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Temporary restoration of endodontically treated teeth - indications, types and characteristics of the materials used

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Abstract
Endodontic treatment aims to remove the affected tissues and bacteria from the root canal space, protect the tooth from recontamination and restore function. Contemporary endodontic practice determines the possibilities for most clinical situations to be resolved in one visit. In some cases, a multi-visit approach is required and the reasons for this may be related to the peculiarities of the root canal anatomy, as well as to the specifics of the pathological process and the treatment plan. Temporary restoration of the endodontic cavity between visits plays a key role in the prognosis of the treated tooth. Complications that can occur during this period are many and are most often associated with recontamination of the root canals, persistent canal infection, cracks and fractures of the crown and roots. In modern endodontic practice, various materials are used for temporary restoration of the endodontic cavity. The requirements for these materials are many and the choice depends not only on the qualities of these materials, but also on the clinical case. The aim of this review article is to present a brief analysis of the reasons for endodontic treatment in one or more visits, as well as the most commonly used materials for temporary restoration of the endodontic cavity in contemporary endodontic practice, and their properties.

Key words: *endodontics, endodontic therapy, endodontic access, temporary obturation, restorative material*

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Historically, endodontic therapy has been discussed since the 17th century[1]. Contemporary endodontic treatment resolves complex clinical cases in one or more visits with a positive short- and long-term prognosis [2]. If the treatment plan requires more than one visit the endodontic cavity needs to be temporary restored which may affect the final result of the therapy. Acording to some authors (Abott, 1994) failures in this procedure are the second most common cause of pain symptoms in the endodontic treatment [3]. One of the first studies on the properties of materials and methods for temporary restoration of endodontically treated teeth is conducted by Fraser in 1929 [4]. Since then, there is still no standard protocol for the isolation of the endodontic cavity during the interappointment period.

I. Single-visit or multi-visit approach in endodontic treatment

In the recent years many authors consider methods for endodontic treatment in one visit [5,6]. One of the most frequently pointed out positive aspects of this clinical approach is the lack of need for temporary restoration. This significantly reduces the risks of recontamination and fracture of the treated tooth [7,8,9]. The placement of permanent restoration without compromising the isolation, as well as the ability to take an impression for indirect restoration at the same visit (inlay, onlay, overlay or crown) are other prominent advantages. Last but not least, it is important to note the cost of time and resources for both the patient and the therapist, as well as the staff [10].

Dentists who prefer endodontic treatment in several visits point to postoperative pain. A number of studies have shown the presence of such postoperative sensitivity of varying duration - from one day to several weeks [11]. Symptoms also vary and include sensitivity during eating to constant, severe pain and even tooth mobility. However, some researchers have not found a specific relationship between postoperative symptoms and endodontic treatment in one or more visits [12]. Initial endodontic diagnose is another important factor which may be the reason for postoperative pain and to influence the decision for treatment plan including more than one visit. Multi-visit treatment will be the possible approach in most of the cases of non-vital pulp, as well as in those with periapical lesions. However, there are studies in the literature that support both opposites [13,14].

Another group of studies analyzing the implementation of endodontic treatment in one or more visits consider the healing process as a major sign of success. In most of them, the researchers did not find a relationship between the number of visits and the healing process [15,16,17,18].

The benefits of single-visit endodontic treatment can be summarized as follows:

1. Convenience for the patient and the dentist due to the lack of need for additional visits. The need for repeated general medication such as antibiotic premedication or sedation is ruled out, as well as the risks of repeated anesthesia.
2. Reducing the risk of complications during treatment.
3. The obturation of the root canals is facilitated because they are well irrigated and cleaned, the dentist is well oriented to the anatomy and features of the endodontic space.
4. Exclusion of the risks from the temporary restoration - micropermeability and reinfection, cracks, fractures, etc.
5. Restoration of masticatory function with final restoration immediately after the endodontic treatment.

Unfortunately, in many clinical cases, endodontic treatment requires more than one visit and it is usually related to the endodontic pathology, complex root canal anatomy or difficulties and complications during treatment [19,20,21,22].

The advantages of the single- and multi - visit approach in endodontic treatment is not fully understood. There are evidences in the literature to support both treatment plans [23]. The limited possibilities of modern methods of treatment still define endodontic treatment as a complex and lengthy procedure with a difficult to predict postoperative period. It concerns both the structural integrity of the treated teeth and the condition of the surrounding tissues [24]. This means that the provision of individual treatment procedures, including temporary restoration, requires future research and the innovations [25].

