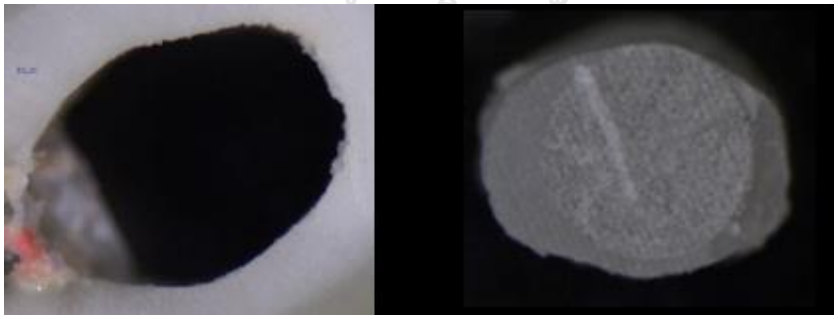


Figure183. Cervical side of group10 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

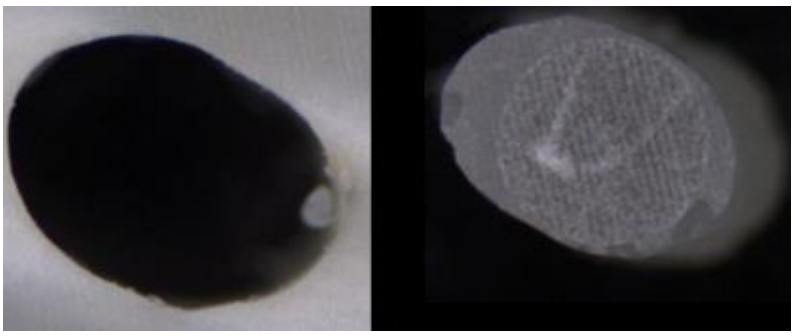


Figure184. Apical side of group10 sample2 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

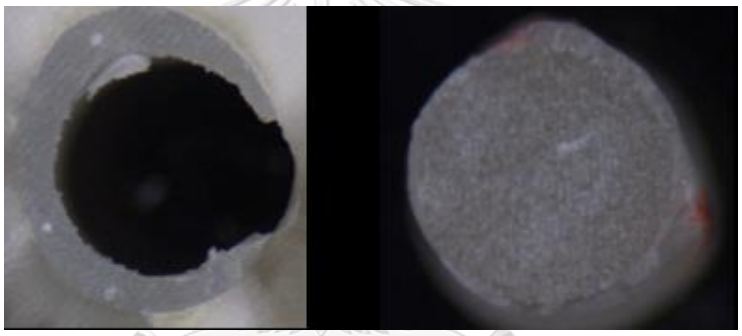


Figure185. Cervical side of group10 sample3 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

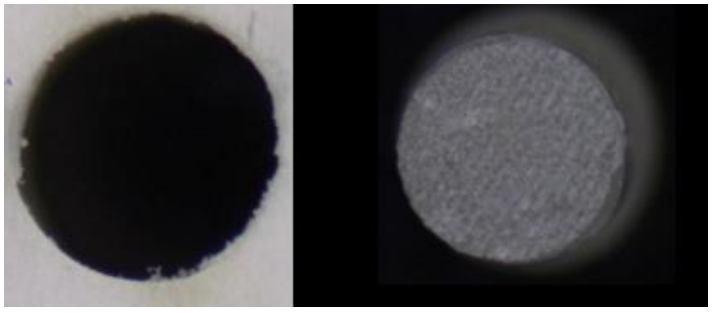


Figure186. Apical side of group10 sample3 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

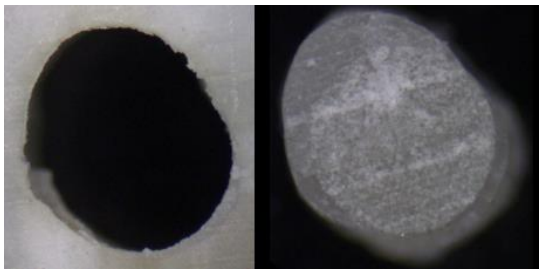


Figure187. Cervical side of group10 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

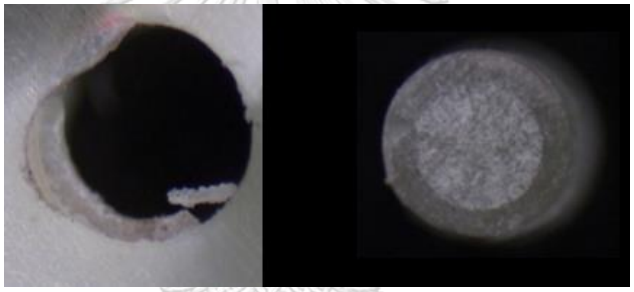


Figure188. Apical side of group10 sample4 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

