

ARTICLE / INVESTIGACIÓN

Effect of push-out bond strength of a conventional and a bulk-fill composite resin as a biotechnological technique to root dentin of primary anterior teeth

Shahram Mosharrafian¹, Pegah Khazaei², Pegah Rahbar³, Zahra Hosseini⁴*

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¹ Department of Pediatric Dentistry, Tehran University of Medical Sciences, Tehran, Iran.² University of California, Los Angeles, School of Dentistry.³ Dentist, Department of Pediatric Dentistry, Ahvaz Jundishapur University of Medical Sciences, Khuzestan, Iran.⁴ Kermanshah University of Medical Sciences, Kermanshah, Iran.

Corresponding author: zahrahosseini69@gmail.com.

Abstract: This study aimed to compare the push-out bond strength of a bulk-fill and a conventional composite resin to root dentin of primary anterior teeth using a 7th-generation dentin bonding agent. This in vitro study evaluated 24 primary anterior teeth randomly divided into two groups: Filtek P60 conventional and Filtek bulk-fill composite resins. Single Bond Universal adhesive was used for bonding. After filling the coronal part of the canal with composite resin, the teeth were mounted in acrylic resin and sliced to obtain a 1-mm-thick section of each root. Next, the sections underwent the push-out bond strength test. After determining the push-out bond strength, the failure mode was selected under a light microscope at $\times 40$ magnification. The data were analyzed with two-way ANOVA and t-test. The mean push-out bond strength was 13.37 ± 4.40 MPa in the conventional and 5.40 ± 2.91 MPa in the bulk-fill composite resin groups. This difference was statistically significant ($P=0.001$). In the traditional group, 50% of failures were cohesive in the conventional combined resin group, while in the bulk-fill composite resin group, 75% of losses were mixed. Filtek P60 traditional composite resin and Single Bond Universal 7th-generation bonding agent were determined as an appropriate choice for fabricating intracanal composite posts in primary anterior teeth.

Key words: Push-out, Bond strength, Bulk-fill composite resin, Root dentin, Primary anterior teeth.

Introduction

Preserving primary teeth is of utmost importance¹⁻⁵. Early childhood caries (ECC) is a common cause of early immediate tooth loss, which refers to the presence of one or more carious (cavitated or non-cavitated), lost or restored tooth surfaces in any of the primary teeth of a 71-month-old child or younger^{6,7}. Severe ECC refers to any sign of caries in smooth surfaces of the teeth in children under the age of 3. ECC often results in losing a significant portion of tooth structure and pulpal involvement⁸. Therefore, restoration of teeth with ECC remains a challenge in pediatric dentistry. Stainless steel crowns used to be the treatment of choice for such teeth. However, many parents no longer accept them due to their unesthetic appearance.

A suitable restoration for such teeth should restore the primary function while providing favorable esthetics¹⁰. Open-face crowns, polycarbonate crowns, and composite resin restorations have been suggested to treat carious primary teeth¹¹. Composite resin restoration of severely damaged teeth often requires pulpectomy and placement of intracanal post to serve as a retainer¹². In addition, the fabrication of a post and core is imperative to retain and stabilize the composite resin crown and resist masticatory forces¹³. In cases where a small amount of coronal tooth structure remains, restorations with posts often result in a better function than those without a post¹⁴. Several posts can be used for this purpose, such as prefabricated metal posts, fiber-reinforced posts, orthodontic wires, cast posts with retentive grooves, short composite resin posts, and biologic

posts^{15,16}. Considering the physiological root resorption in primary teeth, only the coronal 3 mm of the root should be used to obtain adequate retention and resistance in severely damaged teeth¹⁷. Due to increased demand for esthetics, composite resin and fiber posts are increasingly used for the anterior teeth due to advantages such as optimal corrosion resistance, biocompatibility, mechanical strength¹⁸, reinforcement of composite resin crown, improved transparency, optimal esthetics, higher flexibility compared with metal posts, and easy application^{19,20}. Also, these posts have a modulus of elasticity close to dentin, which decreases stress accumulation and root fracture²¹. Many attempts have been made to enhance the efficacy of dentin-bonding agents while reducing their procedural steps. Thus, some progress was made in multi-step dentin bonding agents, which were difficult for children due to their technique sensitivity and time-consuming nature.

