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ORIGINAL RESEARCH

To Evaluate the Effect of Presence and Absence of Smear Layer with Different Instruments and Obturation Methods on Microleakage of Root Canal-Filled Teeth: An *in vitro* Study

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ABSTRACT

Aim: To evaluate the effects of presence and absence of smear layer with different instruments and obturation methods on microleakage of root canal-filled teeth.

Materials and methods: A total of 100 extracted human maxillary central incisors with closed apices and single roots were taken for the study. The teeth were divided into six groups A to F consisting of 15 teeth each. Control group consisted of 10 teeth with five positive and five negative teeth each.

Groups A,B,C and D were instrumented with rotary files and groups E and F were instumented with conventional stainless steel files.

Groups A, B, C and D were flushed with 3 ml of EDTA to remove the smear layer prior to obturation. All teeth were flushed with 5% NaOCl, then obturated with AH-26 sealer with lateral condensation technique on groups C, D, E, F and injectable thermoplasticized gutta-percha obturation technique on groups A and B.

Using electrochemical technique the current flow in the circuit was observed for 45 days. The magnitude of the current for each tooth was directly proportional to the extent of leakage. At the intervals of 10, 20, 30 and 45 days the groups A-F were compared to identify statistically significant differences using students t-test.

Results: Significantly less microleakage occurred when the smear layer was removed and when the canals were obturated with thermoplasticized gutta-percha. Canals instrumented with engine driven NiTi files exhibited less leakage than hand instrumented canals.

Conclusion: Rotary instrumentation of the root canals provides a superior preparation in comparison to hand instrumentation. Removal of smear layer increases the resistance of microleakage. Thermoplasticized gutta-percha obturation appears to provide a superior seal as compared to lateral condensation.

Keywords: Canal preparation, Microleakage, NiTi files, Smear layer removal.

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INTRODUCTION

The success of root canal treatment is dictated by three parameters that is effective biomechanical instrumentation of the root canal to produce a debris-free surface, disinfection and dissolution of organic matter to eliminate bacterial pathogens and a three-dimensionally sealed and obturated canal. These factors are in turn determined by the anatomy and physiology within the root canal.[1] Of equal importance is the smear layer produced as a direct result of mechanical instrumentation. The endodontic smear layer was first described by Mccoom and Smith in SEM study and is composed of a 1 to 2 μ thick outer layer that occludes the dentinal tubules and an inner layer that penetrates the dentinal tubules to a depth less than or equal to 40 μ.[2] This smear layer can effectively preclude the penetration of sealer and/gutta-percha into the dentinal tubules, thereby increasing the likelihood of microleakage.[3] Microleakage is defined as the passage of bacteria, fluids and chemical substances between the root structure and filling of any type. Smear layer may thus provide a passage for substances to leak around or through its particles at the interface between the filling material and tooth structure.

Smear layer removal calls for a combination of solution to dissolve both organic and inorganic debris. The use of NaOCl during instrumentation and high volume flush with EDTA solution followed by NaOCl was found most effective in removing debris and smear layer from root canal walls (Yama et al 1983).[2]

Cold lateral condensation of gutta-percha is currently the most accepted obturation technique. Root canal obturation with injected thermoplasticized gutta-percha was shown to replicate a seal equal to, if not superior to that of other obturation methods.[4]

Effective instrumentation of the canal is a prerequisite for effective delivery of irrigant within the root canal system (Ram 1977). Furthermore, consistent and uniform canal preparation facilitates condensation of root canal filling which in turn enhances the apical seal.

The recent introduction of nickel-titanium instruments has been welcomed because of their superiority compared to traditional stainless steel endodontic files with regard to elasticity and resistance to torsional fracture (Walia et al, 1998).[5] Although NiTi files cause significantly less canal transportation, remain more centered in the canal, remove less dentin, and produce a rounder canal, it is not known whether their use has any effect on the sealing ability (Fraunhofer et al, 2000).

