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Original Article

SEM Analysis of the Endodontic Cavity Wall after Removal of Restorative Materials Used as Temporary Restoration

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Abstract

Aim: The aim of the present in vitro study was to analyze the endodontic cavity walls for presence of remnants of conventional glass ionomer cement and flowable light cure composite used as temporary restorative materials of endodontically treated teeth. The dentine surface of the access cavity was observed with scanning electron microscopy after the final removal of the temporary restoration using high-speed turbine and diamond bur or ultrasonic device and diamond tip.

Materials and methods: Twenty-one extracted intact human molars were selected for this study. Endodontic access, enlargement of the coronal one third of the root canals and standard irrigation were performed. Teeth were then restored with two different materials – conventional glass ionomer cement (Ketac Molar Easymix, 3M ESPE, USA) and flowable light cure composite (Vertise flow, KERR, USA) and divided in four groups according to the method of removal and type of material used for temporary restoration. One sample, positive for temporary material remnants, was used as a control group. After the removal of the restorative material, all specimens were prepared for SEM examination. Scanning Electron Microscopy (Prisma E SEM, Thermo Scientific, Eindhoven, The Netherlands) was used to examine the surface morphology of the samples. The samples were sputter-coated with gold using vacuum evaporator (JEOL JFC-1200). The images were recorded at 20 kV acceleration using various magnifications (×150, ×500, and ×1000).

Results and conclusions: Remnants were detected in all specimens, regardless of the material for temporary restoration or method of removal.

Keywords

glass ionomer, light cure composite, material remnants, magnification

INTRODUCTION

Post-endodontic restoration plays an important role in the short- and long-term prognosis of endodontically treated teeth.[1] Contemporary approach in endodontic treatment provided by advanced technology and techniques determines a single visit therapy.[2,3] Unfortunately, some clinical cases still require multiple visit therapy, which demands temporary restoration of the endodontic cavity.[4,5] The mechanical properties of the materials used for endodontic cavity isolation until the next appointment may influence the prognosis due to recontamination or microleakage, which helps the residual root canal microflora to flourish. Polymicrobial characteristics of the endodontic

and periapical pathosis are a challenge for scientists. In their research, Zehnder and Belibasakis analyze the evidence of new bacterial species, bacteria interaction, and the immune response as some of the unsolved problems.[6] Pre-endodontic build-up may also be described as a temporary restorative procedure along with the interappointment sealing of the endodontic access.[7,8] The type of adhesion of restorative materials used for temporization may hinder the procedure of their removal and remnants will alter the following protocol of final restoration. The provisional quality of post-endodontic build-up depends on the amount of coronal dentine left and, at the same time, on its surface characteristics. Excessive loss of sound dentine during the removal of temporary restorative materials will make the tooth less resistant to masticatory forces.[9] Detailed control at this stage is of greatest importance.

AIM

This study is focused on the registration of temporary material remnants left on the endodontic cavity walls after controlled removal using magnification and an alternative light source. Scanning electron microscopy with different magnifications was used to analyze the dentine surface.

MATERIALS AND METHODS

Teeth irrigation and obturation

Twenty-one intact upper and lower molars were selected, extracted, and provided for this study. Inclusion criteria were absence of carious lesions, non-carious defects or cracks and crown or root fractures, and complete root formation. Traditional endodontic access was prepared using a diamond bur turbine. For enlargement of the coronal one-third of all root canals Gates Glidden numbers 1, 2, and 3 were used.

Passive irrigation was provided using a syringe and a needle in the following sequence: the needle entered every single root canal until it was blocked and then withdrawn half to one millimeter. The first solution was 3% sodium hypochlorite, which filled in the whole space of the endodontic access. After the last root canal irrigation, sodium hypochlorite was left in the cavity for 10 min then sucked out and the same sequence was performed with 17% EDTA. This procedure was repeated twice (Hillesheim et al.[10]). Ethanol 90% was used for final irrigation. Root canals and endodontic access were then dried with a cotton pellet and paper points (No. 40-15).

Orifices and pulp chamber were isolated with phosphate cement and the access cavity was obturated with conventional glass ionomer cement or flowable light cure composite according to the manufacturer's guide. The teeth were then left for 24 hours in 0.9% NaCl solution.