In this respect, 7th-generation dentin bonding agents were introduced to simplify the bonding procedure. In this system, acid, primer, and bonding agent are all supplied in one bottle, which facilitates the application of this bonding agent in non-cooperative children²³. Conventional methacrylate-based composite resins have long been used to restore primary anterior teeth. However, limited curing depth and the possibility of an inadequate degree of conversion of monomers to polymer in deep areas are among the drawbacks of conventional composite resins²⁴, which can deteriorate their physical, mechanical, and biological

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properties^{25,26}. They can be applied in bulk to decrease the application steps and save time²⁸. Also, they can be used in 4-mm-thick increments (versus 2 mm in conventional composite resins)²⁹ with lower polymerization shrinkage compared with traditional composite resins³⁰.

Since severe destruction of primary anterior teeth often necessitates pulpectomy, the reconstruction of such teeth requires efficient dentin bonding agents, and retention should be obtained from the root dentin. Thus, this study assessed the push-out bond strength of a bulk-fill and a conventional composite resin to root dentin of primary anterior teeth using a 7th-generation dentin bonding agent.

Materials and methods

Study design

This in vitro study evaluated 24 primary anterior teeth extracted due to severe coronal caries within the previous six months. The ethics committee of the Tehran University of Medical Sciences approved the study.

Teeth preparation

The collected teeth were immersed in 0.5% chloramine T solution for one week and stored in distilled water. The teeth were then decorated at 1 mm above the cemento-enamel junction using diamond discs perpendicular to the long axis of the tooth.

Sample size measuring

The sample size was calculated at 12 in each group according to a previous study by Torres *et al.*³⁰, assuming

$\alpha=0.5$, $\beta=0.2$, mean difference of 3.3, and standard deviation of 3.16 using Minitab software.

Inclusion criteria and groups

Inclusion criteria were the absence of dental caries and fractures. The teeth were randomly assigned to two groups. The root canals were instrumented with three sizes of k-files (Mani Inc., Japan) and rinsed with saline solution. They were then dried with paper points (PT Dent, USA). After completion of filing, the root canals were not filled with zinc-oxide eugenol to prevent the possible effect on pulpal dentin. Instead, 1 mm of zinc phosphate paste was applied to create an apical seal for composite resin packing. Next, the coronal 3 mm root canal was filled with composite resin to serve as an intracanal post. Patients with COVID-19, dental infections, and neoplastic lesions of the oral cavity have been excluded from the study. Table 1 presents the composition of this study's bonding agent and composite resins.

Study procedure

Single Bond Universal 7th-generation bonding agent was used for bonding composite resins in both groups. In group 1, Filtek P60 conventional composite resin was incrementally applied according to the manufacturer's instructions and packed into the root canal with a condenser. Each layer was light-cured for 20 seconds. In group 2, Filtek bulk-fill composite resin was applied in the root canal in bulk in one step according to the manufacturer's instructions and light-cured for 40 seconds. All the samples in both groups were light-cured using an LED light-curing unit (WoodPecker, China) at a light intensity of 800–1000