Numerous studies over the past years have endeavored to assess qualitatively the leakage potential of root canal filling materials. These methods include using bacteria (Setlzer 1955), fluorometric assay (Wiley 1970), radioactive isotope penetration (Marshall, Kapsimalis 1961, 1966), SEM (Wollard 1976) and dye penetration methods including methylene blue, India ink and silver staining (Hovland 1985). Although the assessment of the linear penetration of dye or radioisotopes has been most common, a disadvantage of the technique is that the tooth can only be tested at one time. It is then sectioned either longitudinally or transversely and the length and depth of penetration of the agent is measured in an apical-coronal direction.[6] The electrochemical technique (Jacobson and von Fraunhofer 1976) appears to offer advantages in terms of quantifiable data, speed, accuracy and efficiency as well as continuous testing.[7,8]

The present *in vitro* study was carried out to evaluate the effect of presence and absence of smear layer with different instruments and obturation methods on microleakage of root canal-filled teeth.

MATERIALS AND METHODS

Hundred freshly extracted single-rooted human maxillary central incisors with closed apices were selected for the study. The teeth were stored in 5% NaOCl solution for 24 hours to remove organic debris. The teeth were then decoronated, so that all the roots were approximately 10 to 12 mm long, the teeth were then stored in 0.9% saline solution until ready for use. The roots were randomly divided into six groups namely A, B, C, D, E and F (Table 1) consisting of 15 teeth each. In addition 10 teeth were taken as positive and negative control group consisting of 5 teeth each. Groups A, B, C and D were instrumented with ProTaper rotary files using crown down technique as per manufacturer's instructions up to F3.

Groups E and F were instrumented with K type hand files using a step back technique. Canals in these two groups were instrumented to a master apical file size No 30 and step back flared in 1 mm increments each to size 70 with H files. The negative and positive control groups were also prepared in the above manner. The canals of all teeth were flushed with 1 ml of 5% NaOCl solution using a 3 ml syringe with a 23 Gauge needle. The needle in all cases did not bind and was introduced as far apically as possible. The same total volume of 10 ml of 5% NaOCl was carefully controlled in all groups prior to final irrigation. Prior to final irrigation all the roots of the control group were longitudinally grooved with high speed water cooled handpiece.

Groups A, C, E and the positive control group received a final rinse with 3 ml of 17% EDTA which remained in the canal for 5 minutes followed by irrigation with 10 ml of 5% NaOH to remove the smear layer.

Teeth in groups B, D, F and the negative control group received a final rinse of 10 ml of 5% NaOCl after instrumentation. The canal of all groups were dried with paper points and placed in 0.9% saline solution prior to obturation. Groups A and B were obturated with Obtura II thermoplasticized gutta-percha technique using AH-26 sealer. Groups C, D, E and F were obturated using lateral condensation technique and AH-26 sealer. Coronal gutta-percha of all roots were removed with a warmed instrument leaving the apical 10 mm of filling material in each specimen intact.

The specimens were stored in 100% humidity for 48 hours to allow complete setting of the sealer and then placed in 0.9% saline solution.

Leakage within the canals was assessed by an electrochemical technique (Fig. 1). A PVC insulated copper wire with a 5 mm bared end was inserted coronally into the obturated canal and sealed in position with sticky wax. Thereafter all exposed surfaces and the tooth/wire junction except the tooth apex were sealed with thee layers of nail varnish.

Each tooth was continuously immersed in 0.9% NaCl solution, where it formed one electrode of the circuit and

Table 1: Various test groups, method of preparation and number of specimens used in each group

Groups	*Method of preparation*	*No. of specimens*
Group A	Rotary instrumentation + smear layer removed + thermoplasticized gutta-percha obturation technique	15
Group B	Rotary instrumentation + smear layer intact + thermoplasticized gutta-percha obturation technique	15
Group C	Rotary instrumentation + smear layer removed + lateral condensation technique	15
Group D	Rotary instrumentation + smear layer intact + lateral condensation technique	15
Group E	Hand instrumentation + smear layer removed + lateral condensation technique	15
Group F	Hand instrumentation + smear layer intact + lateral condensation technique	15
Positive control	Hand instrumentation + smear layer removed + no obturation	5
Negative control	Hand instrumentation + smear layer intact + roots completely sealed with 2 coats of sticky wax	5