According to the obturation material and method of removal, the teeth were divided in four groups as follows: group 1: (n=5) restored with conventional glass ionomer cement; removal method – high speed turbine and diamond bur; group 2: (n=5) restored with flowable light cure composite; removal method – high speed turbine and diamond bur; group 3: (n=5) restored with conventional glass ionomer cement; removal method – ultrasonic device with a diamond tip; group 4: (n=5) restored with flowable light cure composite; removal method – ultrasonic device with a diamond tip. Control group: (n=1) positive for temporary material remnants.

Sample preparation for SEM analysis

After the removal of the restorative material, the root and crown portion of all teeth were separated 2 mm below the cemento-enamel junction with turbine and a diamond bur. A furrow was prepared mesiodistally on the crown fragment, engaging both proximal and occlusal surfaces. Crown was separated in two fragments, vestibular and oral, in the area of the furrow and subjected to chemical fixation for SEM examination. The following protocol was followed for each sample: 1 min tap water, 20 min 3% sodium hypochlorite, 20 min 17% EDTA, 30 min 70% ethanol, 30 min 90% ethanol, and 10 min left on a flat surface to dry. The exposure in 17% EDTA aims to remove the smear layer formed during the temporary restorative material removal procedure. A clean dentinal surface will be revealed and firmly attached remnants will be exposed and registered on SEM.

SEM analysis of prepared samples

Scanning electron microscopy (Prisma E SEM, Thermo Scientific, Eindhoven, The Netherlands) was used to examine the surface morphology of the samples. The samples were sputter-coated with gold using a vacuum evaporator (JEOL JFC-1200). The images were recorded at 20 kV acceleration voltage using various magnifications.

Statistical analysis

Pearson's chi-square test was used for statistical analysis. $p<0.05$ was considered a significance level.

RESULTS

Twenty-four hours after teeth irrigation (with sodium hypochlorite, EDTA and ethanol), and obturation with conventional glass ionomer cement or flowable light cure composite, the obturation material was removed.

Removal of the restorative material with turbine and diamond bur was controlled under magnification (×7) with a microscope (CMO, Karl Zeiss Jena, Germany). An alternative light source (LED light source adapted for the research) was used until no remnants of the material were detected **(Fig. 1)**.

Temporary material remnants are observed in control groups on SEM. Glass ionomer cement (not presented) and light cure composite have the same appearance **(Fig. 2)**.

The SEM analysis revealed temporary material remnants in all samples restored with glass ionomer cement (Group 1 and Group 3) regardless of the method for removal ($p \leq 0.05$). The remnants were detected as small individual particles or clusters of particles with an irregular shape, surrounded by a clean dentinal surface. They were registered at different magnification ranges (×150, ×500), usually localized at the occlusal and middle third of the cavity wall **(Fig. 3)**.

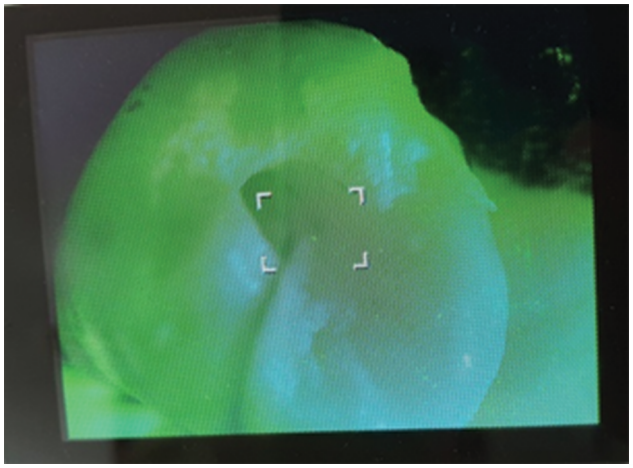

Figure 1. The appearance of material remnants under magnification (×7) and alternative light source (LED).

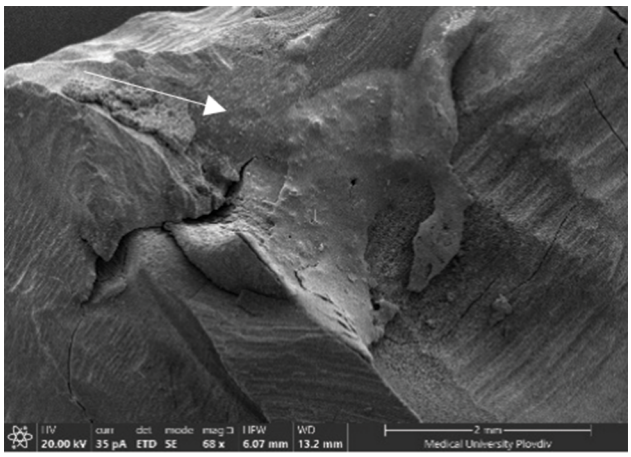

Figure 2. Control group positive for temporary material remnants. The arrow shows the remnants.