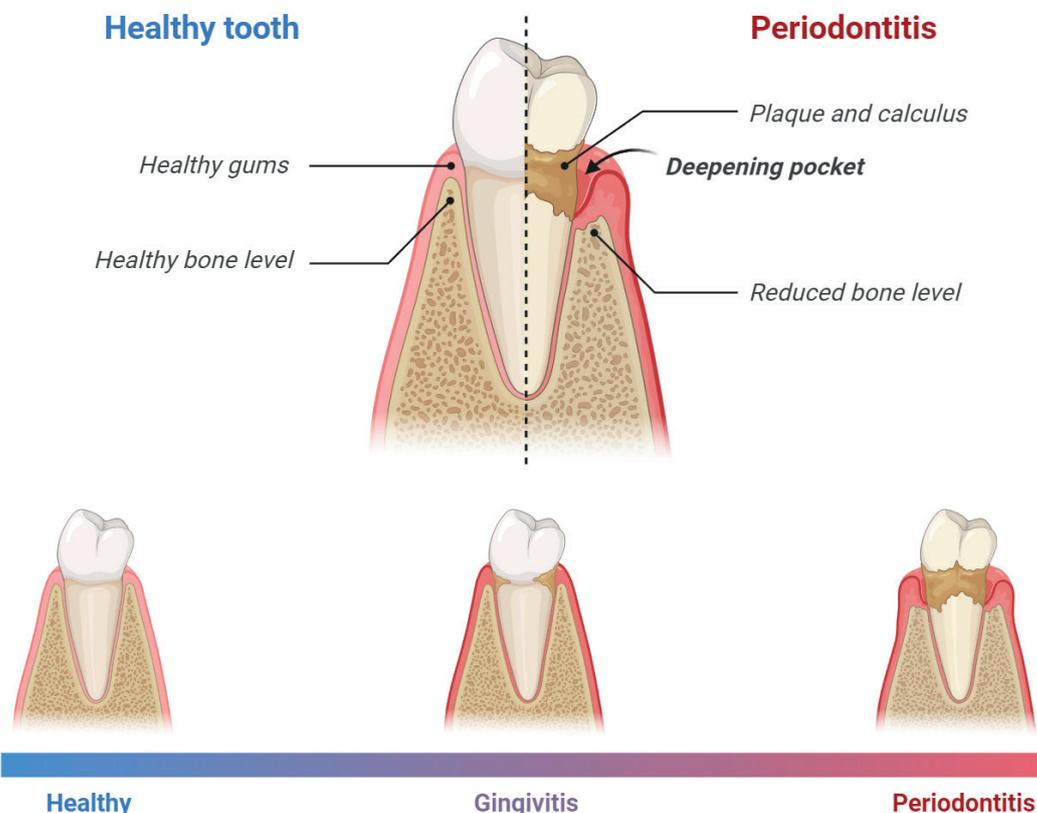


Figure 1. Periodontitis diseases, also known as gum disease, are a group of inflammatory diseases that affect the tissues surrounding the teeth. They are caused by bacteria that form plaque on the teeth and gums. If plaque is not removed regularly, it can harden into tartar, which can irritate the gums and lead to inflammation.

mW/cm². The tip of the light-curing unit was placed 2 mm away from the tooth surface. The samples were incubated in distilled water at 37°C for 24 hours (Kavoosh Mega, Iran) and then underwent 2000 thermal cycles at 5/55°C with a dwell time of 30 seconds and a transfer time of 10 seconds (TC300; Vafaie Industrial, Iran). Next, the samples were mounted in transparent acrylic resin. A section was made at the midpoint of the prepared root of each tooth with 1-mm thickness using a water-cooled diamond blade on a Labcut 250B cutting machine (Extec, corp, Enfield, CT). The push-out bond strength test was then performed using a universal testing machine (2050; Zwick/Roell, Ulm, Germany). Using a stainless steel cylindrical plunger with a diameter matching the root canal, the load was applied to the bonding interface in an apicocervical direction at a 0.5 mm/min crosshead speed. Maximum load causing debonding was recorded in Newtons (N). The load in Newtons was divided by the surface area in square millimeters (mm²) to determine the bond strength in megapascals (MPa). Before the push-out test, both sides of the sliced section were photographed by a digital camera (DSC-HX100v CyberShot, Sony, Japan), and the photographs were fed into AutoCAD 2013 software. The cross-sectional area was calculated using the formula $A=H((A1+A2)/2)$

A1 is the circumference on one side, A2 is the circumference on the other, and H is the height (thickness) of the root slice in millimeters. The AutoCAD software measured A1 and A2, and H was measured by a digital caliper (Mitutoyo, Japan). After the push-out test, the samples were inspected under a light microscope (SZX2-2b16; Olympus,

Japan) at ×40 magnification to determine the failure mode, categorized as mixed, cohesive, and adhesive.

Data analysis

The data were analyzed with SPSS 22 via t-test at a 0.05 level of significance³¹⁻³⁷.

Results

Push-out bond strength

Table 2 shows the mean push-out bond strength of the two groups. The t-test showed a significant difference in bond strength between the two groups, such that the conventional composite resin yielded a significantly higher bond strength (P<0.001).

