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A Comparative Evaluation of Microleakage Among Bulk Fill Composite Restoration and Zirconia Reinforced Glass Ionomer Cement Used As A Core Build-Up Material In Endodontically Treated Teeth: An In-Vitro Study

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Abstract

The success of endodontic treatment is generally depending upon the apical as well as the coronal seal. Thus, determining the effectiveness of coronal seal and further leading to microleakage of newer materials such as Bulk fill composite resin (Filtek Bulk fill) and Zirconomer being introduced in clinical practice is needed. the purpose of the present study was to evaluate and compare the microleakage among bulk fill composite and zirconomer (Zirconia Reinforced Glass Ionomer Cement) used as a core build-up material in endodontically treated teeth. Twenty-eight extracted permanent mandibular first molar teeth were collected. Standardized endodontic treatment was performed in all collected sample teeth. The core build-up of group 1 was restored with Bulk Fill Composite 3M™ ESPE™Filtek™ Bulk Fill Composite. The core build-up of group 2 was restored with Zirconomer (Zirconia Reinforced Glass Ionomer Cement) SHOFU. All restored sample was placed in artificial saliva for seven days. Teeth were subjected to thermocycling after that microleakage assessment was done using the dye

penetration method. All samples were sectioned longitudinally with a water-cooled diamond disk. The sections of each sample were examined under a stereomicroscope at 10x magnification. In the results, it was found that after comparing the microleakage between the two groups the mean rank of group 1 was found 12.57 and in group 2 the mean rank was found to be 16.43. The Mann-Whitney test was applied for the comparison. Both groups had shown an amount of microleakage but the bulk fill composite (Group 1) exhibit less extensive microleakage compared to Zirconomer (Group 2), but there was no statistically significant difference (p-value = 0.227) between the microleakage of the two groups.

Keywords: Bulk-fill composite, Core build-up, Endodontically treated teeth, Microleakage, Zirconomer.

Introduction

Dental caries, widely known as tooth decay, is one of the most predominant chronic diseases of people globally, individuals are susceptible to this disease throughout their lifetime. Dental caries is a progressive, irreversible microbial disease affecting the dental hard tissues exposed to the oral environment, resulting in the demineralization of the inorganic constituents followed by the destruction of organic constituents leading to cavity formation.[1]

There is growing awareness among people regarding the importance of preserving natural teeth, and thus endodontic treatments are gaining popularity worldwide. Conventional endodontic treatment has a high success rate of up to 95%, but failure has been noted in 5% to 10% of cases. The success of endodontic therapy generally depends upon apical as well as coronal seals. **Marshall and Masseler** (1961) were the first to report on coronal leakage. [2]**Torabinejad*et al.*** (1990) then found bacterial products at the apex of a root-filled tooth after 3 months in the absence of coronal restoration. [3]**Ray and Trope** in the year 1995 published a study showing a possible relationship between the quality of coronal restoration and the apical status of endodontically treated teeth. [4]

Microleakage is defined as the 'diffusion of bacteria, oral fluids, ions and molecules into the tooth and the filling material interface' or 'defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between the tooth and restorative material. [5] Coronal microleakage is an important factor in the result of endodontic therapy. [6]**Swanson and Madison** stated that whenever there is a loss of coronal seal, reinfection occurs within 3 days.[7] In endodontic treatment, it is important to seal the access cavities at the end of treatment and a proper coronal restoration will prevent bacterial dissemination in canals. The restoration of endodontically treated teeth should provide adequate marginal seal and strength to the remaining tooth structure and not only try to achieve functional but also aesthetic harmony. The success of treatment can also be achieved by selecting proper restorative material to fill the access cavity.

The popularity of composite resin has increased because of its excellent aesthetic and other features. The new and evolving trend in restorative materials, called "bulk fill" dental composites, is slowly swapping all additional resin-based restoratives in the market. These bulk-fill composite restoratives can be light cured to an increment thickness of 4 mm in class I cavity and 5 mm for class II cavity or more along with a high degree of conversion, minimal shrinkage, and superior physical and mechanical properties.

Recently, Zirconia reinforced glass Ionomer (Zirconomer) was introduced that could overcome the disadvantage of previously used tooth-coloured

restorative material.Zirconia-reinforced glass Ionomer is a high-strength restorative material reinforced with ceramic and zirconia fillers. The addition of zirconia as a filler particle in the glass component of Zirconomer improves the mechanical properties of the restoration by reinforcing the structural integrity of the restoration in load-bearing areas where amalgam is the material of choice. [8]A new formulation of GICs (Zirconomer) by SHOFU, Japan, incorporated zirconia filler particles which lead to good abrasive resistance with a fast setting reaction.It also improved the masticatory as well as the bending strengths of the set cement.

