

Incidence of Dentinal Crack Formation during various Endodontic Procedures

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ABSTRACT

Endodontic procedures, including root canal enlargement, filling, post preparation, and retreatment, cause loss of tissue and put excessive pressure on the teeth, making them susceptible to vertical root fractures (VRFs). The amount of the remaining tooth structure is an important determinant in VRFs. Moreover, cracks that occur during endodontic procedures can propagate by occlusal forces, with repeated stress finally resulting in VRFs. The prognosis of a tooth with a VRF is poor. The final apical preparation size is an important factor in root canal cleanliness.

KEYWORDS: Dentine Cracks, Re Treatment, Post Space, Ferrule, And Canal Instrumentation

INTRODUCTION

The main aim of endodontics is air tight seal of the root canal system which is achieved by proper anatomical form of the root canal system. Root canal instrumentation and irrigation are important procedure in disinfecting the canals.¹ Endodontically treated teeth are highly affected by the risk of biomechanical failure compared with sound teeth.² Endodontic procedures, including root canal enlargement, filling, post preparation, and retreatment, cause loss of tissue and develops excessive forces on the teeth, making them susceptible for dentinal crack formation in root.³ Many factors such as age related structural changes like craze lines on enamel or wasting diseases, chemo-mechanical preparation and intracanal dressings, as well as obturation or restorative procedures during or after endodontic treatment may lead to the deterioration of tooth structure. The susceptibility fracture depends primarily on the apical preparation of canal and its enlargement and the method used to elimination of mishaps, which are stress concentration sites.⁴ Thus, different bio mechanical techniques of root canal preparation and systems, with different instrument design, lead to different levels and severity of dentinal damage to the root canal wall.⁵ In this article we are discussing various endodontic procedure which leads to formation of root dentin defect.

ROOT CANAL INSTRUMENTATION

The final apical preparation size is an important factor in root canal cleanliness. However, enlargement of the apical region with larger instruments may cause excessive crack formation and root canal transportation, especially

in curved canals. There is currently no consensus on the optimum final apical preparation size.⁶ Numerous studies have concluded that root canal instrumentation with nickel titanium (NiTi) rotary instruments leads to crack formation in root dentin. However, there are limited data on the interrelation between the size of the apical preparation and crack formation.³ During root canal instrumentation there are complications such as perforations, ledge formation, transportation of canal, and formation of cracks in the root dentin. Biomechanical preparation of the canal with larger apical diameter instrument end up damaging the root dentin, which becomes more prone to dentinal cracks and; thereby, causing failure of treatment.⁷ According to Kim *et al.* and Bier *et al.*, varying degree of taper to endodontic canal shaping instruments are one of the most common contributing factor for crack formation in root dentin.⁸ Rotational force is applied to the canals of the root by NiTi rotary instruments, thus creating craze line or micro cracks in root dentin. Formation of dentinal defects may be associated with the design of tip, cross-sectional geometry, taper type, flute form, and pitch.⁹ M-wire alloy NiTi material with controlled memory NiTi wire have good flexible properties than those made from conventional NiTi wire. Thus, such flexibility of Pro taper next rotary files may have contributed as less number of dentinal defects formation as compared to Pro taper and Hero shapers.¹⁰ Capar *et al* concluded that the swaggering motion and less taper of the pro taper next instruments could change the root canal volume thus produces lesser dentinal defects.¹¹ Study by Banu Uysal *et al* stated that, root canal instrumentation with the ProTaper Universal NiTi rotary (especially the F2 file) system had a significant effect on the initiation of apical cracks.¹² The highly tapered design of ProTaper instruments could explain the increased crack

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susceptibility. The first crack propagation was associated with F4 instruments (#40 and a .06 taper). This might be attributed to the stiffness of the larger instruments and excessive dentin removal.³ According to Christopher A. Etrich et al, stated that, NiTi instruments tend to induce various degrees of dentinal damage during root canal preparation. On the other hand, PTN files represent satisfactory results with minimal micro crack defects.¹³ Methods for the diagnosis of cracks that may compromise teeth are all based on optical assessment, surgical loupes, microscopes, dyes and transillumination.¹⁴

Cross-sectional anatomy of root canals varies; flat, oval and C-shaped canals are commonly found. Although rotary systems tend to produce rounder canal preparations and smoother canal walls, the Self-Adjusting File (SAF) (ReDent-Nova, Ra'anana, Israel) was specially designed to overcome this problem. The SAF works with an up-and-down grinding motion that removes dentin from the canal walls.¹⁵ The hollow, flexible and compressible design of the SAF achieves 3-dimensional adaptation of the root canal. Features of this adaptive design can reduce the risks of over preparation or weakening the canal wall.¹⁶