II. Types of materials and methods for temporary restoration of endodontically treated teeth

Temporary restoration of endodontically treated teeth is a responsible procedure and it may jeopardize the final result of the treatment [26]. The challenges associated with it are discussed as far back as 1969 by Tagger and Osone [27, 28]. Of paramount importance are the qualities of the various materials, as well as the specific protocol for working with them [29]. Bobotis *et al*. examine seven materials for temporary restoration (zinc-oxide calcium sulphate - Cavit 3M ESPE, USA), glass ionomer cements, classical zinc phosphate cement, polycarboxylate cement and zinc oxide eugenol cements (IRM), as well as light cured materials TERM [30]. During the testing period, all materials show different degrees of micropermeability. Since the relevant study in 1989, some innovations in the content of materials or the introduction of new components have been proposed, but there is still no established universal product for everyday practice [31,32,33]. Light cured composites, whose properties such as hard dental tissues bond, abrasion resistance, water absorption, solubility, color characteristics, define them as preferred in contemporary dentistry in a multi-visit approach.

According to Devika *et al.* [34] the temporary restorative material has to meet the following requirements:

- to provide adequate isolation of the operative field against the penetration of bacteria, organic products and fluids from the oral environment into the root canal system;
- to prevent the influence of the drug, insert in the endodontic space by the factors of the oral environment.
- to provide a stable and long-lasting bond with the hard dental tissues;
- to allow to be shaped in accordance with the external contours of the tooth in order to prevent complications arising from over-contouring;
- easy to remove from the cavity;
- X-ray positive;
- with good abrasion resistance;
- with a short setting time;
- to have antibacterial properties;
- to ensure good marginal integrity;
- be insoluble in oral fluids.

There is still no material that sufficiently meets all the requirements, but it should be noted that contemporary light cured composite materials meet most of these criterias [35,36.]

Characteristics of materials for temporary restoration of endodontically treated teeth

The materials used in contemporary dentistry for temporary restoration of the endodotic cavity can be systematized in general in the following groups [37, 38]:

1. Zinc oxide calcium sulphate materials
2. Zinc oxide eugenol materials
3. Glass ionomer cements
4. Light cured materials

Characteristics of the individual groups

1. Zinc oxide calcium sulphate materials;

Representatives - Cavit (3M ESPE, USA), MD Temp (Meta Biomed Co., Korea), Coltosol (Coltene, Germany), Calasept Temp (Directa Dental Group, Sweden).

Composition:

- zinc oxide;
- glycerin;
- calcium sulphate - hemihydrate.

Features:

- obturation takes the least time;
- no preliminary preparation of the cavity walls is required;
- are the easiest to remove compared to materials from other groups;
- difficult to form in the proximal and marginal areas;
- can be easily deployed from the cavity when removing the appliances of insulation (rubber dam, retraction cord, etc.);
- poor aesthetics;
- their retention in the cavity is macromechanical;
- their behavior during function can be defined as problematic due to their low resistance to abrasion, soluble in oral liquids, they are brittle and it is likely to easily fracture part of the obturation;
- do not contribute to the stability of other dental tissues [34,39];
- have a long setting time by hygroscopic hardening after contact with moisture which increases their volume. Their hygroscopic properties can lead to cracks and fractures of the coronary hard dental tissues [40,41].

Temporary restorative materials based on zinc oxide calcium sulphate are in most cases available in reusable containers, which carries risks of transmission of infections. Finger shaping of the amount of material and subsequent application in the cavity is a possible reason for contamination of the endodontic space.

2. Zinc oxide-eugenols

Representatives - IRM (Dentsply Sirona, UK), Neodyne - α (Neo Dental Chemical Products, Japan)

Composition:

- zinc oxide;
- eugenol;
- polymethyl methacrylate;

Features:

- relatively easy work protocol;
- short setting time;
- can be removed relatively easily;
- polymethyl methacrylate increases the abrasion resistance and hardness of the material as well as its compressive strength;
- acceptable abrasion resistance;
- the connection with the cavity walls is mainly macromechanical and the degree of isolation of the operational field between visits may be unsatisfactory;
- easily fractured at the edges;
- do not provide any support to the other hard dental tissues;
- the insulating properties are violated when the material is subjected of abrupt temperature changes.

Manufacturers recommend the use of the material for a long period of time, but this is often associated with alteration of the insulation of the cavity. The change in the dust-liquid ratio allows to influence some of its properties such as hardness, antibacterial activity [39, 42, 43].