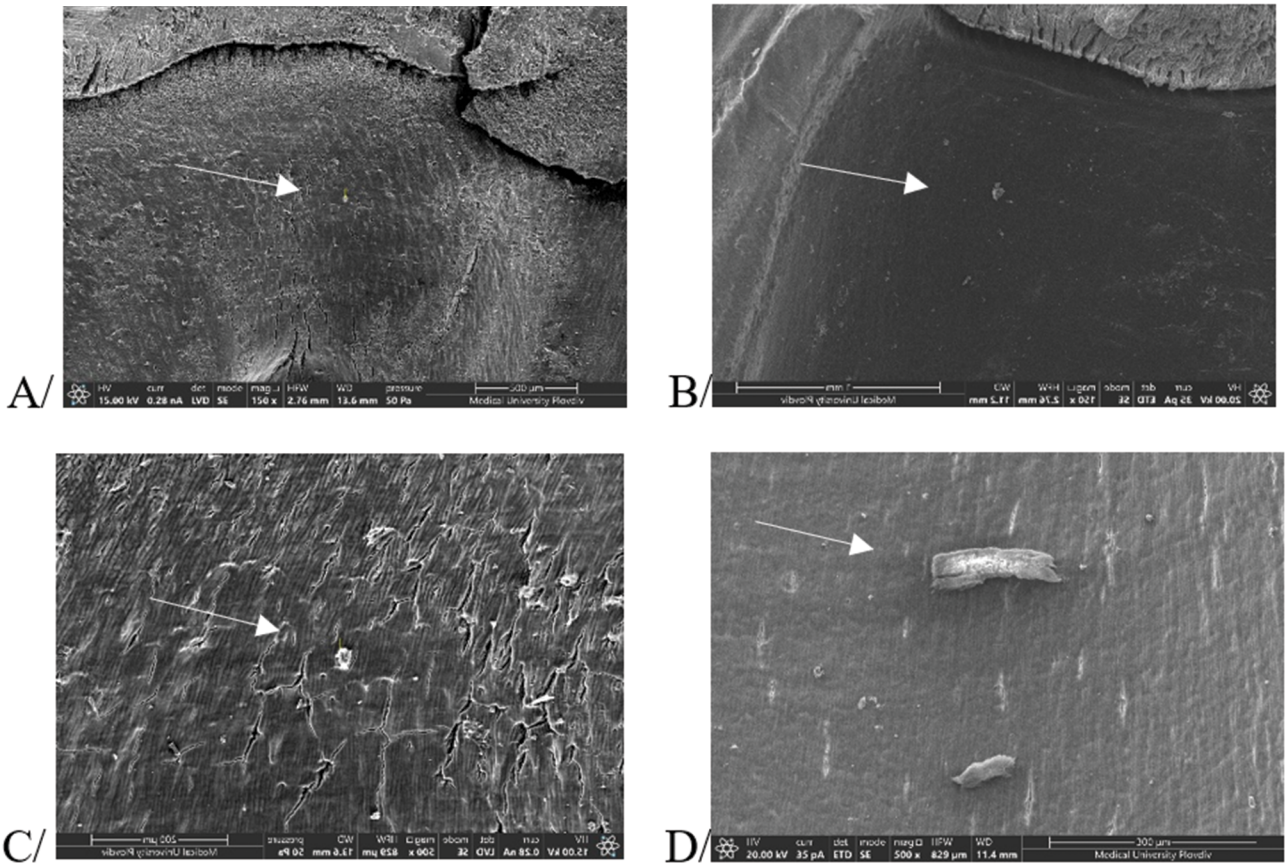

Figure 3. Glass ionomer cement remnants after removal with: **A**. turbine (magnification ×150); **B**. ultrasound (magnification ×150); **C**. turbine (magnification ×500); **D**. ultrasound (magnification ×500). The arrows point at the remnants.

