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Original research

EFFECT OF TRIBOCHEMICAL SURFACE TREATMENT TECHNIQUE ON THE PUSH-OUT BOND STRENGTH OF NOVEL CAD/CAM POST RESTORATIONS

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ABSTRACT

Objectives: The purpose of this study was to investigate the effect of tribochemical surface treatment (TBC) on the push-out bond strength (PBS) of novel CAD/CAM post materials to root canal dentin.

Materials and Methods: Fifty-two freshly extracted human maxillary central incisors were selected and endodontically treated. The teeth were randomly divided into 7 groups according to the post material used: fiber-reinforced composite post as control (FRC), zirconia (ZR), lithium disilicate (LDS), zirconia-reinforced lithium silicate (ZLS), nano-ceramic (RMC_CE), nanoparticle-filled (RMC_LU), and polymer-infiltrated-ceramic (RMC_EN). Then the posts, except FRC, were randomly assigned into two sub-groups according to the surface treatment technique used: Control (no treatment), TBC (CoJet). Following post space preparation, posts were cemented with dual-cure self-adhesive resin cement. A total of 156 sections were obtained (n=12), 3 sections on each root of the tooth. The PBS test was performed for each slice and the results were analyzed by using two-way ANOVA and Tukey HSD tests (α=0.05). The fracture modes were examined.

Results: The lowest PBS values were obtained for ZR post groups that untreated (17.24±1.33 MPa) and tribochemical coated (23.09±2.16 MPa) ($p<0.05$). The highest PBS values were obtained for untreated RMC_CE (42.45±2.42 MPa) and RMC_LU (45.22±2.32 MPa) groups ($p=0.215$) and, tribochemical coated RMC_CE (43.55±2.63 MPa) and RMC_LU (45.38±2.59 MPa) groups ($p=0.821$). Significant differences were observed between the remaining post groups ($p<0.05$). Tbc has been significantly increased the PBS values of LDS, ZLS, and ZR post groups ($p<0.05$). Adhesive failure was the most common failure mode. (n=78).

Conclusion: The results of this study proved that the PBS values of the CAD/CAM RMC post groups were higher than the FRC, ZR, LDS, and ZLS post groups, and TBC increased the PBS values of all CAD/CAM post groups.

Keywords: CAD-CAM, post-restorations, push-out bond strength, surface treatment.

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INTRODUCTION

Intracanal post-and-core restorations are required to ensure long-term restorative success in endodontically treated teeth where more than 50% of the coronal structure is damaged.[1] Post systems can be classified as cast, prefabricated, and milled according to the technique used.[2] Cast or prefabricated metallic posts have been used for decades. However, metal-free post materials have become more common due to the increasing esthetic demands of the patients.[3] Prefabricated fiber-reinforced composite (FRC) post materials show an elastic modulus (about 20 GPa) similar to dentine (about 18.6 GPa), which reduces the fracture probability of weakened root compared to metal posts.[2,4] In parallel with the development of Computer-Aided Design/Computer-Aided Manufacture (CAD/CAM) technology, various materials are available, such as metal, glass fiber, zirconia, ceramics, resin-composites, and hybrid materials, as post-and-core restorations. Zirconia (Y-TZP) materials are popular for post restorations especially in the anterior region due to aesthetic reasons instead of metallic posts.[5] Besides, they have higher fracture strength, toughness, and chemical stability than FRC post systems.[6-8] Previous studies have reported that the fracture resistance of endodontically treated teeth may be increased by using Y-TZP post restorations by their superior physical and mechanical features.[7,8] However, the higher elasticity modulus of Y-TZP material (about 300 GPa), when compared to the dentin, is the main disadvantage that may cause unfavorable force distribution and root fracture.[9] Another disadvantage of the Y-TZP post is the difficulty in removing it from the root canal when a failure occurs with the indication of retreatment.[6,7] Furthermore, Y-TZP has inadequate bonding capacity to resin-based materials and dentine tissue.[4] Due to these disadvantages, different CAD/CAM restorative materials, especially with lower elasticity modulus than Y-TZP, are investigating for post-and-core restorations in the anterior region.