Newer materials should be tested in an attempt to gain an effective coronal seal and decrease the rate of treatment failures. Thus, evaluating the microleakage of newer materials such as Bulk fill composite resin (Filtek Bulk fill) and Zirconomer is essential. It is said that closing the door on microleakage opens the door to a more expectable and effective way possible for successful endodontic treatment.

Materials And Methods

The present study was an In-Vitro Study to evaluate and compare the microleakage among Bulk Fill Composite & Zirconia Reinforced Glass Ionomer Cement in endodontically treated teeth. Before the start of the study, a protocol for the intended study was presented to the Institutional Ethical Committee (IEC). Ethical Clearance was obtained after the presentation and consideration of the committee members.

The sample size was calculated using data obtained from previous research conducted by **Kranthikumar Reddy. S***et al.* A Comparative Evaluation of Marginal Adaptation of Different Bulk fill Composites Using Stereomicroscopy: An In-Vitro Study. [9] A total of thirty-five extracted human permanent mandibular first molar teeth were collected. All teeth were viewed under a microscope for micro-fracture, and fracture line, and those teeth were excluded. Teeth those which were fulfilling the inclusion criteria were selected by the Simple Random Sampling technique. The total sample size was 28 for two groups, thus, there was 14 samples in each of the two groups to be compared. Inclusion criteria were extracted permanent mandibular first molar teeth extracted for periodontal reasons. And full root length. Exclusion criteria were grossly decayed tooth, observable fracture line, the tooth with an anatomic defect, the tooth with accessory canals, calcified canal, excessive curvature.

Calibration and training were done to ensure the consistent depth and size of cavity preparation and mixing of zirconomer and placement of both restorations. The cavity preparation and restoration were done by only one operator to avoid inter-operator errors.

Then, the teeth were immersed in a hydrogen peroxide solution. Extracted teeth were cleaned for remaining connective tissues and debris using ultrasonic scaling and stored at 4^{o}C in physiological saline till its use. All selected teeth were stabilized in a rectangular block of modelling wax having a dimension of the length of 20 mm, width of 17 mm, and height of 17 mm. [10] Standardized endodontic access openings of 4.0 × 4.0 mm wide and 5mm deep teeth were made using an airotor and round bur. [11, 12] The depth of the cavity was kept 5 mm deep to ensure the standardized restorative procedure for restoration. The depth and width were measured by the UNC-15 probe. The prepared access was flushed with 2.5% of sodium hypochlorite and a size 10 K file was inserted into the canal then 15 K-file (Dentalkart) was inserted into the canal until it appeared at the apical foramen. The working length of the canal was calculated by reducing 1 mm from this precise length. All the teeth were prepared with rotary

ProTaperfiles (Dentsply/Maillefer, Switzerland). The orifice was enlarged with the SX instrument. Then, S1, S2, FI, F2, and F3 files were used consecutively with torque and speed per the recommendations of the manufacturer. The root canals were irrigated with 2.5% sodium hypochlorite (NaOCl). After the final preparation, the canals were irrigated with 5 ml of 17% ethylene diamine tetra acetic acid (EDTA) (OrikamNeoedta Gel) solution for 30 seconds followed by 5 mL of 2.5% sodium hypochlorite (NaOCl).[8] The last and final irrigation was done with saline. All teeth were prepared in the same sequence as described. The root canals were dried with the paper points and obturation was done with the matching gutta-percha cone (Dentsply/Maillefer, Switzerland) and AH plus sealer (Dentsply/Maillefer, Switzerland) with the single-cone technique. [8] After the obturation, all the samples were stored in 100% humidity for 48 hours to allow the sealer to set. [8]

Group 1: Included 14 tooth samples which were restored with Bulk Fill Composite as a core build-up restoration (3M™ ESPE™Filtek™ Bulk Fill Composite).

Group 2: Included 14 tooth samples which were restored with Zirconomer (SHOFU Japan) as a core build-up restoration.