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Analysis of the teeth restored with flowable light cure composite (groups 2 and 4) showed that remnants can be detected on the surface of the cavity in all samples regardless of the method for removal ($p \leq 0.05$). They were seen under different magnifications (×150, ×500) as scattered irregular small-sized particles mainly localized on the occlusal one third of the cavity **(Fig. 4)**.

DISCUSSION

The clinical approach in some cases of endodontic pathology requires more than one appointment.[11,12] Isolation of the endodontic space until the next visit, on the other hand, is crucial for the treatment outcome, because it retains the results from the already provided procedures and protects the tooth against recontamination. Temporary restoration of the endodontic access in this manner plays an important role as part of the treatment.[13,14] A possible path for microleakage is the contact area between the material and the tooth surface. The integrity of the provisional restoration during the interappointment period is also important because cracks and reduced thickness are premises for recontamination. According to Sivakumar et al., in addition to preventing bacterial ingress, provisional restorations used during endodontic treatment must also meet the following three criteria: the tooth functioning must not be altered, the operator must have adequate access to the root canal system, and the patient has to be able to maintain daily oral hygiene to prevent caries and retention of plaque and calculus.[15] It means that the material used for sealing the endodontic cavity between the appointments needs to be resistant to masticatory forces and the dental practitioner has to be able to easily remove it from the cavity. Glass ionomer cements and light cure composites meet these requirements but their removal from the cavity is an issue because of the type of adhesion with the hard dental tissues and their shade, which resembles the tooth structures. Total removal may influence the quality of the final restoration by altering the effect of dentine bonding agents as Hansen and Asmussen stated in their research.[16] Dimashkieh et al. propose a technique for removing composite resin restorations underlining the difficulties in detecting thin layers of the material on the cavity wall.[17] These findings support our statement that temporary material remnants may reduce the contact surface for optimal adhesion of the final restoration. Control during this procedure is usually provided with a naked eye or magnification. According to some new studies, additional methods for improving visibility are used.[18-20] Clean endodontic cavity surfaces are mandatory for the quality of the final restoration providing better adhesion with the restorative material.[21,22]