Lithium disilicate (LDS) glass-ceramic CAD/CAM restorative materials with the elastic modulus of 90-100 GPa have been successfully used in clinics for many years.[10] The proven clinical performance of LDS encourages the manufacturers to development of its modifications such as reinforcing with polycrystalline ceramics. Zirconia-reinforced lithium silicate (ZLS), such as VITA Suprinity (VITAZahnfabrik, Bad Sackingen, Germany), is one of the current commercial examples, which combines the superior characteristics of glass-ceramic and Y-TZP materials. Besides their superior mechanical properties, they have provided exceptional aesthetics results due to their similar optical features with natural dentition and show an elastic modulus of 70 GPa.[6,10]

Recently, the CAD/CAM resin matrix ceramic (RMC) materials, which include the composite resin nano-ceramic (RMC_CE, Cerasmart, GC Dental Products, Tokyo, Japan), nanoparticle-filled ceramic (RMC_LU, Lava Ultimate, 3M ESPE, Seefeld, Germany) and polymer-infiltrated-ceramic-network (RMC_EN, Vita Enamic, Vita Zahnfabrik, Bad Sackingen, Germany), have been developed to combine the positive features of both ceramics and polymers. RMCs have some superiorities compared to ceramic materials such as easier milling and adjustment, similar elasticity modulus to dentin (10~20 GPa), higher fatigue or fracture resistance, fewer crack propagations, better stress distribution, and less wear for opposing teeth.[6,11] While most of these restorative materials are already being used as core material, their performance as a post-and-core restoration has not been evaluated.

In addition to the good mechanical features of the post material, the bonding strength to root dentin is also an important criterion for the post-and-core restorations. The achievement of long-term successful bonding is influenced by various factors, such as the type, shape, size, and surface of posts, adhesive coupling agent, resin cement, and the surface of root dentin.[12] However, there is little information about the currently available CAD/CAM post materials bonding strength to the root dentin. Therefore, in this study, the push-out bond strength (PBS) of post materials (with and without additional surface treatment) to root dentin that fabricated with currently available CAD/CAM restoratives have been evaluated. The null hypothesis of this study was that the PBS of CAD/CAM post restorations would not differ with the type of material and also with additional surface treatments.

MATERIAL AND METHODS

The present study was permitted by the Local Clinical Research Ethics Committee of the Ordu University (#2020/232). The sample size of the PBS test was calculated using a power analysis (G*Power 3.1.9.2, Düsseldorf, Germany) that an alpha error probability of 0.05 and a power of 97.05%. It has been shown by power analysis that 10 samples (effect size = 0.408) were required for each test group.

Fifty-two freshly extracted single-rooted human permanent maxillary incisor teeth with no cracks, caries, restoration, and no shorter roots than 12 mm were selected. All teeth were decoronated 2 mm coronal to the cement-enamel junction using a diamond bur (SWS Dental, İzmir, Turkey) under copious water maintaining root length at 10 mm. The remaining root canals of the tooth were prepared up to size R50 file with the Reciproc system (VDW, Munich, Germany). The root canals were irrigated with 5 mL 5% sodium hypochlorite and 5mL of 17% ethylenediaminetetraacetic acid, between the use of each canal instrument. The final irrigation has been performed with 5 mL distilled water and dried with absorbent paper tips (Reciproc Paper Point, VDW, Munich, Germany). The root canals were obturated with a gutta-percha (VDW, Munich, Germany) and AH Plus sealer (Dentsply, Konstanz, Germany) via lateral condensation. The access openings of the canals were also sealed with a temporary filling material (Cavit, 3M ESPE, Neuss, Germany) and all specimens were kept in 100% humidification for 7 days at 37°C. The filling material in root canals has been removed with a Peeso Reamer canal drill set up to size #3 (Mani, ZZlinker, Shingai), leaving only a 3-mm apical root filling intact. The final shapes of the root canals were enlarged with the FRC post systems drill set (Cytec Blanco, Hahnenkratt GmbH, Königsbach, Germany) up to a blue drill with a diameter of 1.8 mm at the coronal part. Then, the root canals were irrigated with 5 mL distilled water and dried.