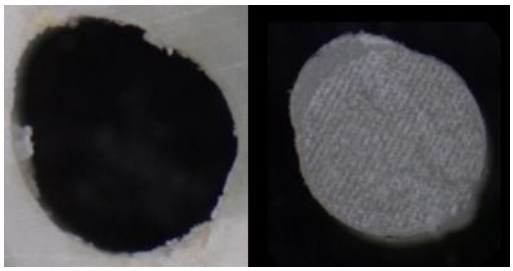


Figure189. Cervical side of group10 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

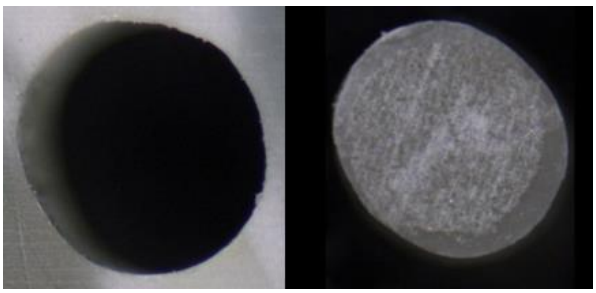


Figure190. Apical side of group10 sample5 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

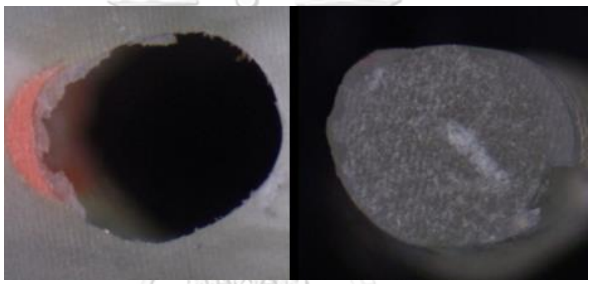


Figure191. Cervical side of group10 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

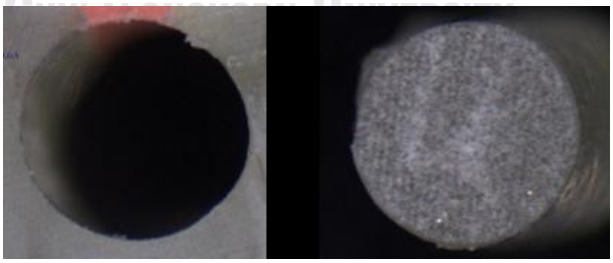


Figure192. Apical side of group10 sample6 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

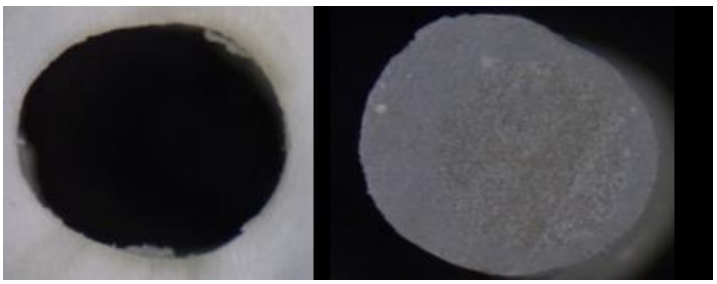


Figure193. Cervical side of group10 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

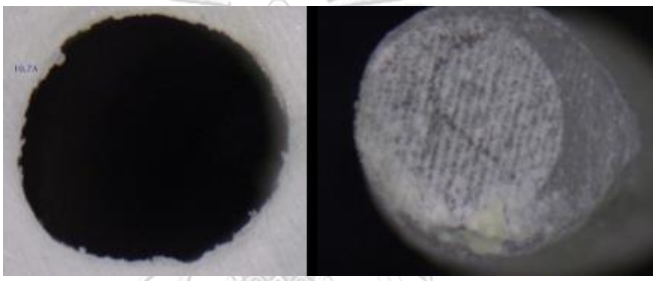


Figure194. Apical side of group10 sample7 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

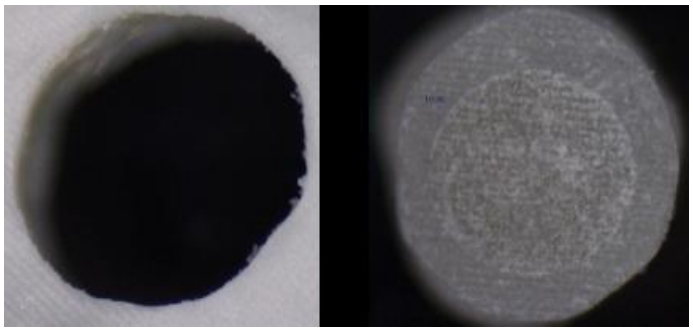


Figure195. Cervical side of group10 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