The content of eugenol in these materials is considered as a contraindication when composite materials will be used for post-endodontic restoration. The reason is the inhibitory effect of this agent on the polymerization initiator [44]. In one study on the effect of IRM on the adhesive bond strength of composite materials Yap *et al.* found that a dust/liquid ratio of 10g/1g during the preparation of the material did not have a negative effect on the subsequent composite recovery. When the ratio is 10g/2g, then the strength of the adhesive bond decreases sharply. Another study by the same authors showed that the dust/liquid ratio also affects the micropermeability of composite fillings that are placed after IRM [45]. New research on the subject has led to the introduction of polymerization accelerators to be applied before the procedure of filling the cavity with a composite material, when the filling material was previously IRM [46]. The results of the application of this technique seem promising, but nevertheless in modern dentistry the use of eugenol-containing agents when composite materials are considered for the final restoration is not recommended [47].

3. Glass - ionomer cements
Representatives - Ketac Molar Easymix (3M ESPE, USA), Ketac N100 (3M ESPE, USA), Fuji II (GC Corp., Japan), Vitro Fil R (DFL, Brazil)
Composition:
- calcium-aluminum-silicate glass particles;
- organic acid;
- water.
Conventional and resin-modified GICs are used for temporary restoration.
Features:
- available in powder/liquid form and in capsule form;
- short setting time, but the sensitivity to re- and dehydration is maintained for the next 24 hours in conventional GICs and it is necessary to cover surfaces, which are in contact with oral liquids, with an insulating agent [48 49];
- the nature of the bond with dentin is chemical;
- before placement of the material a clean tooth surface, conditioning / etching of dentin and enamel are requred[50];
- their removal from the cavity can also be noted as a disadvantage. In addition, their chemical bond with hard dental tissues requires the dentin layer to which the glass ionomer cement is bound to be removed before the definitive restoration can be performed. This applies to both resin-modified GICs and compomers;
- the use of matrix systems at proximal cavities is necessary.
- good adhesion to hard dental tissues;
- good maintenance of the cavity walls during operation;
- their abrasion resistance is satisfactory especially in view of the period for which they are used;
- acquire final hardness shortly after placement in the cavity;
- relatively aesthetic;
- show satisfactory fracture resistance, which is cohesive rather than adhesive, a factor which has a profound effect on the insulating properties [51];
- release fluorine, which has a positive effect on the isolation of the endodontic space [52].
Some of the shortcomings of conventional GICs in terms of mechanical strength properties have been addressed in resin-modified glass ionomer cements and compomers [53, 54, 55].
4. Light cure materials for temporary restoration:
Representatives - Bioplic (Biodynamics, Brazil), Fill Magic Tempo (Coltene, Germany), Luxatemp (DMG, Germany), Revotek LC (GC, Japan), Vertise flow (Kerr, USA)
Composition:
- dimethacrylate groups;
- organic particles;
- silicon dioxide.
- sodium fluoride;
Features:
- ready-to-use materials that are applied directly to the cavity;
- no prior preparation of the hard dental tissues is required;
- a clean dentinal surface is required;
- acquire final strength immediately after installation;
- cannot be deployed from the cavity when removing the insulating appliances;
- the polymerization shrinkage may lead to reinfection of the endodontic space;
- the material is flowable which is considered as convenience during application in the cavity;
- the polymerization is carried out under a light source. Some of the materials as Bioplic (Biodinamica, Brazil), Fill Magic Tempo (Coltene, Germany) acquire an elastic consistency after hardening by absorbing moisture from saliva. As a result, the volume of the obturation increases, which is considered a positive effect in terms of the degree of isolation [57, 60, 61]. Other members of the group (Vertise flow) do not change after curing;
- some of the rrepresentatives of this group have weak adhesion to the cavity wall and they are mainly used for pre-endodontic build up [58];
- their removal from the cavity may require handpiece (Vertise flow) or just a hand instrument (Biolplic, Fill Magic Tempo) [60,61].
- micromechanical bond to hard dental tissues;
- support the walls of the cavity;
- abrasion resistant;
- good aesthetics;
- the extended and sensitive work protocol requires a clean tooth surface and the use of matrix systems at proximal cavities;

- the removal of these materials is difficult. The hybrid layer needs to be cleaned as well before the definitive restoration is applied, which means that more sound dental tissues will be possibly sacrificed [62,63].