The FRC post with a diameter of 1.8 mm at the coronal part and a length of 20 mm has been shortened to the length of 10 mm from the coronal part and served as the control group. One of the FRC post specimens has been digitally scanned using a dental lab scanner (Ceramill map600, Amann Girrbach, Koblach, Austria), and the digital post design performed using CAD software (Ceramill Mind, Amann Girrbach, Koblach, Austria) for the fabrication of other post specimens. Then the CAD/CAM post specimens have been manufactured using a milling machine (Ceramill Motion 2, Amann Girrbach, Koblach, Austria) from the CAD/CAM blocks listed in Table 1.

Table 1. The post materials (composition), manufacturers, and lot numbers of the test groups.

Group	Material (Composition)	Manufacturer	Lot Number
FRC	Cytec Blanco; glass fiber post system (60% glass fiber, 40% epoxy resin matrix)	Hahnenrratt GmBH,	027656
LDS	IPS e.max CAD; lithium disilicate-reinforced glass-ceramic block (SiO_2-Li_2O-K_2O-MgO-P_2O_5- Al_2O_3)	Ivoclar Vivadent	U49077
ZLS	Vita Suprinity; zirconia-reinforced lithium silicate glass-ceramic (SiO_2-Li_2O-K_2O-P_2O_5-Al_2O_3-ZrO_2-CeO_2)	Vita Zahnfabrick	47610
ZR	In Coris TZI; high-translucent monolithic zirconia block (99% ZrO_2-HfO_2-Y_2O_3, <.5% Al_2O_3, <.5 %SiO_2)	Sirona Dental Systems	2014211887
RMC_CE	Cerasmart; composite resin nano-ceramic RMC block (71 wt% SiO_2-barium glass, 29 wt% UDMA, DMA, Bis-MEPP)	GC Dental Products	1410071
RMC_LU	Lava Ultimate; nanoparticle-filled RMC block (80 wt% SiO_2-ZiO_2, 20 wt% Bis-GMA, UDMA, Bis-EMA, TEGDMA)	3M ESPE	3314A2
RMC_EN	Vita Enamic; polymer-infiltrated-ceramic-network RMC block (86 wt% SiO_2-Al_2O_3-Na_2O-K_2O-B_2O_3-ZrO_2-CaO, 14 wt% UDMA, TEGDMA)	Vita Zahnfabrick	68251

UDMA: Urethane dimethacrylate; DMA: Dodecyl dimethacrylate; Bis-MEPP: 2, 2-Bis (4-methyacryloxypolyethoxyphenyl) propane; Bis-GMA: Bisphenol-A-glycidyl methacrylate; Bis-EMA: Bisphenol-A-ethoxylate glycidyl methacrylate; TEGDMA: Triethylene glycol dimethacrylate.

After the milled post specimens' dimensions have been controlled, the LDS and ZLS post specimens crystallized, and the Y-TZP post specimens (ZR) sintered according to the manufacturer's introductions. Then, each post group was randomly divided into two subgroups according to surface treatment procedures; no further treatment was applied, and the tribochemical silica-coated (TBC). TBC was not applied to the FRC post system that was selected as the control group. The TBC CAD/CAM post specimens have been tribochemical coated with silica-modified 30 µm aluminum oxide (SiO_x-Al_2O_3) (Cojet Sand, 3M ESPE, Seefeld, Germany) under 2.5 bar pressure for 15 seconds using an intraoral sandblaster (Prophyflex 3, KaVo Dental GmbH, Biberach, Germany). A 3 methacryloxypropyltrimethoxysilane coupling agent (3M Espe Sil, Minnesota, USA) was applied onto the surface of all CAD/CAM post specimens and waited for 5 min to dry according to the manufacturer's recommendations.