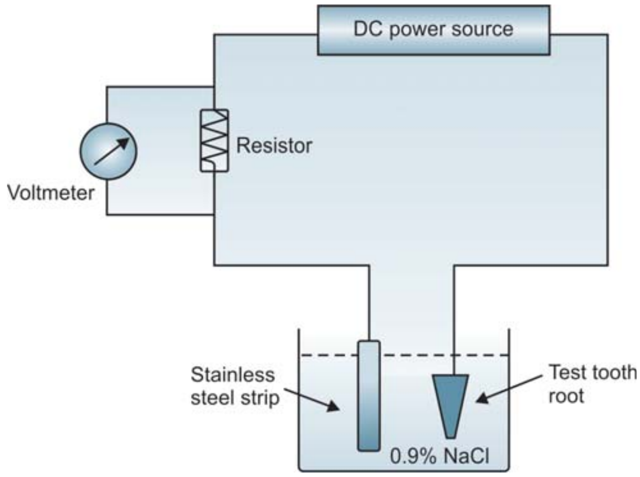

Fig. 1: Schematic representation of electrochemical leakage test circuit

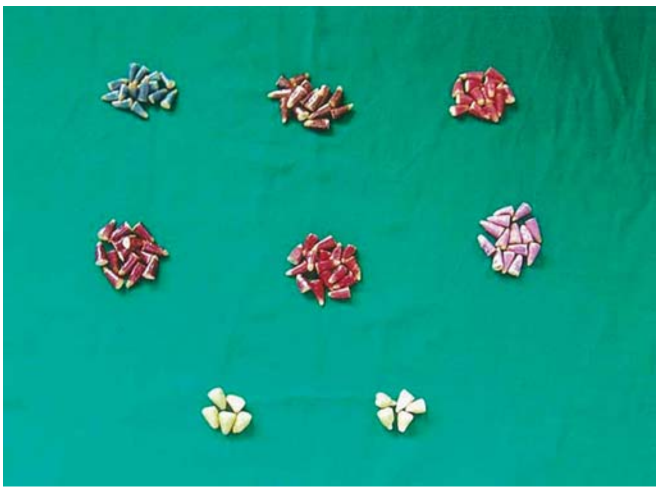

Fig. 2: Teeth specimens used in the study

the other electrode being a stainless steel strip. A 10 V direct current was applied between the electrodes and the current flow denoting onset of leakage was measured by current resistance drop across a 10 Ohm resistor placed in series with the electrodes and power source. The electrochemical technique is based on the principle that an electric current will flow between two pieces of metal when both are immersed in an electrolyte and are connected by an external power source. When leakage occurs an electrolytic pathway is established between the copper and stainless steel. The magnitude of the current for each tooth was directly

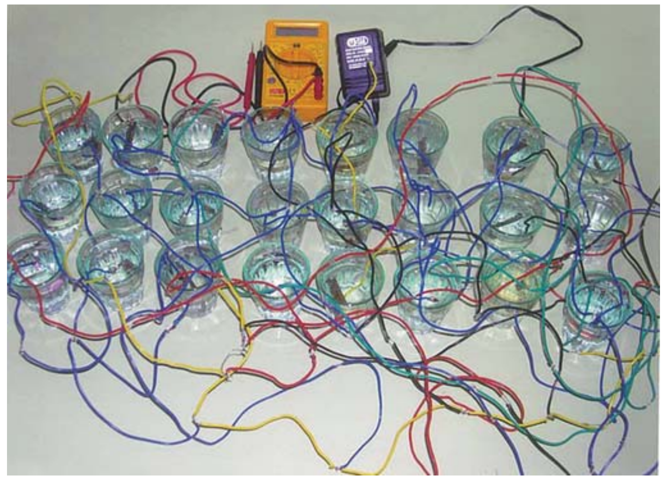

Fig. 3: Electrochemical leakage test circuit

proportional to the extent of leakage. The positive controls were prepared biomechanically dried but not obturated and a 22 Gauge wire was fixed within the root 10 mm from the working length. Each of the positive controls was then sealed with two coats of sticky wax except in the apical 3 mm (Fig. 2). The three negative controls were biomechanically prepared as previously described and the roots completely sealed with two coats of sticky wax (Fig. 3). Measurements from the control were taken daily along with the experimental specimens for 45 days. The temperature of the electrolyte solution in each container was maintained daily at room temperature. From the data obtained mean values, standard deviations were determined and statistically analyzed.