Combination of different materials will enhance their properties [64]. For example, good peripheral bonding of light cure composites is most often combined with the positive manipulative and insulating characteristics of zinc oxide calcium sulphate materials [65]. It needs to be mentioned that achieving and maintaining adequate isolation of the endodontic space between visits depends not only on the quality of the materials used, but also on a number of other factors like the clinical situation, experience of dentist, specific protocol of the manufacturer etc. [66,67]

From a clinical point of view, the variety of determining factors is extremely large [68,69,70]. The following should be taken into account:

- the degree of destruction and condition of the hard dental tissues
- location of the gingival border
- the contacts with the antagonists and the adjacent teeth
- type of occlusion and articulation
- pre-endodontic construction
- characteristics of the oral environment – microflora, temperature amplitudes
- natural and artificial solvents in food can also affect the insulating properties of temporary restoration. They lead to a decrease in the microhardness of the materials and, accordingly, to the abrasion resistance [70, 71, 72].

In most studies, light cure materials show the best insulating properties for the examined period. This is an understandable fact given the formation of a hybrid layer. In an adhesive system with a self-etching primer, part of the smeared layer remains included in the hybrid layer and the enamel is not subjected to sufficient demineralization by the etching agent [73]. Nevertheless, the connection is stable enough. Another problem arises with these materials, and it is related to the influence of the solutions for irrigation of the root canals, as well as their polymerization shrinkage. Sodium hypochlorite adversely affects the adhesive bond and impairs its properties [74]. The reason is the released oxygen, which oxidizes the hybrid layer. As the concentration of the solution increases, its negative impact also increases. In cases where the temporary restoration is completely removed and replaced with a new one after each visit, this negative effect has less impact. Studies testing sodium ascorbate to treat cavity walls before applying light cure composite have shown conflicting results. The aim of these studies is to administer an antioxidant agent that will prevent the negative effects of the oxygen released from the irrigation solutions on the adhesive bond [75,76,77].

GICs have a chemical bond to hard dental tissues, but in most studies their insulating properties in temporary restoration of endodontically treated teeth are defined as unsatisfactory [78,79].

The degree of destruction of hard dental tissues is crucial for maintaining asepsis and antiseptics not only between visits but also during treatment. The insulation of the operative field depends not only on the materials used for temporary restoration of the cavity, but also on the substrate with which they come into contact - enamel, dentin, cement, restorative materials [80]. When endodontic treatment is required for teeth in which coronary restoration appears intact, the clinician often prefers to remove all restorations, as the evaluation of previous endodontic treatment also applies to subsequent post-endodontic restoration [81]. In frequent situations, the treatment plan does not include complete removal of old obturations, which are defined as intact. Tulunoglu *et al*. make a comparative analysis of the penetration of magenta in the contact between old amalgam and composite fillings left in the formation of the endodontic cavity, and three materials for temporary recovery – IRM, Coltosol and Clip, as well as between the cavity wall and the listed three materials. The results show satisfactory insulation of the cavity in the contact between the two filling materials, from which it follows that the old filling materials do not violate the insulation of the endodontic cavity between visits. This conclusion is made by other authors as the results show a higher degree of dye penetration in the contact between the temporary restoration material and the cavity wall, compared to its contact with the existing filling material [82,83.]

The properties of the restorative materials used in modern conservative and endodontic treatment could be subjected to critical analysis. In everyday dental practice, the above-mentioned materials are used in all cases when it is necessary to restore missing hard dental tissues or in case of poor aesthetics. This includes carious lesions, non-carious defects, fractures, endodontic access, prosthetic, orthodontic, surgical, or periodontal treatment. Regardless of the contact tooth structure, its composition and characteristic after the treatment procedures, the materials used are the same or very similar. For example, zinc oxide calcium sulphate materials, also known as classical temporary restorative materials, are used to achieve the purpose of isolating the endodontic space. These materials are sometimes used when temporary restoration is needed in conservative dentistry and pediatric dentistry. The same applies to GIC and composites. The characteristics of the cavity wall in vital and non-vital teeth differ not only due to the presence or absence of vital pulp, pulp pressure and dentin biomechanics, but also with respect to the agents with which this cavity wall comes into contact [84]. The qualities, the requirements for the mechanical-strength properties, the peculiarities of the macro- or micromechanical bond, in accordance with the period of stay in the cavity, determine contradictory criteria for

evaluation of the advantages of one or another material. Light cure composites, with their micromechanical adhesive bond, abrasion resistance and aesthetics, should be the choice of cavity restoration materials. These qualities, on the other hand, are considered negative in temporary restoration due to their sensitive work protocol, difficulties in removing from the cavity, economic aspects and more. The development of materials for each specific clinical situation would provide the best possible conditions in the postoperative period.