After the endodontic procedure, the access cavity was filled with 3M™ ESPE™FiltekTM Bulk Fill Composite. All samples were etched with 32% phosphoric acid (Scotchbond™ Universal Etchant)**.** The etchant was applied for 15 seconds to the enamel and dentin and was rinsed using water for 15 seconds spray afterward which was air dried for 5 seconds to leave the dentin moist and shiny according to the manufacturer instructions.

In all samples, nanofilled adhesive Adper™ Single Bond 2 (3M ESPE, USA) was applied followed by light curing. Curing for adhesive was done for 10 seconds with the LED curing unit (Premium Plus CO2 Curing Light) with an output of 1,000 mW/cm2. The preparation was restored with bulk-fill composite (Filtek™ Bulk fill composite, 3M ESPE, USA). The depth of the access was measured with a UNC-15 probe. Then, the 5 mm bulk increment was placed as the final increment using Teflon-coated instruments. The restoration was condensed and carved using Teflon-coated instruments followed by light curing (Premium Plus CO2 Curing Light) for 20 seconds.

Group 2: Zirconomer (Zirconia Reinforced Glass Ionomer)

After the endodontic procedure, the access cavity was filled with Zirconomer (Zirconia Reinforced Glass Ionomer) SHOFU Japan. Two level scoops of powder were dispensed with the measuring scoop provided onto a mixing pad. One drop of liquid is dispensed separately on a mixing pad. Standard Powder to Liquid ratio: 3.6 g/1.0 g (3.6:1.0 m/m) was taken according to the manufacturer instructions. A measuring scoop was used to level off the powder for accurate dispensing. The liquid bottle was inverted before use to dispense drops of bubble-free liquid. The dispensed powder was divided into 2 equal portions; the first half was introduced to the dispensed liquid and it was mixed for 5-10 seconds with the plastic spatula. After that remaining half was added and mixed until it had reached a thick putty-like consistency. Mixing was completed within a total of 30 sec. The prepared cavity was rinsed with water and dried. Then, 5 mm of bulk increment was filled into the cavity using a plastic filling instrument. The restoration was condensed using a condenser. After seven minutes of placement, the material was hard enough. Petroleum jelly was used as a lubricant to prevent excess heat and desiccation of the cement. After finishing, the surface

was coated with petroleum jelly for protection against moisture.

All restored teeth werestored in artificial saliva at 37°C for 7 days. The pH of the artificial saliva was 7. Thermocycling was done at 5°C and 55°C: 500 cycles with a dwell time of 30 seconds and a transfer time of 15 seconds as per the standardized ISO protocol. All samples were immersed in a mesh bag in a thermocycling chamber at 5°c and also at 55°C.

Method of microleakage assessment: [8,13]

The samples were coated with three layers of nail polish except for the 1 mm area around the access preparation. The samples were then immersed in 2% methylene blue for 24 hours. After 24 hours of immersion, the samples were washed in tap water and dried. All samples were sectioned longitudinally with a water-cooled diamond disk. The sections of each sample were examined under a stereomicroscope at 10x magnification. All results were recorded.

Scoring Criteria: [8]

Dye leakage was graded as per the following criteria.

- 0- No leakage—if the dye was not penetrated along the guttapercha and pulp chamber.
- 1- Slight leakage—if the leakage was just reaching into the dentin.
- 2- Moderate leakage—if the leakage was to the pulp chamber.
- 3- Extensive leakage—if the leakage was penetrating until the floor of the pulp chamber and root canal.

Results

Data were analysed using SPSS version 26. The level of significance was kept at 5%. Descriptive statistics was used to calculate frequency and percentage of samples according to microleakage score. Descriptive statistics was used to calculate median and mode of microleakage score. Comparison of microleakage between two groups was calculated using Mann-Whitney test where p value was 0.05.

Figure no. 1. Shows the distribution of the score of microleakage in group 1 and group 2 for each sample of 14 samples in each group.

In the present study Table, no. 1 shows the distribution of the number of samples according to microleakage score in frequency and percentage. In group 1 score 1 was observed in 3 (21.40%) samples, score 2 was observed in 7 (50.00%) samples, score 3 was observed in 4 (28.6%) samples. Among fourteen samples in group 2 score 1 was observed in 2 (14.30%) samples, score 2 was observed in 4 (28.60%) samples, and score 3 was seen in 8 (57.10%) samples.

In group 2, the highest score of 3 was seen in most of the 8 samples out of 14 samples whereas in group 1 highest score of 3 was observed in most of the 4 samples out of 14 samples, and score 1 was seen in 3 samples of group 1 compared to group 2 which was seen in 2 samples. In group 1 score of 2 was observed in most of the 7 samples out of 14 samples whereas in group 2 score of 2 was observed in only 4 samples out of 14 samples.