A self-etch bonding agent (Clearfil SE Bond 2, Kuraray Noritake Dental, Okayama, Japan) was applied onto the root dentin of each group according to the manufacturers' instructions [Clearfil SE Bond 2 Primer applied using the micro brush (20 s) and dried with mild air (5 s), the mixture of Clearfill SE Bond 2 Bond and Clearfil DC Activator applied using the micro brush and dried with mild air]. A dual-cure self-adhesive resin cement (Panavia SA Plus, Kuraray Noritake Dental, Tokyo, Japan) has been loaded into the root canal using automix tips according to the manufacturers' instructions and the post specimens were quickly seated into the root canals under finger pressure. The excess cement was partially light-cured for 5 seconds with an LED light-curing unit (Valo Led, Ultradent, South Jordan, USA) at 1000 mW/cm^2 for easy removal, and the remainder light-cured for 40 seconds top of the post. All specimens were stored at 100% humidity in an incubator at 37°C for 24 hours. Then, the roots of the tooth were perpendicularly embedded into an auto-polymerizing acrylic resin block (Panacryl, Arma Dental, Istanbul, Turkey) using a cylindrical Teflon mold (Ø=25 mm, h = 20 mm). The acrylic blocks horizontally cut into six slices using a precision cutting machine (Mecatome T180, Presi Metallography, Eybens, France) under copious water to obtain 1-mm sections. The 2nd, 4th, and 6th slices were selected for the PBS test (N=156, n=12) and the apical side of each slice was marked.

Each root slice has been mounted on a universal testing device (AGS X, Shimadzu Corp., Tokyo, Japan) and subjected to increasing load at a crosshead speed of 0.5 mm/min in the apical-coronal direction until failure occurred. A load of failure was recorded in Newton (N), and the PBS values were converted to MegaPascal (MPa) by dividing the failure load to the bonded area (mm^2). The total bonding area was calculated as $(\pi(r1 - r2)\sqrt{(r1 + r2)^2 \times h^2})$, where π: is the constant 3.14, r1: is the radius of the post from the upper part of the specimen, r2: is the radius of the post from the lower part of the specimen, and h: is the height of the specimen. The mode of failure was assessed at x25 magnification in a stereomicroscope (Leica SP1600, Leica, Wetzlar, Germany), classified into three groups; adhesive (between the post and the cement or the dentin and the cement), cohesive (within the resin cement), and mixed failure (a mixture of adhesive and cohesive).

According to Leneve's homogeneity test, the groups were normally distributed (F = 1.353, p = 0.196). The PBS results were evaluated with the two-way analysis of variance (ANOVA) for descriptive statistics and the effects of independent variables (surface treatment, post type, and their interaction). The mean PBS values (MPa) of the post groups were multiply compared by using the Tukey HSD test (α = 0.05). The pairwise comparisons of the same surface treatment applied post type groups were performed by using the Paired Sample t-test. The PBS values of each post group have been allocated for coronal, middle, and apical regions and these subgroups were multiply compared by using the Tamhane's test. All the computational work was performed using SPSS 20.0 V statistical software (SPSS Inc., Chicago, IL) and significance was evaluated at $p < 0.05$ for all tests.

RESULTS

According to the 2-way ANOVA results post type, surface treatment, and their interactions were significant on the PBS values ($p < 0.001$) (Table 2).

Table 2. Two-way ANOVA results of PBS values.

Source	SS	df	MS	F	P
Post Type (A)	11531.320	6	1921.887	327.830	.000
Surface Treatment (B)	379.600	1	379.600	64.751	.000
A X B	222.682	5	44.536	7.597	.000
Error	838.330	143	5.862		
Total	198737.887	156			

*p<0.05 indicates a significant difference.

The mean, standard deviation (SD) of PBS values (MPa) of test groups, the Tukey HSD multiple comparisons, and pairwise comparisons results according to the Paired Sample t-test are presented in Table 3.

Table 3. The mean, standard deviation (SD) of PBS values (MPa) of test groups with statistical summaries.

