ORIGINAL ARTICLE

An In Vitro Evaluation of Apical Microleakage of Single Cone Obturation Versus Lateral Condensation Obturation Technique

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ABSTRACT

Introduction: The aim of this in-vitro study was to use dye penetration method to compare the apical microleakage of matched taper single-cone and cold lateral condensation technique in teeth prepared with ProTaper instruments.
Materials and Methods: Eighty (80) human extracted single rooted teeth were used.The teeth were randomly divided into two experimental groups of thirty (30) teeth each and two negative and positive control groups of ten (10) teeth each. The groups were as follows: Group I, Teeth were obturated using single cone obturation technique; Group II, Teeth were obturated using a cold lateral condensation technique. In positive control Group; teeth were instrumented and left unobturated, whwre as in negative control Group, teeth were instrumented and five (5) teeth were obturated with single cone obturation technique and five (5) teeth with the Lateral condensation technique.The access cavities of all teeth were obturated with Ketac Molar (3M ESPE) to ensure a coronal seal. The specimens were stored for 24 hours in 100% humidity at 37^{O}C to allow the sealer to set. After that the surface of all roots in experimental and positive control groups were then covered with two layers of nail polish, except for the apical area (2mm). In the negative control group all surfaces of the roots, including the apical area, were covered with two layers of nail polish. Each tooth was subsequently immersed in a freshly prepared 5% aqueous methylene blue dye solution (PH 7.0) at 37^{O}C for seven days, and stored in incubator. Following storage, the roots were cut along their long axis and evaluated under a stereomicroscope to measure the depth of dye penetration.
Results: The negative controls showed no dye penetration while, the positive controls showed completely dye penetration. Mean and standard deviation of leakage for experimental groups were, for Single Cone Obturation, 6.42 (SD ±3.18), for Lateral Condensation Obturation, 6.44 (SD±1.8). There was no significant difference between the two groups (p=0.245).
Conclusion: Both the single cone and the lateral condensation obturation techniques proved equally effective in achieving the apical seal.

Key words: Dye penetration method, Protaper endodontic files, single cone obturation.

INTRODUCTION

The aim of root canal therapy is to attain clean canal that allows for the three-dimensional obturation of root canal system along with a hermetic seal.[1] Obturation provides a seal that prevents reinfection of the canal and subsequent leakage into the periradicular tissues.[2] It is suggested that incomplete obturation of the root canals (60%) is still one of the major cause of root canal treatment failure.[3] Majority of endodontic therapies use gutta perch as root canal obturation material in several different obturation techniques.[4] Currently, the most commonly used gutta-percha obturation technique is cold lateral condensation,[5] and is still the standard with which all other techniques are compared. However, its ability to reproduce the internal surface of root canal has been questioned. Incomplete fusion of gutta-percha cones, voids and lack of surface adaptation has been questioned.[4]

Because of the widespread use of the rotary NiTi systems, manufacturers have produced gutta-percha cones that match the taper of canals prepared with these systems. Preparation of a root canal with rotary NiTi instruments and the use of a sealer with these cones may provide three dimensional obturation of the root canal.[6] Recently, gutta-percha points for ProTaper (Dentsply Maillefer) have been introduced for simple, time-efficient obturation. In this system, root canals are prepared with the ProTaper instruments and filled with the point that fits the size of the finisher file. The manufacturer claims that ProTaper gutta-percha points perfectly fit canals that have been prepared with ProTaper files.

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Many investigators in their clinical and in-vitro studies concluded that majority of endodontic failures showed incomplete obturation,[7-9] which leads to microleakage.[10] Therefore leakage tests are used for the evaluation of the excellence of a root canal filling. A number of scientific articles have been published about various techniques and materials that have been used for achieving a better endodontic obturation with a minimum apical microleakage. In all these studies, it is generally acknowledged that the assessment of the apical leakage of particles or solutions between a root canal filling and the root canal walls is a proper method to establish the quality of an endodontic obturation. The most generally used method for the assessment of apical microleakage is the linear measurement of tracer penetration (e.g. dyes penetration), different concentrations of aqueous solutions of eosin (3, methylene blue,[11-13] or India ink,[14-16] radioisotopes,[17] or bacteria,[18] electro-chemical[19] along the root filling. Measurements were made after the application of different preparation methods, such as longitudinal splitting[11,13], cross-sectioning[12,17], or decalcification and clearing of the root.[14-16]