Reference:

[1]. Castellucci A. A Brief History of Endodontics Endodontics Vol. 1 2 – 5.
[2]. Setzer FC , Kim S. Comparison of long-term survival of implants and endodontically treated teeth. J Dent Res. 2014 Jan; 93(1):19-26.
[3]. Abbott PV. Factors associated with continuing pain in endodontics. Aust Dent J. 1994 Jun;39(3):157-61.
[4]. Fraser CJ. A study of the efficiency of dental fillings. J Dent Res. 1929 Aug;9(4):507-17.
[5]. Wong AW, Zhang S, Li SK, Zhu X, Zhang C, Chu CH. Incidence of post-obturation pain after single-visit versus multiple-visit non-surgical endodontic treatments. BMC Oral Health. 2015 Aug;14:15-96.
[6]. Almeida DO, Chaves S, Souza R, Soares F. Outcome of Single- vs Multiple-visit Endodontic Therapy of Nonvital Teeth: A Meta-analysis. J Endod. 2012 Sep;38(9):1164-9.
[7]. De Castro PH, Pereira JV, Sponchiado EC Jr, Marques AA, Garcia Lda F. Evaluation of marginal leakage of different temporary restorative materials in Endodontics. Contemp Clin Dent. 2013 Oct;4(4):472-5.
[8]. Tsesis I, Rosen E, Tamse A, Taschieri S, Kfir A. Diagnosis of vertical root fractures in endodontically treated teeth based on clinical and radiographic indices: a systematic review. J Endod. 2010 Sep;36(9):1455-8.
[9]. Laustsen M H , Munksgaard E C, Reit C, Bjørndal L. A temporary filling material may cause cusp deflection, infractions and fractures in endodontically treated teeth. Int Endod J. 2005 Sep;38(9):653-7.
[10]. Figini L, Lodi G, Gorni F, Gagliani M. Single versus multiple visits for endodontic treatment of permanent teeth: a Cochrane systematic review. J Endod. 2008 Sep;34(9):1041-7.
[11]. El Mubarak AH, Abu-bakr NH, Ibrahim YE. Postoperative pain in multiple-visit and single-visit root canal treatment: J Endod. 2010;36(1):36–39.
[12]. Wang C, Xu P, Ren L, Dong G, Ye L. Comparison of post-obturation pain experience following one-visit and two-visit root canal treatment on teeth with vital pulps: a randomized controlled trial. Int Endod J. 2010;43(8):692–697
[13]. Albashaireh ZS, Alnegrish AS. Postobturation pain after single- and multiple-visit endodontic therapy. A prospective study. J Dent. 1998;26(3):227–232.
[14]. Imura N, Zuolo ML. Factors associated with endodontic flare-ups: a prospective study. Int Endod J. 1995;28(5):261–265.
[15]. K B. Trial suggests no difference between single-visit and two-visit root canal treatment: Evid Based Dent. 2013;14(2):48.
[16]. Paredes-Vieyra J, Enriquez FJ. Success rate of single- versus two-visit root canal treatment of teeth with apical periodontitis: a randomized controlled trial. J Endod. 2012;38(9):1164–1169.
[17]. Penesis VA, Fitzgerald PI, Fayad MI, Wenckus CS, BeGole EA, Johnson BR. Outcome of one-visit and two-visit endodontic treatment of necrotic teeth with apical periodontitis: a randomized controlled trial with one-year evaluatio. J Endod. 2008;34(3):251–257.
[18]. GS Gill, AC Bhuyan, C Kalita, L Das, R Kataki, and D Bhuyan. Single Versus Multi-visit Endodontic Treatment of Teeth with Apical Periodontitis: An *in vivo* Study with 1-year Evaluation. Ann Med Health Sci Res. 2016 Jan-Feb; 6(1): 19–26.
[19]. Yang YM, Guo B, Guo LY, Yang Y, Hong X, Pan HY, Zou WL, Hu T. CBCT-Aided Microscopic and Ultrasonic Treatment for Upper or Middle Thirds Calcified Root Canals. Biomed Res Int. 2016 Jul;4793146.
[20]. R S Emara , H M Abou El Nasr, R M El Boghdadi. Evaluation of postoperative pain intensity following occlusal reduction in teeth associated with symptomatic irreversible pulpitis and symptomatic apical periodontitis: a randomized clinical study. Int Endod J. 2019 Mar;52(3):288-296.
[21]. Zancan RF, Vivan RR, Lopes MR, Weckwerth PH, Andrade FB, Ponce JB, Duarte MA. Antimicrobial Activity and Physicochemical Properties of Calcium Hydroxide Pastes Used as Intracanal Medication. J Endod. 2016 Dec;42(12):1822-1828.
[22]. Chong BS, Pitt Ford TR. The role of intracanal medication in root canal treatment: Int Endod J. 1992;25(2):97–106.
[23]. Wong AW, Zhang C, Chu CH. A systematic review of nonsurgical single-visit versus multiple-visit endodontic treatment. Clin Cosmet Investig Dent. 2014 May 8;6:45-56.
[24]. Kruse C, Spin-Neto R, Reibel J , Wenzel A, Kirkevang L. Diagnostic validity of periapical radiography and CBCT for assessing periapical lesions that persist after endodontic surgery. Dentomaxillofac Radiol. 2017 Oct;46(7):20170210.
[25]. JOE Editorial Board. Temporary restorations: an online study guide. J Endod. 2008 May;34(5 Suppl):e131-4.
[26]. Shahi S, Samiei M, Rahimi S, Nezami H. In Vitro Comparison of Dye Penetration through Four Temporary Restorative Materials. Iran Endod J. 2010 Spring;5(2):59-63.
[27]. Tagger M, Tagger E. Marginal leakage to dyes of "Cavidentin": a temporary filling material used in endodontics. Refuat Hapeh Vehashinayim 1969 Dec;18:14-22.
[28]. Osone M, Koga Y. Clinical results of improved Shikwa Gakuho: Calvital Article in Japanese 1969 Aug;69(8):69-72.
[29]. Sivakumar JS, Kumar BN, Shyamala PV. Role of provisional restorations in endodontic therapy. J Pharm Bioallied Sci. 2013 Jun; 5(Suppl 1): S120-4
[30]. Bobotis HG, Anderson RW, Pashley DH, Pantera Jr EA. A microleakage study of temporary restorative materials used in endodontics. J Endod. 1989 Dec;15(12):569-72
[31]. Abramovitz I, Beyth N, Paz Y, Weiss EI, Matalon S. Antibacterial temporary restorative materials incorporating polyethyleneimine nanoparticles: Quintessence Int. Rest. Dent. Vol. 44, number 3, Mar. 2013
[32]. Wolcott S, Barr J. Temporary restorations in endodontics: a review. Compend Contin Educ Dent. 2006 Nov;27(11):596;599-600.
[33]. https://pubchem.ncbi.nlm.nih.gov/compound/Methylene-blue
[34]. Devika warrier E et al. A Review on Temporary Restorative Materials. Int J Pharm Sci Res. 2016 Aug;7(8): 0975-9492.
[35]. Pieper CM, Zanchi CH, Rodrigues-Junior SA, Moraes RR, Pontes LS, Bueno M. Sealing ability, water sorption, solubility and toothbrushing abrasion resistance of temporary filling materials. Int Endod J. 2009 Oct;42(10):893-9.
[36]. Lim KC. Microleakage of intermediate restorative materials. J Endod. 1990 Mar;16(3):116-8.
[37]. Balkaya H, Topçuoğlu HS, Demirbuga S. The Effect of Different Cavity Designs and Temporary Filling Materials on the Fracture Resistance of Upper Premolars: J Endod. 2019 May;45(5):628-633