Surface Treatment / Post Type	N	None	TBC	t-Test*
FRC	12	34.85 (2.41)^{d}	-	
LDS	12	30.39 (2.1)^{c}	34.77 (3.11)^{d}	P<.001
ZLS	12	23.46 (2.2)^{b}	30.09 (2.46)^{c}	P<.001
ZR	12	17.24 (1.33)^{a}	23.09 (2.16)^{b}	P<.001
RMC_CE	12	42.45 (2.42)^{fg}	43.55 (2.63)^{g}	P=.300
RMC_LU	12	45.22 (2.32)^{g}	45.38 (2.59)^{g}	P=.877
RMC_EN	12	38.39 (2.38)^{e}	39.77 (2.92)^{ef}	P=.218

The Tukey HSD comparisons of PBS values (MPa) for the post types in same surface treatment application groups are presented as superscripts and significant differences indicate with different letters (p<0.05). *The pairwise comparisons of PBS values (MPa) for the same surface treatment applied post type groups according to the Paired Sample t-test (p<0.05).

The lowest PBS values were obtained for the ZR post group not only for untreated (17.24 ± 1.33 MPa) but also TBC surface treatment applied (23.09 ± 2.16 MPa) groups (p < 0.05). When untreated post groups were multiply compared; the highest PBS results were obtained for RMC_CE (42.45 ± 2.42 MPa) and RMC_LU (45.22 ± 2.32 MPa) groups with no significant difference (p = 0.215). Significant differences were also observed between the remaining post groups (p<0.05). When TBC surface treatment applied post groups were multiply compared; similarly the highest PBS results were obtained for RMC_CE (43.55 ± 2.63 MPa) and RMC_LU (45.38 ± 2.59 MPa) groups with no significant difference (p = 0.821). Also, significant differences were observed between the remaining post groups (p < 0.05).

While the additional surface treatment with TBC has been increased the PBS values of all CAD/CAM post groups, these differences were statistically significant for LDS, ZLS, and ZR post type groups according to the pairwise comparisons with Paired Sample t-test (p < 0.05).

According to the multiple comparisons of root regions for each post group, the PBS of the coronal region (18.70~47.74 MPa) was significantly higher than the apical region (16.39 ~ 43.42 MPa) for each post group (p<0.05). A significant difference has been detected between the PBS values of coronal and middle regions for untreated ZR and RMC_LU; between the PBS values of middle and apical regions for untreated RMC_CE and RMC_EN and TBC surface treatment applied ZR, ZLS, RMC_LU, RMC_EN post groups (p< 0.05) (Fig. 1).

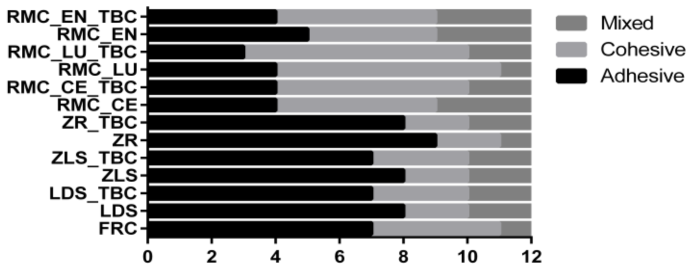

Figure 1. The mean (±SD) of PBS values of root region groups. *Significant differences between the related root region according to the Tamhane's test (p<0.05).

The results of the failure modes of the test groups were presented in Table 4.

Table 4. Failure modes of experimental groups

Groups	Adhesive	Mixed	Cohesive	Total
FRC	7	1	4	12
LDS	8	2	2	12
LDS_TBC	7	2	3	12
ZLS	8	2	2	12
ZLS _TBC	7	2	3	12
ZR	9	1	2	12
ZR_TBC	8	2	2	12
RMC_CE	4	3	5	12
RMC_CE_TBC	4	2	6	12
RMC_LU	4	1	7	12
RMC_LU_TBC	3	2	7	12
RMC_EN	5	3	4	12
RMC_EN_TBC	4	3	5	12
Total	**78**	**26**	**52**	**156**

The most commonly observed failure mode was an adhesive failure (n = 78), followed by cohesive (n = 52) and mix failure (n = 26).

DISCUSSION

In this study, endodontically treated maxillary incisors were restored with FRC and various novel CAD/CAM materials, and the PBS and fracture modes were evaluated. According to the results of the present study, the post type, and also the surface treatment has been affected the PBS values. Therefore, the null hypothesis was rejected.