RESULTS

All specimens showed leakage after immersion at 10 days (Table 2). When leakage behavior for all the six groups were compared, statistically significant difference were found only between group a specimen and all other groups throughout the test time. No statistically significant differences were noted among the leakage currents for test groups B to F. Thus group A exhibited less leakage than specimen prepared using different methodologies. No current flow occurred with the negative control throughout the entire test period. The positive controls exhibited leakage

Table 2: Comparison of mean apical microleakage current values and standard deviation values of all groups at various time intervals of 10, 20, 30 and 45 days

Groups	*10 days*	*20 days*	*30 days*	*45 days*
A	5.23 ± 0.013	6.75 ± 0.03	7.31 ± 0.013	8.05 ± 0.013
B	7.29 ± 0.013	8.56 ± 0.017	9.32 ± 0.008	9.15 ± 0.013
C	6.63 ± 0.023	8.09 ± 0.015	8.69 ± 0.16	8.83 ± 0.013
D	8.55 ± 0.032	9.07 ± 0.013	9.09 ± 0.014	9.21 ± 0.021
E	9.16 ± 0.017	9.53 ± 0.013	9.54 ± 0.013	9.43 ± 0. 019
F	8.35 ± 0.028	8.89 ± 0.029	9.17 ± 0.033	9.27 ± 0.024

within a few minutes of immersion and thereafter exhibited a mean steady leakage current of 9.67 μA throughout the test.

DISCUSSION

All the specimens evaluated in the present study exhibited leakage throughout the test period. As, yet there is no single established method or set of materials available that can consistently and completely seal the instrumented root canals.[10,11]

Electrochemical leakage is reported to show a progressive increase to a plateau value (Osins et al 1983, Delivanis and Chapman 1982).[11,12] A rise to peak value followed by a decline (Mattison and von Fraunhofer 1983, Amditis et al 1993).[7,9] Or a long-term continuous changes in leakage behavior have been attributed to the dimensional changes or solubility of the sealant (Mccoomb and Smith 1976).[7,11,13]

Group A specimens showed the least mean leakage at each interval of 10, 20, 30 and 45 days. Group A specimens were subjected to rotary instrumentation, the reduced leakage may be due to the conservation of the original canal path and greater accuracy of final apical diameter (Pertot et al 1995, Glosson et al 1998).[6] An accurately and well-instrumented canal exhibited fewer irregularities, coronal-apical preparation technique enhances irrigant efficiency as it provides radicular access necessary to position the needle effectively. Moreover, the funnel form shape of the canal acts as a reservoir for the irrigant to better cleanse the root canal space.

The decreased leakage in smear free canals of group A may be due to improved mechanical leakage of gutta-percha into patent tubules with better adhesion to cleaner canal walls and a greater canal wall sealing surface area in the absence of smear layer (Karagoz et al 1994).[2] The effect of removing the smear layer was more pronounced for thermoplasticized gutta-percha than for laterally condensed gutta-percha. These observations were similar to studies by White et al 1984, Kennedy et al 1986.[14,15]

The p-values for all the groups were found to be highly significant at each interval of 10, 20, 30 and 45 days. This implies that the leakage of all groups was distinct and highly significant.

Within the experimental parameters, this study suggests that smear layer removal is beneficial to root canal sealing. Obturation with thermoplasticized gutta-percha provides a superior seal as compared to lateral condensation and canals instrumented with rotary NiTi files reduce the extent of microleakage in root canals. Furthermore *in vivo* studies are necessary to evaluate the electrochemical mode of leakage for long-term analysis.

CONCLUSION

The present concludes that:

- Rotary instrumentation of the root canals provides a superior preparation in comparison to hand instruments.
- Removal of smear layer is beneficial for root canal sealing.
- Thermoplasticized gutta-percha obturation appears to provide a superior seal compared to lateral condensation.

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