In spite of the unquestionable improvements, until today no material fulfills all necessities and enviable properties to hermetically seal the root canal system. Apical leakage is still a repeated incident in root-filled teeth, which raises concern regarding the quality of obturation provided by the currently available filling materials.[20,21] A number of studies have evaluated the apical sealing capability of root canal fillings using different methods.[22] Dye penetration method is frequently used to assess leakage due to its simplicity and cost effectiveness.[23]

OBJECTIVES

The aim of this in-vitro study was to use a dye penetration method to compare the apical microleakage of matched taper single-cone and cold lateral condensation technique in teeth prepared with ProTaper instruments.

MATERIALS AND METHODS

This prospective experimental interventional study was conducted at the Department of Operative Dentistry and Department of Science of Dental Materials at Dr.Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, (DIEKIOHS) Dow University of Health Sciences, Karachi, Pakistan and testing was carried out at the Department of Materials Engineering at NED University Karachi, Pakistan. The duration of the study was six (6) month.

Eighty (80) single rooted, non carious, unrestored human teeth, extracted for periodontal reasons were selected. Teeth that contain cracks and broken down teeth were excluded from the study. Extracted teeth were taken from Oral and Maxillofacial Surgery Department of (DIEKIOHS). Extracted teeth were selected, the storage and handling of teeth was conducted according to ISO/TS 11405 standard. All the teeth were radiographed on the buccal and proximal views to check for single root and single canal. Endodontic access was prepared conventionally and the canal system prepared using Protaper system (Denstply Pakistan) following standard protocol.[24] Access cavity was prepared by using diamond round bur, canal orifice was located by using manual canal finder; working lengths were calculated using a size 10 file until its emergence at the apical foramen and then subtracting 2mm. Canal preparation was conducted following crown down technique, coronal third of the canal was prepared by using Sx and S1 files, middle canal was prepared by using S2 and apical portion of the canal was prepared by F1, F2. Sodium hypochlorite (5.25%) was used as an irrigation solution during instrumentation. After final irrigation the canal was subsequently dried with sterile paper points.

The samples were divided into two groups of 30 each specimens to act as experimental groups. Teeth in group I were obturated using single cone obturation technique; a thin coating of the endodontic sealer (Apexit, Ivaclor Vivadent) was manually deposited in the canal using paper point. After that size F2 gutta-percha was coated with Apexit (Ivaclor, Vivadent) sealer, gently seated in the canal. After warming the coronal material was vertically condensed with a endodontic plugger size 4 (Dentsply Maillefer). Teeth in group II were obturated using a cold lateral condensation technique. A size 30 gutta-percha cone was inserted to the working length and a tight fit- assured. The master cone was coated with Apexit (Ivaclor, Vivadent) sealer, gently seated in the canal and condensed with a finger spreader. Accessory gutta-percha cones were inserted until they could not be introduced any further. After warming the coronal material was vertically condensed with an endodontic plugger size 4 (Dentsply Maillefer).

The samples in the control group were divided into two control subgroups of 10 teeth each. Those in the positive control group were instrumented and left unobturated. Those specimens teeth in the negative control group were instrumented and five teeth were obturated with single cone obturation technique and five teeth with the Lateral condensation technique.

The access cavities of all teeth were obturated with Ketac Molar (3M ESPE) to ensure a coronal seal. The specimens were stored for 24 hours in 100% humidity at 37^{o}C to allow the sealer to set. The surface of all roots in experimental and positive control groups were then covered with two layers of nail polish, except for the apical area (2mm). So the tracer could penetrate the canal via the apical region only. In the negative control group all surfaces of the roots, including the apical area, were covered with two layers of nail polish. Each tooth was subsequently immersed in a freshly prepared 5% aqueous methylene blue dye solution (PH 7.0) at 37 ^{O}C for seven days, and stored in incubator. A 7-day immersion period in 5% methylene blue was used, as the procedure did not engage any supplementary active penetration device. In addition, all the canals were prepared to the same final apical size and a same operator conducted both the preparation and obturation on each tooth. After removal from the dye, the specimens were washed with distal water, dried and the nail varnish was removed with scalpel. The root of each tooth was grooved longitudinally on both sides, using a rotating diamond disc under constant cooling with distilled water without disturbing the gutta-percha filling. The roots were sectioned and each half of the roots was examined under stereomicroscope. The amount of leakage was measured in each half of each tooth, from the working length to the most coronal part of the root canal to which the dye had penetrated. Each section was photographed under a stereoscopic microscope (MOTIC, Hong Kong).