The descriptive statistics were calculated using median and mode as shown in Graph no. 2. The median of group 1 was 2 and in group 2 it was 3 while the calculated mode in group 1 was 2 and in group 2 it was 3. Median and mode were higher in group 2 (Median- 3, Mode- 3) compared to group 1 (Median- 2, Mode- 2) as shown Figure no. 2.

The Mann-Whitney test was applied for the comparison of the microleakage between the two groups. The mean rank of group 1 was found 12.57 and in group 2 the mean rank was found to be 16.43. Results of the study showed that the microleakage was observed in both groups but there was no statistically significant difference (p-value = 0.227) between the microleakage

when compared between group 1 and group 2 as shown in Table no. 2.

Discussion

The rising trend in restorative materials, which is the so-called "bulk fill" dental composites, is slowly replacing all other resin-based restoratives in the market, which is also used as a core build-up material. Also, another type of cement, zirconomer (Zirconia Reinforced Glass Ionomer Cement) is used as a core build-up material which needs to be evaluated and compared for microleakage assessment in endodontically treated teeth. Thus, the present study was conducted to evaluate and compare the microleakage of Bulk Fill Composite Restoration against the microleakage of Zirconia Reinforced Glass Ionomer Cement used as a core build-up material in endodontically treated teeth. In earlier research, it was found that molars requiring endodontic treatment are 52.6%. The mandibular first molar was treated most often (18.8%), followed by the maxillary first molar (13.5%) and the mandibular second molar (12.0%). [14]

Thermocycling is the in-vitro process of subjecting a restoration and tooth to temperature extremes that imitate those found in the oral cavity. Literature suggests that the evaluation of microleakage must include thermocycling to simulate intraoral conditions.[15] To best mimic the oral conditions, thermocycling was undertaken in the current study, and the samples were subjected to thermocycling following 500 phases at 5°C and 55°C at a dwell period of 30 seconds and a transfer time of 15 seconds as per the standardized ISO protocol. [8]

Methylene blue (2%) was used in this study because of its low cost, ease of application, and low molecular weight of dye, which is smaller than bacteria. The molecular weight of this dye is lower than bacterial toxins. This dye exhibits microleakage the same as butyric acid which is a metabolic product for microbes. [8]

In the present research in group 1 score 1 i.e., slight leakage (if the leakage was just reaching into the dentin) was found in 3 (21.40%) samples these findings are supported by a study conducted by **Mohammed K Fahmi***et al.* [8] when compared the microleakage score of bulk fill composite placed in bulk and when placed with an increment technique it was found that score 1 i.e., slight leakage (if the leakage was just reaching into the dentin) was observed in 10 samples when placed in bulk. In the present study in group 1 score 2 i.e., Moderate leakage (if the leakage was till the pulp chamber) was found in 7 (50.00%) samples contrary to this finding study conducted by **Mohammed K Fahmi***et al.* [8] when compared the microleakage score of bulk fill composite placed in bulk and when placed with an increment technique it was found that score 2 i.e., Moderate leakage (if the leakage was till the pulp chamber) was observed in 3 samples. This contrary result was observed because of the technique sensitivity of the bulk-fill composites as the literature suggests that the incrementally filled bulk-fill composites sealed significantly better than the bulk-fill composite used with the bulk technique.

In the present study, it was found that in group 1 (Bulk Fill composites) score 3 i.e., Extensive leakage (if the leakage was penetrating until the floor of the pulp chamber and root canal) was observed in 4 (28.6%) samples these findings are supported by the result of a study conducted by **Mohammed K Fahmi***et al.* [8] found that score 3 i.e., extensive leakage was found in only 1 case when compared the microleakage score of bulk fill composite placed in bulk and with an increment technique. Extensive leakage was observed in only 1

sample but in the findings from the study conducted by **Mohammed K Fahmi***et al.* [8], the author concluded that the incremental technique performs well when compared to the bulk fill technique. In the present study moderate score and the extensive score were observed in 7 (50.00%) and 4 (28.6%) samples respectively these findings were observed because of the technique sensitivity of bulk fill composite material and there is a plethora of studies which supports the benefits of incremental techniques: **Loguercio *et al*. [16],Al-Harbi et al. [17],Tiba et al. [18],Moezyzadeh and Kazemipoor[19],Jang et al. [20],and Reis et al. [21]**

In the present study Bulk fill composite i.e., Group 1 exhibits an extensive leakage in 4 (28.6%) samples, these results are in line with the study conducted by **ReetubritaBho***et al.* found that the highest mean values of microleakage were seen in group 1 (packable bulk fill composite) 1.18 ± 0.49. [7] also, another study conducted by **Dodiya***et al.* found less amount of marginal adaptation with composite. [22] Literature states that leakage in composites can be clarified based on polymerization shrinkage which results in a poor bonding ability to tooth structures.