[38]. Peralta SL, Leles SB, Dutra AL, Guimarães VB, Piva E, Lund RG. Evaluation of physical-mechanical properties, antibacterial effect, and cytotoxicity of temporary restorative materials. J Appl Oral Sci. 2018; 26:e20170562.
[39]. Liberman R, Ben-Amar A, Frayberg E, Abramovitz I, Metzger Z. Effect of repeated vertical loads on microleakage of IRM and calcium sulfate-based temporary fillings: J Endod. 2001 Dec;27(12):724-9.
[40]. Laustsen MH, Munksgaard EC, Reit C, Bjørndal L. A temporary filling material may cause cusp deflection, infractions and fractures in endodontically treated teeth. Int Endod J. 2005 Sep;38(9):653-7.
[41]. Lübbers D. A temporary filling material may cause cusp deflection, infractions and fractures in endodontically treated teeth. Int Endod J. 2006 Apr; 39(4):330-1.
[42]. Friedman S,Shani J, Stabholz A, Kaplawi. Comparative sealing ability of temporary filling materials evaluated by leakage of radio sodium. Int Endod J. 1986;19:187-93.
[43]. Al-Nazhan S, Sapounas G. and Spangberg LSW. In vitro study of the toxicity of a composite resin, silver amalgam and cavit. J Endod. 1988; 14: 236-8
[44]. Carvalho CN, de Oliveira Bauer JR, Loguercio AD, Reis A. Effect of ZOE temporary restoration on resin-dentin bond strength using different adhesive strategies. J Esthet Restor Dent. 2007;19(3):144-52;
[45]. Yap AU, Shah KC, Loh ET, Sim SS, Tan CC. Influence of eugenol-containing temporary restorations on bond strength of composite to dentin. Oper Dent. 2001 Nov-Dec;26(6):556-61.
[46]. Wongsorachai RN, Thanatvarakorn O, Prasansuttiporn T, Jittidecharaks S, Hosaka K, Foxton RM, Nakajima M. Effect of Polymerization Accelerator on Bond Strength to Eugenol-Contaminated Dentin. J Adhes Dent. 2018;20(6):541-547.
[47]. Pires CW, Lenzi TL, Soares FZM, Rocha RO. Zinc oxide eugenol paste jeopardises the adhesive bonding to primary dentine. Eur Arch Paediatr Dent. 2018 Jun;19(3):163-169.
[48]. Menezes-Silva R, Cabral RN, Pascotto RC, Borges AFS, Martins CC, Navarro MFL, Sidhu SK, Leal SC. Mechanical and optical properties of conventional restorative glass-ionomer cements - a systematic review. J Appl Oral Sci. 2019 Feb 21;27:e2018357.
[49]. Asif M, Ahmed MA, Malik S, Choudhry Z, Mughal N, Naz F. Evaluation Of Loosely Bound Water Loss From Different Compositions Of Glass Ionomer Cement. J Ayub Med Coll Abbottabad. 2018 Oct-Dec;30(Suppl 1)(4):S633-S638.
[50]. Avila WM, Hesse D, Bonifacio CC. Surface Conditioning Prior to the Application of Glass-Ionomer Cement: A Systematic Review and Meta-analysis. J Adhes Dent. 2019;21(5):391-399.
[51]. Mitchell CA, Douglas WH, Cheng YS. Fracture toughness of conventional, resin-modified glass-ionomer and composite luting cements. Dent Mater. 1999 Jan;15(1):7-13.
[52]. Krämer N, Schmidt M, Lücker S, Domann E, Frankenberger R. Glass ionomer cement inhibits secondary caries in an in vitro biofilm model. Clin Oral Investig. 2018 Mar;22(2):1019-1031.
[53]. Najeeb S, Khurshid Z, Zafar MS, Khan AS, Zohaib S, Martí JM, Sauro S, Matinlinna JP, Rehman IU. Modifications in Glass Ionomer Cements: Nano-Sized Fillers and Bioactive Nanoceramics. Int J Mol Sci. 2016 Jul 14;17(7):1134.
[54]. Forsten L. Resin-modified glass ionomer cements: fluoride release and uptake. Acta Odontol Scand. 1995 Aug;53(4):222-5.
[55]. Davidson CL. Advances in glass-ionomer cements. J Appl Oral Sci. 2006;14 Suppl:3-9.
[56]. https://multimedia.3m.com/mws/media/273485O/ketac-molar-easymix-brochure.pdf
[57]. https://www.gcamerica.com/products/operatory/REVOTEK_LC/ H