Frequency of different modes of failure

Table 3 shows the frequency of different failure modes in the two groups. In the conventional group, 50% of failures were cohesive in the composite resin, while 75% of failures were mixed in the bulk-fill group.

Discussion

Dental sciences have been considered an essential part of medical research related to human health. This study compared the push-out bond strength of a bulk-fill and a conventional composite resin to root dentin of primary ante-

Materials	Components	Mode/steps of application	Manufacturer
Single Bond universal Self-etch 1-step	MDP phosphate monomer, methacrylate resins, HEMA, Vitrebond™ copolymer, filler, Ethanol, water, initiators, silane	The adhesive was rubbed on the tooth surface for 20 s, gently air-dried for 5 s, and cured for 10 s.	3M, St. Paul, MN, USA
Filtek P60 %fillers/wt: 83.0	BIS-GMA, UDMA, BIS-EMA	Each increment was applied with a 2 mm thickness and cured for 20 seconds.	3M, St. Paul, MN, USA
Filtek bulk-fill %fillers/wt: 64.5	ERGP-DMA, urethane-DMA, 1,12-dodecane-DMA	Each layer was applied with a 4 mm thickness and cured for 40 seconds.	3M, St. Paul, MN, USA

Table 1. Composition of bonding agent and composite resins used in this study.

Composite resin	Minimum	Maximum	Mean	Std. deviation	P-value
Bulk-fill	2.81	12.54	5.40	2.91	0.041
Conventional	7.03	21.94	13.37	4.40	

Table 2. Mean push-out bond strength (MPa) of the two groups.

Composite resin		Cohesive in composite	Cohesive in dentin	Adhesive	Mixed
Conventional	Number	6	2	0	4
	Percentage	50%	16.7%	0%	33.3%
Bulk-fill	Number	0	0	3	9
	Percentage	0%	0%	25%	75%

Table 3. Frequency of different modes of failure in the two groups.

rior teeth using a 7th-generation dentin bonding agent. The mean push-out bond strength of the conventional composite was significantly higher than that of the bulk-fill composite resin. Afshar *et al.*²³ assessed the push-out bond strength of 5th, 6th-, and 7th-generation bonding agents to root dentin of primary anterior teeth and found no significant difference between them. However, the mean value reported for the 7th-generation bonding agent in their study (12.28 MPa) was lower than that in the present study (13.37 MPa) when a conventional composite resin was used. Differences in age and morphology of the teeth, storage media, and operators' expertise may be responsible for the difference in the results. Also, thermocycling was performed in the present study, which was not conducted in the study above.

Some other studies assessed the shear or tensile bond strength of different composite resins and bonding agents to primary tooth crowns. Yaseen and Reddy²² reported a shear bond strength of 17.39 MPa for the Clearfil S3 Bond 7th-generation bonding agent, which was higher than the value in the present study. This difference might be attributed to using different bonding agents to assess shear bond strength to dentin far from the pulp chamber (dentin close to dentin enamel junction). Dentin near the dentin enamel junction contains fewer dentinal tubules with smaller diameters than dentin around the pulp chamber. Thus, dentin far from the pulp chamber has more calcified tissue, the primary substrate for etching and bonding and can yield higher bond strength. Thus, the difference between the study above and the present study might be attributed to the difference in the histology of bonded dentin in the crown (far from pulp) and root (close to the pulp) and the difference in the cross-sectional area to which the load was applied.

Ilie *et al.*⁴¹ assessed the shear bond strength of two bulk-fill composite resins and two self-etch adhesive systems to primary dentin and reported higher values than the present study. The bulk-fill composite resin used in the present study differed from the bulk-fill composite resins used by Ilie *et al.*⁴¹, which might explain the differences between the results. Pasdar *et al.*⁴² compared the mean push-out bond strengths of three intracanal posts, including short composite post (SCP), glass fiber posts (GFPs) cemented with flowable composite resin, and GFP with glass ionomer cement (GFP + GIC) in anterior deciduous teeth, reporting that the mean push-out bond strengths of SCP were 14.74±6.04 Mpa, which was higher than the other groups. This finding was slightly higher than the present study results concerning conventional composite resins. The differences might be attributed to differences in the techniques used and the morphology of the teeth.