The deep access preparations after endodontic treatment can lead to a difficult situation for restorations as they have a high C factor. The distance between the light curing tip and the composite surface to be cured is also a limiting factor for the curing of bulk-fill composite. When the distance between the tip of the curing light and the surface of the resin is more than 2 mm, the intensity of light is reduced significantly. **Annelies Van Ende***et al.* stated that the polymerization process of composite restoration may be compromise ed if the curing light loses its intensity due to attenuation before reaching the bottom of the cavity.[23] This can compromise the polymerization of resins and even the bond between the adhesive and the dental composite and which can lead to microleakage in a bulk-fill composite when used as a core build-up material.

In the present experiment, it was observed that the higher microleakage found in group 2 (Zirconomer) score 3 was observed in 8 (57.10%) samples compared to group 1 (Bulk Fill Composite). These findings of the present study are in accordance with the study conducted by **Mayank U. Patel***et al.*[13] found that the zirconomer exhibited the highest microleakage as compared to composite and amalgam when placed in class I restoration in first and second molars. This could be because of the chemical structure of Zirconomer which contains ceramic particles (zirconia) as fillers. It is possible that the zirconia fillers would cause interference in the chelating reaction between the carboxylic group (-COOH) of poly-acrylic acid and the calcium ions (Ca2+) of tooth apatite.

In the present study the mean rank of microleakage in group 2 was found to be 16.43 compared to group 1 was found 12.57 which means zirconomer shows higher microleakage compared to bulk fill composite this finding of the study was supported by the study conducted by **Rawan Albeshti** and **Saroash Shahid** [24] found that a significant degree of leakage was exhibited in Zirconomer restorations after 24 hours of dye immersion compared to other glass ionomer cement. This is believed to be due to the large size of the filler particles of zirconia which led to poor adaptation at the tooth-restoration interface.

The study was conducted by **Prabhakar***et al.* and it was observed that the marginal adaptation of Zirconomer was inferior compared with conventional GICs.[25] Literature supports that despite being the more modern material, Zirconomer had the highest microleakage when compared with composite and amalgam.

Limitations of the study

The limited sample size was addressed in this study. Hence, studies with a larger sample size are needed for further validation of results.

Recommendations

Additional research is needed to estimate the accurate clinical excellence of these resources to validate their in-vitro predictable outcomes.