[58]. Durmuşlar S, Ölmez A. Microtensile Bond Strength and Failure Modes of Flowable Composites on Primary Dentin with Application of Different Adhesive Strategies. Contemp Clin Dent. 2017 Jul-Sep;8(3):373-379.
[59]. Heydrich RW. Pre-endodontic treatment restorations. A modification of the 'donut' technique. J Am Dent Assoc. 2005 May;136(5):641-2.
[60]. https://biodinamica.com.br/product/bioplic-en/?lang=en
[61]. https://www.coltene.com.br/en/product/fill-magic-tempo/
[62]. Canbay AC, Yiğit O, Altin S. Physico-mechanical and thermal characteristics of commercially available and newly developed dental flowable composites. J Mol Str 2018 Mar;1156:314-319
[63]. https://www.kerrdental.com/kerr-restoratives/vertise-flow-self-adhering-flowable-composite#docs
[64]. Uçtaşli MB, Tinaz AC. Microleakage of different types of temporary restorative materials used in endodontics. J Oral Sci. 2000 Jun;42(2):63-7.
[65]. Kameyama A, Saito A, Haruyama A, Komada T, Sugiyama S, Takahashi T, Muramatsu T. Marginal Leakage of Endodontic Temporary Restorative Materials around Access Cavities Prepared with Pre-Endodontic Composite Build-Up: An In Vitro Study. Materials (Basel). 2020 Apr 5;13(7):1700.
[66]. Al-Nahlawi T, Doumani M, Alalo HA, Habib A. Dentists' Knowledge, Attitude and Practice of Root Canal Treatment Procedure: Survey-based Research. J Contemp Dent Pract. 2019 Mar 1;20(3):347-354.
[67]. Muñoz E, Forner L, Llena C. Influence of operator's experience on root canal shaping ability with a rotary nickel-titanium single-file reciprocating motion system. J Endod. 2014 Apr;40(4):547-50.
[68]. Bhomavat AS, Manjunatha RK, Rao RN, Kidiyoor KH. Endodontic management of badly broken down teeth using the canal projection system: two case reports. Int Endod J. 2009 Jan;42(1):76-83.
[69]. Verma D, Garg PK, Dubey AK. Insights into the human oral microbiome. Arch Microbiol. 2018 May;200(4):525-540.
[70]. Yap AU, Mah MK, Lye CP, Loh PL. Influence of dietary simulating solvents on the hardness of provisional restorative materials. Dent Mater. 2004 May;20(4):370-6.
[71]. Sivakumar JS, Suresh Kumar BN, Shyamala PV. Role of provisional restorations in endodontic therapy. J Pharm Bioallied Sci. 2013 Jun;5(Suppl 1):S120-4.
[72]. Akova T, Ozkomur A, Uysal H. Effect of food-simulating liquids on the mechanical properties of provisional restorative materials. Dent Mater. 2006 Dec;22(12):1130-4.
[73]. Li M, Xu J, Zhang L, Wang C, Jin X, Hong Y, Fu B, Hannig M. Effect of a novel prime-and-rinse approach on short- and long-term dentin bond strength of self-etch adhesives. Eur J Oral Sci. 2019 Dec;127(6):547-555.
[74]. Laustsen MH, Munksgaard EC, Reit C, Bjørndal L. A temporary filling material may cause cusp deflection, infractions and fractures in endodontically treated teeth. Int Endod J. 2005 Sep;38(9):653-7.
[75]. Ozturk B, Ozer F. Effect of NaOCl on bond strengths of bonding agents to pulp chamber lateral walls. J Endod 2004;30:362e5.
[76]. Barutcigil C, Harorl OT, O¨zcan E, Arslan H, Yıldız M. Effects of ethylenediaminetetraacetic acid and sodium hypochlorite onthe bond strength of bonding agents to pulp chamber lateral walls. J Dent Sci 2014;9:229e34.
[77]. Kalyoncuoglu E, Ertas, E. Effect of sodium ascorbate on dentin bond strength after treatment with oxidizing root canal irrigants. J Dent Sci 2015;10:139e44.
[78]. Xie H, Zhang F, Wu Y, Chen C, Liu W. Dentine bond strength and microleakage of flowable composite, compomer and glass ionomer cement. Aust Dent J. 2008 Dec;53(4):325-31.