The present study indicated higher bond strength of conventional composite resin to primary dentin using a 7th-generation bonding agent than a bulk-fill composite resin. No similar study was found in the literature to compare the present study results. However, bulk-fill composite resins are incompatible with 7th-generation bonding agents. Although limited studies are available on deciduous teeth, many studies have assessed the push-out bond strength of root dentin in permanent teeth with highly controversial results. Oskoe *et al.*⁴³ assessed the push-out bond strength of fiber-reinforced composite resin posts to root dentin of permanent teeth using different adhesive systems. They reported that the push-out bond strength values following a one-step self-etch system (27.56 MPa) were higher than those in the present study. This finding might be attributed to differences in primary and permanent dentin. The dia-

meter and number of dentinal tubules in primary dentin are higher than those in permanent dentin. This would decrease the dentin substrate available for bonding to adhesives (reduction of inter-tubular dentin)⁴⁴. On the other hand, the peritubular dentin, which is demineralized faster during the etching process, is thicker in primary dentin than permanent dentin, further reducing the substrate available for bonding⁴⁵. These histological differences are responsible for lower bond strength to primary dentin than permanent dentin.

Dumami *et al.* (2016)⁴⁶, consistent with the present study, showed that the push-out bond strength of a bulk-fill composite resin (SonicFill) was lower than that of conventional composite resins. They attributed the differences in the results to factors that affected the integrity of the Bond between the root dentin and the restorative materials. In addition, factors such as polymerization shrinkage, the C-factor, application method, and polymerization of the composite resin were considered significant. The authors suggested further studies. Concerning the mode of failure, in the conventional composite resin group in the present study, 50% of failures were cohesive within the composite resin.

In contrast, 75% of failures were mixed in the bulk-fill composite resin group, consistent with a previous study on primary dentin⁴⁷. In the conventional composite resin samples, two-thirds of the failures were cohesive, and one-third were mixed. No case of adhesive failure was noted in this group. This result agreed with the bond strength test results in this group. Evidence shows that the fracture mode in primary enamel and dentin is mainly of adhesive and mixed types¹⁷.

However, some authors believe that cohesive failure requires a >14-MPa load to occur^{47,48}. On the other hand, it has been reported that cohesive failures are not rare in primary dentin and might be due to the low micro-hardness of deep dentin. In contrast, some others claim that there is a weak correlation between the failure mode and bond strength in primary dentin⁴⁷. Considering the advantages of self-etch one-step bonding agents, their application with conventional composite resin is recommended for composite resin post-fabrication in primary anterior teeth. However, the Single Bond Universal 7th-generation bonding agent did not seem compatible with Filtek bulk-fill composite. Therefore, future studies with a larger sample size on the push-out bond strength of other composite resins and bonding agents to primary dentin are required to obtain more accurate results. Also, the efficacy of bulk-fill and conventional composite resins for reconstructing severely damaged primary anterior teeth with fiber posts should be evaluated. Last, in vivo studies are required to assess the efficacy of bulk-fill composite resins with different bonding agents for composite resin post-fabrication in primary anterior teeth in the clinical setting.

The present study was limited to the low number of samples and experimental groups. However, the main strength point of this survey is the first use of push-out bond strength of a conventional and a bulk-fill composite resin technique to root dentin of primary anterior teeth.

Conclusions

The present study compared the push-out bond strength of a conventional composite resin and a bulk-fill composite resin to root dentin of primary anterior teeth using a

7th-generation dentin bonding agent. The results showed that the conventional composite resin had significantly higher bond strength than the bulk-fill composite resin.

The conventional composite resin is recommended for composite resin post-fabrication in primary anterior teeth. However, they also noted that the Single Bond Universal 7th-generation bonding agent did not seem compatible with Filtek bulk-fill composite. Therefore, future studies with a larger sample size on the push-out bond strength of other composite resins and bonding agents to primary dentin are required to obtain more accurate results. Further studies are needed to evaluate the efficacy of bulk-fill and conventional composite resins for reconstructing severely damaged primary anterior teeth with fiber posts, and to assess the efficacy of bulk-fill composite resins with different bonding agents for composite resin post-fabrication in primary anterior teeth in the clinical setting.