Figure 1: Distribution of Score of Microleakage in each sample

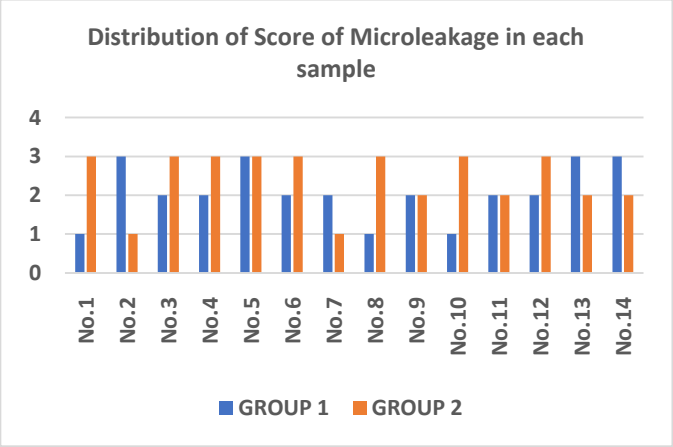

Figure 2: Descriptive Statistics of Microleakage Score

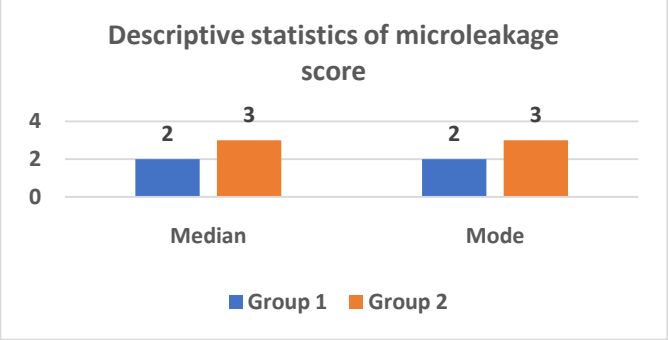

Table1: Distribution of the number of samples according to microleakage score

Group		Microleakage			
		Score 0	Score 1	Score 2	Score 3
Group 1	n	0	3	7	4
	%	0%	21.40%	50.00%	28.60%
Group 2	n	0	2	4	8
	%	0%	14.30%	28.60%	57.10%

Table 2: Comparison of microleakage between two groups

Group	Mean rank	p-value
Group 1	12.57	0.227 (NS)
Group 2	16.43	

Mann Whitney test; NS: Non-significant difference (p = 0.05)

Conclusion

From the present study, we can conclude that marginal microleakage should be considered in the evaluation of a restorative material because it has been directly related to the success or failure of the restorations as well as endodontic treatment. For the betterment of endodontic treatment, one should strive to achieve the highest marginal adaptation quality to increase success rates and prognosis of treatment. It can be concluded that the resistance to microleakage of zirconomer is inferior to that of Bulk Fill (Composite 3M™ ESPE™Filtek™ Bulk Fill Composite). According to the results of this study Zirconomer (Zirconia Reinforced Glass Ionomer Cement) SHOFU exhibited the highest microleakage as compared to composite. The selection of proper restorative material should be taken into consideration for the success of endodontic treatment.

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Legends Figures

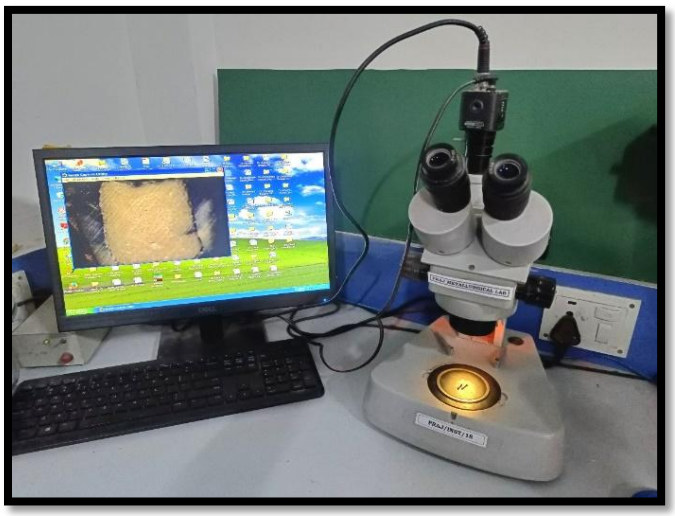

Figure 1: Each Sample Was Examined Under a Stereomicroscope At 10x Magnification.

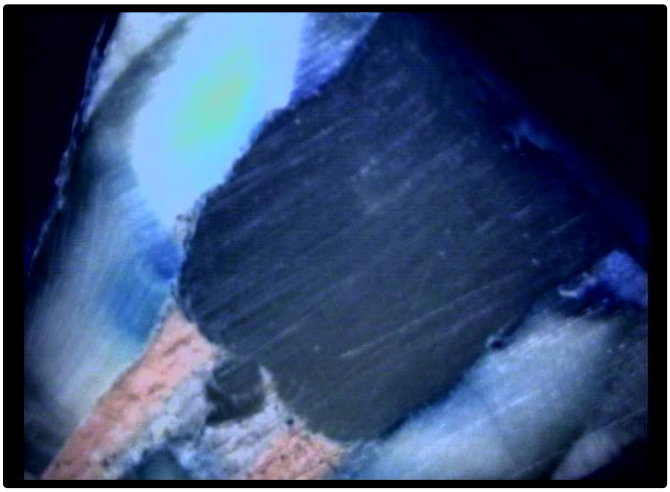

Figure 2: Group 1(Bulkfil Composite): Score 1- Slight leakage—if the leakage was just reaching into the dentin was examined under a stereomicroscope at 10x magnification

Figure 3: Group 2 (Zirconomer): Score 3- Extensive leakage—if the leakage was penetrating until the floor of the pulp chamber and root canal was examined under a stereomicroscope at 10x magnification