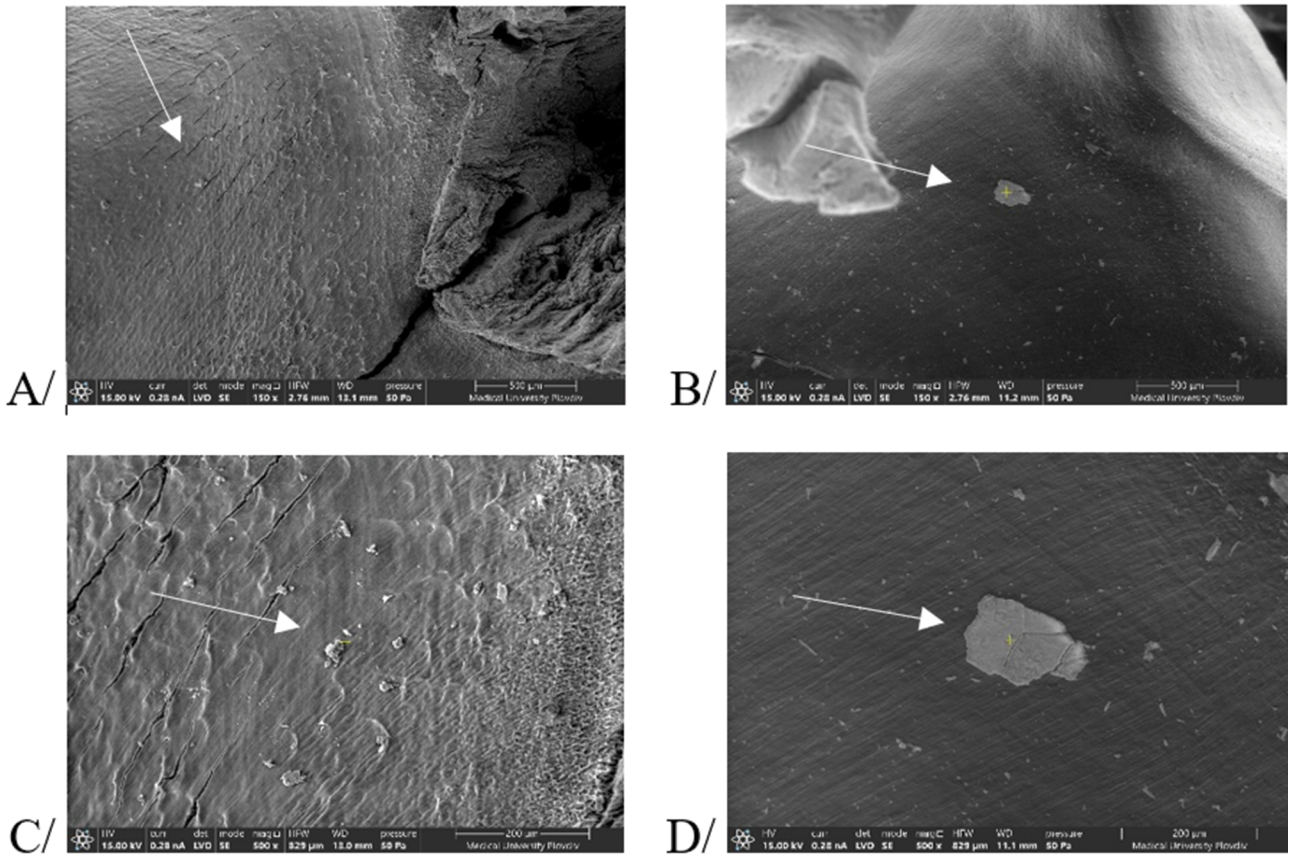

Figure 4. Flowable light cure composite remnants after removal with: **A**. turbine (magnification ×150); **B**. ultrasound (magnification ×150); **C**. turbine (magnification ×500); **D**. ultrasound (magnification ×500). The arrows show the remnants.

Scanning electron microscopy evaluation of the endodontic cavity wall for temporary restorative material remnants gives detailed information about the quality of the dentinal surface before the procedure of post-endodontic restoration.[23,24] This study shows that remnants are present on the access cavity wall in all examined specimens.

CONCLUSIONS

The short- and long-term prognosis of the endodontic treatment depends on different factors and one of them is the quality of post endodontic restoration. In most cases, adhesive materials are preferred for this procedure. Temporary material remnants may influence the quality of the adhesion because they will block the contact between dentine and restorative material. This study shows that small, individual or group of temporary restorative material remnants are observed in all examined specimens. It is concluded that their size and number may not interfere with the final result of the post endodontic restoration. Improving the methods for control of the removal of temporary restorative material will ensure a better prognosis of the endodontically treated tooth.

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Competing Interests

The authors have declared that no competing interests exist.

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СЭМ-анализ стенки эндодонтической полости после удаления реставрационных материалов, используемых в качестве временной реставрации

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Резюме

Цель: Цель настоящего исследования *in vitro* заключалась в анализе стенок эндодонтической полости на наличие остатков обычного стеклоиономерного цемента и текучего светоотверждаемого композита, используемых в качестве временных реставрационных материалов эндодонтически пролеченных зубов. Поверхность дентина в полости доступа наблюдали с помощью сканирующей электронной микроскопии после окончательного удаления временной реставрации с помощью высокоскоростной турбины и алмазного бора или ультразвукового аппарата и алмазной насадки.

Материалы и методы: Для этого исследования был отобран 21 интактный коренной зуб человека. Выполнен эндодонтический доступ, расширение коронковой трети корневых каналов и стандартное орошение. Затем зубы были восстановлены двумя разными материалами – обычным стеклоиономерным цементом (Ketac Molar Easymix, 3M ESPE, США) и текучим светоотверждаемым композитом (Vertiseflow, KERR, США) и разделены на четыре группы в зависимости от метода удаления и типа реставрационного материала, используемого для временной реставрации. Один образец, положительный на временные остатки материала, использовался в качестве контрольной группы. После удаления реставрационного материала все образцы были подготовлены для СЭМ-исследования. Сканирующую электронную микроскопию (Prisma E SEM, Thermo Scientific, Эйндховен, Нидерланды) использовали для исследования морфологии поверхности образцов. Образцы напыляли золотом с помощью вакуумного испарителя (JEOL JFC-1200). Изображения были записаны при ускорении 20 kV с использованием различных увеличений (×150, ×500 и ×1000).

Результаты и заключение: Остатки были обнаружены во всех образцах, независимо от материала для временной реставрации или метода удаления.

Ключевые слова

стеклоиономер, светоотверждаемый композит, остатки материала, увеличение