Overall, the present study provides valuable information on the bond strength of conventional and bulk-fill composite resins to primary dentin using a 7th-generation dentin bonding agent. However, more studies are needed to confirm these findings and to evaluate the clinical efficacy of bulk-fill composite resins for restorative dentistry in children.

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Bibliographic references

- Anil S, Anand PS. Early Childhood Caries: Prevalence, Risk Factors, and Prevention. *Front Pediatr*. 2017;5:157.
- Rad M., Shahraavan A., Haghdooost AA. Effective Factors on Oral Health Behaviors of 12-year-old Children in Cities and Villages of Iran: a Path Analysis. *J Dent Shiraz Univ Med Sci*, 2018 ; 19(3): 225-231.
- Monajem Zade SM, Elyashkil M, Fathi A, Asadinejad SM. Evaluate risk markers for periodontal disease in children with type 1 diabetes: a systematic review and meta-analysis. *Turk Online J Qualitative Inq*. 2021;12:5715-5722.
- Motisuki C, Santos Pinto L, Giro EM. Restoration of severely decayed primary incisors using indirect composite resin restoration technique. *International journal of pediatric dentistry*. 2005 ;15(4):282-6.
- Khamisi N, Fathi A, Yari A. Antimicrobial resistance of *Staphylococcus aureus* isolated from dental plaques. *Academic Journal of Health Sciences*. 2022;37(1):136-140.
- Chunawalla YK, Zingade SS, Bijle MN, Thanawalla EA. Glass Fibre Reinforced Composite Resin Post & Core In Decayed Primary Anterior Teeth—A Case Report. *International Journal of Clinical Dental Science*. 2011 4;2(1).
- Malekafzali B, Beheshti M, Mirkarimi M, Ahmadi R. Treatment of early childhood caries: A literature review. *Journal of Islamic Dental Association of Iran*. 2010;21(4):297-306.
- Colak H, Dülgergil CT, Dallı M, Hamidi MM. Early childhood caries update: A review of causes, diagnoses, and treatments. *J Nat Sci Biol Med*. 2013;4(1):29-38.
- Hamrah MH, Mokhtari S, Hosseini Z, Khosrozadeh M, Hosseini S, Somaya Ghafary E, et al. Evaluation of the Clinical, Child, and Parental Satisfaction with Zirconia Crowns in Maxillary Primary Incisors: A Systematic Review", *International Journal of Dentistry*. 2021; 2021:7877728.
- Maalekipour M, Safari M, Berekatain M, Fathi A. Effect of Adhesive Resin as a Modeling Liquid on Elution of Resin Composite Restorations. *International Journal of Dentistry*. 2021;2021:1-9.
- Vafaei A, Ranjkesh B, Løvschall H, Erfanparast L, Jafarabadi MA, Oskouei SG, Isidor F. Survival of Composite Resin Restorations of severely Decayed Primary Anterior Teeth retained by Glass Fiber Posts or Reversed-orientated Metal Posts. *Int J Clin Pediatr Dent* 2016;9(2):109-113.
- Schwartz RS, James W. Post Placement and Restoration of Endodontically Treated Teeth: A Literature Review *Journal of endodontics* 2004; 30(5):289-301.
- Bijelic J, Garoushi S, Vallittu PK, Lassila LV. Short fiber reinforced composite in restoring severely damaged incisors. *Acta Odontologica Scandinavica*. 2013 ;71(5):1221-31.