[79]. Erdilek N, Ozata F, Sepetcioglu F. Microleakage of glass ionomer cement composite resin and glass ionomer resin cement. J Clin Pediatr Dent. 1997 Summer;21(4):311-4.
[80]. Adnan S, Khan FR. Comparison of Micro-Leakage around Temporary Restorative Materials Placed in Complex Endodontic Access Cavities: An In-Vitro Study. J Coll Physicians Surg Pak. 2016 Mar;26(3):182-6.
[81]. Vârlan C, Dimitriu B, Vârlan V, Bodnar D, Suciu I. Current opinions concerning the restoration of endodontically treated teeth: basic principles. J Med Life. 2009 Apr-Jun;2(2):165-72.
[82]. Sarne S, Mante MO, Mante FK. Marginal leakage of combinations of glass-ionomer and composite resin restorations. J Clin Dent. 1996;7(1):13-6.
[83]. Turner JE, Anderson RW, Pashley DH, Pantera EA Jr. Microleakage of temporary endodontic restorations in teeth restored with amalgam. J Endod. 1990 Jan;16(1):1-4.
[84]. Abuhaimed TS, Abou Neel EA. Sodium Hypochlorite Irrigation and Its Effect on Bond Strength to Dentin. Biomed Res Int. 2017;2017:1930360.
[85]. Corresponding Author: Bogomil Andonov, email: bogiandonov3@gmail.com

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