STATISTICAL ANALYSIS

Data were analyzed using SPSS version 16. Data were of continuous variables and was normally distributed, statistical descriptive analysis was performed using independent t test to find the statistical difference between the two groups. This enabled the comparison of the apical leakage between the two obturation techniques.

RESULTS

The linear penetration of 5% methylene blue was measured and found to be between 2.12 to 12.21 mm for single cone Obturation and 3.12 to 9.81mm for lateral condensation technique. There were cases where penetration was very small although there were other cases in which a more widespread penetration of 5%methylene blue was observed during microscopic study of serial cross-sections.

The negative controls showed no dye penetration while, the positive controls showed completely dye penetration. Mean and standard deviation of leakage for experimental groups were, for Single Cone Obturation, 6.42mm (±3.18), and for Lateral Condensation Obturation, 6.44 (±1.8%). There was no significant difference between the two groups (p value = 0.245). Positive control groups show 100% leakage while negative control group show no leakage. Dye penetration in the positive control group and absence of dye penetration in the negative control group confirmed the integrity of dye penetration.

Table 1: Mean and standard variation values for the Two Obturation Techniques

Obturation Technique	Sample Size (n)	Mean (mm)	Standard Deviation
Group I Single Cone Obturation	30	6.42	3.18
Group II Lateral Condensation Obturation	30	6.44	1.82

DISCUSSION

Cleaning and shaping play vital in the success of root canal treatment. However, this does not negate the importance of the quality of obturation. This is validated by the fact that nearly 60% of failures in endodontics can be accredited to incomplete obturation of the root canal.[25] Hence, a three - dimensional obturation is critical for endodontic success. Irrespective of the obturation technique employed, micro leakage remains to be the most common cause of endodontic failure. Micro leakage is the passage of bacteria, fluids, and chemical substances between the root structure and filling material of any type.[26]This occurs because of microscopic gaps at the interface of the filling material and the tooth.[27]Microleakage in the root canals is of complex nature as many variables may contribute, such as root filling technique and chemical properties of the sealer and the infectious state of the canal.[28]

A variety of materials and techniques have been developed to improve the quality of root canal obturations. However, none of these materials and techniques provides a leak proof seal[26].Pashley[27] confirmed that microleakage is a severe clinical problem because most dental materials display varying degrees of microleakage. The most significant prerequisites of endodontics are total debridement of the pulpal space, development of a fluid-tight seal at the apical foramen and total obliteration of the root canal.[29] Therefore leakage tests are a relevant way to evaluate the apical seal. Methods used to evaluate apical leakage include dye-penetration, electrochemical, radioisotope, bacterial leakage and fluid filtration methods.

Nicholls[29] stated that poor seal may lead to voids in the apical region of the canal where Stagnation of tissue fluid can occur. The subsequent proteolysis and irritation can result in persistence of existing periapical lesion or formation of fresh lesions. Traditionally, clinical accent has been on the apical sealing of the root canal obturation. Thus, most leakage experiments[30,31] have assessed the quality of apical seal by measuring dye penetration in an apico-coronal direction. This technique is simple to carry out but appears to overestimate microleakage i.e. more than the bacteria infiltration method. This might be due to the difference between the sizes of molecules of dyes and bacteria.[32]

A dye penetration technique was used in this study to evaluate microleakge between two different obturation techniques by microscopic observation (stereomicroscope). Lateral condensation is a generally accepted technique and it was compared to a single cone obturation method. Methylene blue is a small molecular weight dye which has high penetration ability.[32] It is highly susceptible to demineralization and thus can lead to observation bias in clearing techniques.