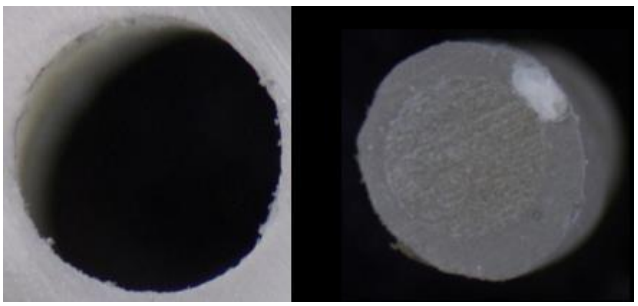


Figure196. Apical side of group10 sample8 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

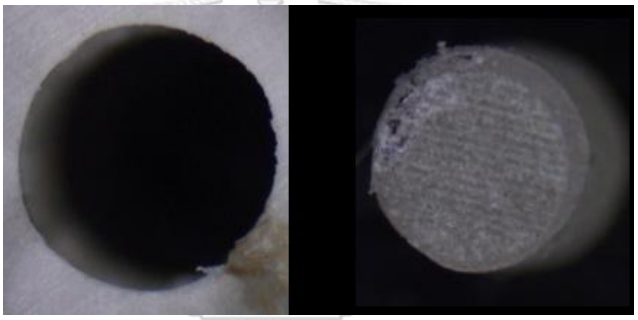


Figure197. Cervical side of group10 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

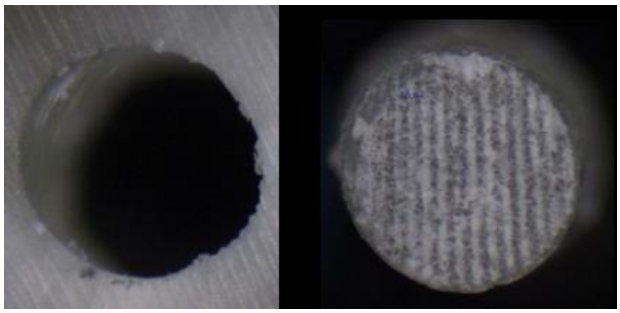


Figure198. Apical side of group10 sample9 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

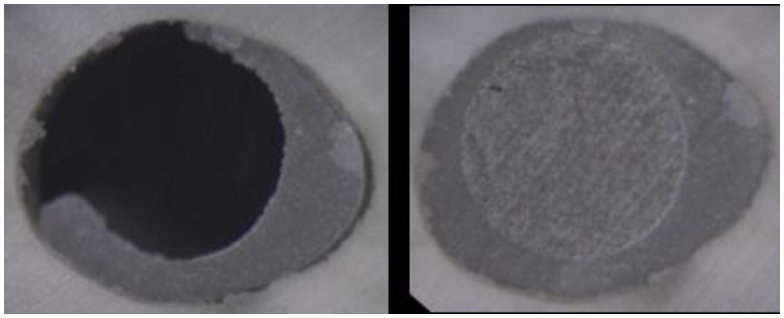


Figure199. Cervical side of group10 sample10 shown adhesive failure between post and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

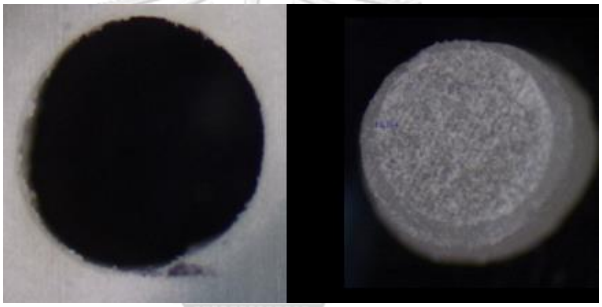


Figure200. Apical side of group10 sample10 shown adhesive failure between intra-radicular dentin and cement analyzed under Stereomicroscope at magnification of 45 (teeth after push out bond strength test (left), post after push out bond strength test (*right*))

VITA

Education

- 2014 DDS (Chulalongkorn University, Thailand)

- 2015-2018 Currently studying for a Master's Degree at Esthetic, Restorative and Implant Dentistry (Chulalongkorn University, Thailand)

- 2016 Certificate in Advanced Implantology (UCLA at Los Angeles, USA)