- Bonchev A, Radeva E, Tsvetanova N. Fiber Reinforced Composite Posts - A Review of Literature. *Int J Sci Res* 2017;6(10):1887–1893.
- Faria AC, Rodrigues RC, de Almeida Antunes RP, de Mattos MD, Ribeiro RF. Endodontically treated teeth: characteristics and considerations to restore them. *J Prosthodont Res*. 2011;55(2):69-74.
- Shah S, Bargale S, Anuradha KVR, Patel N. Posts in Primary Teeth-A Sile for Better Smile. *J Adv Med Dent Scie Res* 2016;4(1):58-64.(14-18)
- Mosharrafiyan S, Sharifi Z. Comparison of Push-Out Bond Strength of Two Bulk-Fill and One Conventional Composite to Intracanal Dentin in Severely Damaged Primary Anterior Teeth. *J Dent (Tehran)*. 2016;13(3):207-214
- Mosharrar R, Molaie P, Fathi A, Isler S. Investigating the Effect of Nonrigid Connectors on the Success of Tooth-and-Implant-Supported Fixed Partial Prosthesis in Maxillary Anterior Region: A Finite Element Analysis (FEA). *International Journal of Dentistry*. 2021;2021:1-12.
- Demiryürek EÖ, Külünk Ş, Saraç D, Yüksel G, Bulucu B. Effect of different surface treatments on the push-out bond strength of fiber post to root canal dentin. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*. 2009 ;108(2):e74-80.
- Bayrak S, Tunc ES, Tuloglu N. Polyethylene fiber–reinforced composite resin used as a short post in severely decayed primary anterior teeth: A case report. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*. 2009 ;107(5):e60-4.
- Falakaloğlu S, Adıgüzel Ö, Özdemir G. Root canal reconstruction using biological dentin posts: A 3D finite element analysis. *J Dent Res Dent Clin Dent Prospects*. 2019;13(4):274-280.
- Yaseen SM, Reddy VS. Comparative evaluation of shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin of primary and permanent teeth: An in vitro study. *Journal of Indian Society of Pedodontics and Preventive Dentistry*. 2009 ;27(1):33.
- Afshar H, Baradaran Nakhjavani Y, Rahro Taban S, Baniameri Z, Nahvi A. Bond Strength of 5(th), 6(th) and 7(th) Generation Bonding Agents to Intracanal Dentin of Primary Teeth. *J Dent (Tehran)*. 2015;12(2):90-98.
- Maalekipour M, Safari M, Berekatain M, Fathi A. Effect of Adhesive Resin as a Modeling Liquid on Elution of Resin Composite Restorations. *International Journal of Dentistry*. 2021;2021:1-9.
- Ghasemi E, Fathi AH, Parvizinia S. Effect of three disinfectants on dimensional changes of different impression materials. *Journal of Iranian Dental Association*. 2019;31(3):169-76.
- Ashtiani AH, Mardasi N, Fathi A. Effect of multiple firings on the shear bond strength of presintered cobalt-chromium alloy and veneering ceramic. *The Journal of Prosthetic Dentistry*. 2021;126(6):803-e1.
- Jafari Navimipour E, Pournaghi Azar F, Keshipour S, Nadervand S. Thermal Stability and Monomer Elution of Bulk Fill Composite Resins Cured from Different Irradiation Distances. *Front Dent*. 2021:18:9.
- Pongprueksa P, De Munck J, Duca RC, Poels K, Covaci A, Hoet P, et al. Monomer elution in relation to degree of conversion for different types of composite. *J Dent*. 2015 ;43(12):1448-55.