The developments and researches about the ideal post-restoration material are also focused on the novel CAD/CAM restorative materials. Therefore, the PBS of post restorations made of novel CAD/CAM materials has been evaluated in the present study. The FRC post systems are commonly used for the restoration of endodontically treated, considering their restrictions, thus served as the control group of the present study.

The untreated RMC post groups showed statistically higher PBS values than the FRC post group. The recently introduced RMC materials have not only the physical and mechanical advantages of ceramics but also improved flexural properties and the higher bonding capacity of composite resins.[11,13] RMC materials have a composite structure that consists of both organic matrix and highly filled ceramic particles with a bridgework silane agent.[13,14] The higher PBS results of RMC materials in the present study may be explained by their mechanical advantages and improved bonding performance. The RMC_EN showed the lowest PBS values compared to RMC_CE and RMC_LU post groups, and no significant differences were obtained between RMC_CE and RMC_LU. The effect of different surface treatments on the bond strength of CAD/CAM fabricated RMC post systems to root canal dentin has been evaluated in a previous study and reported that although no significant difference was observed between post types, while the Cerasmart post group achieved the highest bond strength values (12.54±3.08 MPa), the Vita Enamic post group showed the lowest bond strength values (9.71±1.67 MPa). It has been attributed to the variations in the chemical composition and the inorganic filler ratio of these RMC materials in this previous study.[15] In the present study, the RMC_EN has the highest ratio (86 vol%) of the inorganic filler (porous feldspathic ceramic) contain that strengthened by an interpenetrating polymer matrix when compared to the ratio of RMC_LU (80% by weight) and RMC_CE (71 vol%).[13]

The untreated ZR, ZLS, and LDS post groups have statistically lower PBS values than the FRC post group. On the other hand, the untreated ZR post group has the lowest PBS value (17.24±1.33 MPa) among the all tested post groups. This result could be attributed to the lack of a silica-containing and glass phase of zirconia restorative material that the untreated high crystalline ceramics may not enough bonding performance to resin-based materials. In agreement with this result, the untreated LDS post group showed statistically higher PBS values than the ZLS post group in this study. So, it could be concluded from this result that the increased crystalline content (8-12%), which improves the mechanical behavior of the material, may also weaken the bonding performance of lithium disilicate ceramic materials.[16]

The airborne particle abrasion (sandblasting) with Al_2O_3 particles enhances the bond strength of ceramics by increasing the surface roughness, wettability, and surface energy. Furthermore, the tribochemical silica coating techniques with SiO_x - Al_2O_3 particles, such as the Cojet system (3M ESPE, Seefeld, Germany), not only change the surface morphology but also enhances the chemical connection with bonding agent with the penetrated silica particles and further silane application on the ceramic surface.[17] On the other hand, some studies showed that RMCs should be effectively bonded to the resin-based materials after the hydrofluoric acid (HF) etching technique.[18-21] Since HF etching was declared questionable by the manufacturers of RMC, the TBC surface treatment technique with 30 µm SiOx - Al_2O_3 particles were used for all tested CAD/CAM post materials in this study. After the TBC surface treatment procedure, the silane coupling agents are commonly used to gain additional chemical retention with silica-coated alumina particles which may be buried into the ceramic surface.[22] As expected, the TBC post surface treatment was increased the PBS results of all CAD/CAM post groups. However, this increase was only significant for the LDS, ZLS, and ZR post groups, compared to the untreated ones. According to this result, which was also proven in many previous studies,[23,24] the TBC followed by the silanization technique may significantly increase the bond strength of ceramics by increasing the silica content on the materials, especially for high crystalline ceramics. The RMC materials with integrated polymer components do not require additional TBC surface treatment application, and silanization with a 3-methacryloxypropyltrimethoxysilane coupling agent may be enough to obtain sufficient bond strength results.