Fig 1. Initial Filing and working length assessment

Fig 2. Drying of canal with sterile paper point

Fig 3. Single cone obturation

Fig 4. Marking of apical 2mm of root portion

Fig 5. Tooth samples coated with nail varnish

Fig 6. Sample placed in 5%methylene blue dye

In recent years, rotary nickel-titanium (NiTi) instruments have become popular because of their superiority over stainless steel hand files, elasticity and resistance to torsional fracture[33]. Moreover, rotary NiTi instruments improve working safety, shorten working time and prepare well-shaped root canals with fewer canal transportations[34,35]. Recently, new file designs of rotary NiTi instruments with sharp cutting edges called ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) were introduced. The ProTaper system features just 6 instruments: SX shaper, 2 shaping files (S1 and S2) and 3 finishing files (F1, F2 and F3)[36,37]. This system work with multiple obturation techniques such as single cone obturation.

The single-cone technique consists of a single gutta-percha cone filled at room temperature with sealer layer thicknesses that vary, depending on the adaptation of the single cone to the walls of the canal.[38] Single-cone obturation has not been well regarded because of the use of large amounts of sealer. Porosities in large volumes of sealer, setting contraction and dissolution of the sealer are the main disadvantages of this technique.[39]The poor seal of the material because of shrinkage after setting is a significant problem.[40]

In the literature it has been reported that obturations of lateral condensation had a better treatment outcome than single cone obturations.[41] However, these obturations were done with standardized .02 taper gutta-percha cones, usually with zinc-oxide-eugenol-based sealers. Because large volumes of this soluble sealer were used, dissolution of the sealer leading to microleakage may have had a negative effect on the outcome.[37] In this study, Apexit sealer, a Calcium hydroxide-based, radiopaque root canal sealer was chosen because of less shrinkage for the final endodontic Obturation.

Pommel and Camps[42] compared single-cone, lateral condensation, vertical condensation, Thermafil and System B techniques using a zinc-oxide-eugenol-based sealer and reported that the single-cone technique had the highest leakage. On the other hand, Wu and colleagues[38] studied the leakage of single-cone fillings using a silicone-based sealer for 1 year and concluded that single-cone fillings prevented fluid transport for 1 year.

With the widespread use of rotary NiTi instruments, matched-taper gutta-percha cones were developed and the single-cone technique has become popular again. Gordon and colleagues[43] reported that the cross-sectional area of the .06 taper single-cone technique was comparable with that of lateral condensation, and the taper single-cone technique was faster than lateral condensation. Bal and colleagues[44] compared the sealing ability of root canals prepared with .06 rotary NiTi instruments and obturated with either a .06 or a .02 tapered gutta-percha master cone using lateral condensation and found no difference between the groups.

More recently, Zmener and colleagues[45] prepared the root canals using a rotary system and obturated with single-cone and lateral condensation techniques. They reported that the difference between single-cone and lateral condensation obturation was not significant.

In our study the results showed no significant difference between the two groups and the extent of microleakage in the single cone obturation technique was almost equal to Lateral Condensation technique ($p= 0.245$). This was in agreement with the results of Bal and colleague,[44] Zmener and colleagues[45] and Gordon and colleagues.[43] However Pommel and Camps[42] found the opposite results, which may be because of difference in the sealer.

Wu and Wesselink[38] concluded that data obtained from the linear measurements of dye penetration after longitudinal splitting or decalcification and clearing of roots varied to a much higher extent than the data obtained after cross-sectioning of the samples.

In this study the dye penetration method only provide qualitative data of linear measurement of tracer penetration along the root filling and did not provide any information about the volume of the tracer that penetrated along the root canal obturation, However, the teeth used in this study had single straight canals but posterior teeth have narrow and curved canals with complex anatomy, which might present greater challenges hence are the limitations of the study. Further study is needed to evaluate the sealing ability of obturation of matched-taper gutta-percha cones to determine whether these obturations have an acceptable apical seal.

CONCLUSION

In the current study, the results of matched-taper single-cone obturation were compared with lateral condensation technique and it was concluded that there was no significant difference in efficacy of apical seal achievement between the two groups. However further studies are required to confirm this relationship.


Fig 7. Incubator


Fig 8. Tooth sample after 7days storage in incubator


Fig 9. Scraping of nail varnish


Fig 10. Longitudinal sectioning of tooth with diamond disc

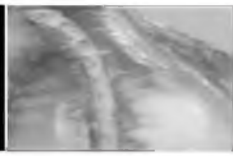
Fig 11. Microleakage assessment under Stereomicroscope


Fig 12. Microlekage assessment with naked eye

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