29. Bucuta S, Ilie N. Light transmittance and micro-mechanical properties of bulk fill vs. conventional resin based composites. *Clinical oral investigations*. 2014 ;18(8):1991-2000.
30. Ilie N, Hickel R. Investigations on a methacrylate-based flowable composite based on the SDR™ technology. *Dental Materials*. 2011 ;27(4):348-55.
31. Fathi A, Salehi A. Antimicrobial resistance properties of *Helicobacter pylori* strains isolated from dental plaque and saliva samples. *Academic Journal of Health Sciences*. 2021;36(4):51-55.
32. Ghorbani F, Gheisari E, Dehkordi FS. Genotyping of *vacA* alleles of *Helicobacter pylori* strains recovered from some Iranian food items. *Trop J Pharm Res*. 2016;15(8):1631-6.
33. Dehkordi FS. Prevalence study of Bovine viral diarrhoea virus by evaluation of antigen capture ELISA and RT-PCR assay in Bovine, Ovine, Caprine, Buffalo and Camel aborted fetuses in Iran. *AMB Express*. 2011;1(1):1-6.
34. Dehkordi FS, Parsaei P, Saberian S, Moshkelani S, Hajshafiei P, Hoseini SR, Babaei M, Ghorbani MN. Prevalence study of *Theileria annulata* by comparison of four diagnostic Techniques in southwest Iran. *Bulgar J Vet Med*. 2012;15(2): 123-130.
35. Dehkordi FS, Haghighi Borujeni MR, Rahimi E, Abdizadeh R. Detection of *Toxoplasma gondii* in raw caprine, ovine, buffalo, bovine, and camel milk using cell cultivation, cat bioassay, capture ELISA, and PCR methods in Iran. *Foodborne Pathog Dis*. 2013;10(2):120-5.
36. Dehkordi FS, Khamesipour F, Momeni M. *Brucella abortus* and *Brucella melitensis* in Iranian bovine and buffalo semen samples: The first clinical trial on seasonal, Senile and geographical distribution using culture, conventional and real-time polymerase chain reaction assays. *Kafkas Univ Vet Fak Derg*. 2014;20(6):821-8.
37. Dehkordi FS, Valizadeh Y, Birgani TA, Dehkordi KG. Prevalence study of *Brucella melitensis* and *Brucella abortus* in cow's milk using dot enzyme-linked immunosorbent assay and duplex polymerase chain reaction. *J Pure Appl Microbiol*. 2014;8(2):1065-9.
38. Ebadian B, Fathi A, Savoj M. In Vitro Evaluation of the Effect of Different Luting Cements and Tooth Preparation Angle on the Microleakage of Zirconia Crowns. *International Journal of Dentistry*. 2021;2021:1-7.
39. Barakati B, Khodadadi R, Asadi P, Fathi A. Evaluate The Effect Of Various Titanium Abutment Modifications On The Behavior Of Peri-Implant Soft Tissue Healing, Inflammation, And Maintenance: A Systematic Review And Meta-Analysis. *Turkish Online Journal of Qualitative Inquiry*. 2021; 12:11401-11410.
40. Abolhasani M, Ghasemi E, Fathi AH, Hayatizadeh MJ. Color Change of Ceramill Zolid FX Following Abrasion with/ without Toothpaste. *Journal of Iranian Dental Association*. 2021;33(3):51-7.
41. Ilie N, Schöner C, Bücher K, Hickel R. An in-vitro assessment of the shear bond strength of bulk-fill resin composites to permanent and deciduous teeth. *Journal of dentistry*. 2014 ;42(7):850-5.
42. Pasdar N, Seraj B, Fatemi M, Taravati S. Push-out bond strength of different intracanal posts in the anterior primary teeth according to root canal filling materials. *Dent Res J (Isfahan)*. 2017 ; 14(5): 336–343.32-*Dent Res J (Isfahan)*. 2017 ; 14(5): 336–343.
43. Oskoe PA, Navimipour EJ, Oskoe SS, Bahari M, Pournaghiazar F. Effect of different adhesion strategies on push-out bond strength of fiber reinforced composite posts. *African Journal of Biotechnology*. 2011;10(76):17593-8.
44. Sardella TN, de Castro FL, Sanabe ME, Hebling J. Shortening of primary dentin etching time and its implication on bond strength. *Journal of dentistry*. 2005 ;33(5):355-62.
45. Uekusa S, Yamaguchi K, Miyazaki M, Tsubota K, Kurokawa H, Hosoya Y. Bonding efficacy of single-step self-etch systems to sound primary and permanent tooth dentin. *Operative dentistry*. 2006 ;31(5):569-76.
46. Dumami A, Yilmaz S, Ozbilen G, Gurbuz CC, Yoldas O. Comparative Evaluation of Push-Out Bond Strength of Bulk-Fill versus DualCure Resin Composites in Root Canals. *Oral Health and Dental Management*. 2016;15(4)212-216.
47. Bolaños-Carmona V, González-López S, Briones-Luján T, De Haro-Muñoz C, José C. Effects of etching time of primary dentin on interface morphology and microtensile bond strength. *Dental Materials*. 2006 ;22(12):1121-9.
48. Burke FJ, McCaughey AD. The four generations of dentin bonding. *American Journal of Dentistry*. 1995 ;8(2):88-92.