In the present study, the PBS values for all groups were significantly higher for the coronal region than the apical region. This situation depends on the density and distribution of the dentil tubules in different parts of the root. It is known that the dentinal tubules in the coronal region are numerous and larger in diameter than the apical region.[25] It also reduces bond strength in limited access to the apical region.[26]

According to the push-out bond test and failure mode analysis performed in the present study, an adhesive failure between the resin cement and the post interface was the most frequent type of failure reported for LDS, ZLS, and ZR post groups. Cohesive failure within the resin cement was the most frequent type of failure reported for RMC post groups. For the FRC post, the most frequent type of failure was adhesive failure between the resin cement and dentine (Fig. 1).

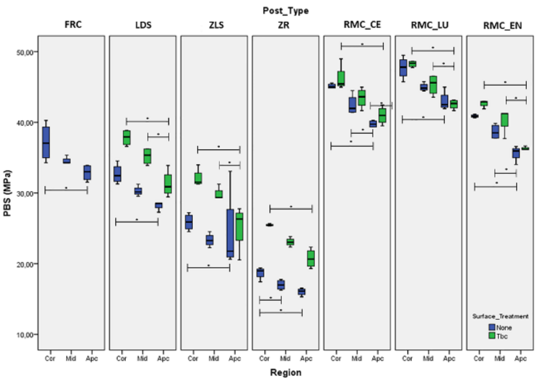

Figure 2. The failure mode of the debonded specimens.

The modes of failures observed in the present study reveal that the surface adhesion properties of the high-density ceramic post systems may be weaker than those of FRC and RMCs post materials, leading to more failures at the interface level between the post and cement.

Various test methods such as microtensile, pull-out and push-out tests can be used to evaluate the bond strength of post restorations to root dentin[27-29].The microtensile test has been highly associated with large data distributions as well as numerous premature failures during sample preparation which is complex and difficult.[30,31] In the pull-out test, regional differences have no effect on the results, as enable the evaluation of the entire root length. Possible failures in the specimen preparation phase can be avoided by not sectioning post cemented roots.[32] However, the bond strength values of the root regions cannot be compared in this test method and a large number of samples are needed. Unlike, in the push-out test it is possible to analyze the cervical, middle, and apical root regions.[29] It is easy to prepare samples and therefore has a low standard deviation rate. The push-out test can provide a more accurate and better estimation of bonding strength because failure occurs in parallel to the bonding area as in oral condition.[31,33] Because of the mentioned advantages, the bond strength of tested post materials to the root dentine had been evaluated using the push-out test in the present study.

The present study has some limitations; PBS of CAD/CAM made post restorations using six different ceramic materials with and without additional surface treatment had been evaluated and compared with FRC posts. The bonding performance of post restorations may significantly improve by using various micromechanical and chemical surface conditioning techniques.[12,15,22] All of the post restorations had been designed in a standard conical shape, smoothbore texture, and a coronal diameter of 1.8 mm. However, the long-term performance of CAD/CAM made post restorations, in various dimensions, design and material parameters may be further investigated in future studies after different surface treatments such as acidic solutions, laser, or plasma applications. In the present study, a chairside type (Cojet) of TBC treatment with 30 µm SiOx - Al_2O_3 particles was used, but a laboratory type TBC treatments (Rocatech or Rocatech Plus) with 50 - 110 µm SiOx-Al_2O_3 particles in various application parameters should be evaluated in future studies. A dual-polymerized and 10-methacryloxydecyl dihydrogen phosphate (MDP) containing bonding agent, and resin cement systems that have been declared with superior bonding results[34,35], were used in the present study. However, other bonding agents and resin cement systems with different application procedures and monomer contain should be evaluated after dynamic, thermal, and hydraulic aging conditions in future studies.

CONCLUSIONS

Within the limitation of this study, the following conclusion should be drawn;

1. The CAD/CAM made RMC post restorations have more sufficient bond strength results to the root dentine than FRC post restorations.

2. Additional TBC surface treatment application is not required for RMC post materials.
3. While the PBS results of LDS, ZLS, and ZR post restorations may be increased with TBC surface treatment, their PBS results were lower than the FRC post group.

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CONFLICT OF INTEREST
The authors declare that they have no competing interest.

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