Ethylenediaminetetraacetic acid (EDTA) can be used as a lubricant gel during rotary canal instrumentation to reduce the incidence of instrument separation and facilitate the instrumentation during biomechanical procedures of root canal. Meanwhile, using EDTA gel reduces the microhardness of radicular dentin and this may contribute to the dentin defect formation. EDTA gel form collect more canal wall debris in the cutting flutes of the files decreasing the cutting efficiency of the file and indirectly increasing the stress on the dentinal wall and enhancing dentinal crack formation. The use of EDTA gel did not significantly affect the incidence of radicular dentinal defects.¹⁷

ROOT CANAL FILLING

Cold lateral or warm vertical compaction is frequently used to fill the root canal system. Cold lateral compaction has been used for many decades and was proven to be clinically effective (Aqrabawi 2006, Marquis et al. 2006, Ozer & Aktener 2009). However, it is time consuming, results in fillings that lack homogeneity (Brayton et al. 1973) and poorly adapts to the canal wall (Budd et al. 1991). Importantly, this technique can create defects on the root canal walls (Bier et al. 2009), which might later propagate into fractures (Shemesh et al. 2009) with severe clinical consequences. Many clinicians continue to use this technique as it does not require special or expensive equipment and is considered safe in controlling the apical extension of the filling (Kec,eci et al. 2005). Warm vertical compaction involves a thermoplasticized filling material, which is compacted vertically with pluggers. As no spreaders are used, it was hypothesized that when warm vertical compaction technique is performed skilfully, root fractures are not likely to occur (Telli et al. 1999). Nonetheless, hydraulic forces during warm vertical compaction could create pressure on the

root canal walls and induce a wedging effect (Blum et al. 1998). Compared to lateral compaction, warm vertical compaction demonstrates better adaptability of the filling material to the canal walls (Budd et al. 1991), but may result in extrusion of filling material into the periapical tissues (ElDeeb 1985, Kec,eci et al. 2005). Blum et al. (1997, 1998) who concluded that vertical compaction of gutta percha created wedging forces capable of damaging the root.¹⁸

Although Buchanan (1996) and the manufacturer of 'BeeFill 2in1' specifically refers to the danger of applying high temperatures on the root and recommend deactivating the heat application after a maximum of 4 s, this limitation refers to minimizing the potential damage to the periodontal ligament (Venturi et al. 2002). Temperature increases measured at the outside surface of the root after application of a warm plugger are apparently not sufficient to damage the periodontal ligament

(Weller & Koch 1995, Venturi et al. 2002). The effect of direct contact of a plugger at 200 degree Celsius with the root canal wall has not been addressed. Nonetheless, the effect of extreme temperatures on dentine was previously discussed in relation to laser treatment (Stabholz et al. 2004, De Moor et al. 2009) and forensic medicine (Ferreira et al. 2008) and concluded that elevated temperatures could cause cracks on dentine surfaces. In the current study, no correlations were found between the remaining dentine thickness and the appearance of defects. The single cone or passive compaction method, where accessory gutta-percha cones are passively inserted along the master cone (Souza et al. 2009), could be a less damaging alternative as this method did not inflict any damage on the dentine of extracted teeth (Shemesh et al. 2009).¹⁹

POST SPACE PREPARATION/FERRULE

The rehabilitation of root-filled teeth demanding intraradicular retention is related to several factors such as quantity and quality of dentin walls, post system, post cementation length, presence of a ferrule, and final restoration.²⁰ The correct choice of the post system used for weakened teeth rehabilitation and the ferrule effect are crucial for prognosis and longevity of the treatment. Traditionally, flared teeth have been restored using cast metal posts and are often unsuccessful because of a lack of retention. Moreover, rigid materials like the different alloys used in cast posts and cores may increase the risk of vertical root fractures.¹³ On the other hand; glass fiber posts have similar mechanical properties to dentin but also present standardized geometry and cannot be well adapted to flare root canals. This fact can result in a thick line of resin cement, affecting the bond strength and fracture resistance of the restorative complex. However, the development of new post surface treatment techniques improved bond strength between composite resins and glass fiber posts. Thus, glass fiber posts can be relined with composite resin previous to cementation in flared

root canals, contributing to a reduced volume of luting cement and a better fit to the root canal.²¹ Nevertheless, the effect of the interaction among ferrule presence, post system, and post length regarding the biomechanical behavior of weakened root-filled teeth is still unclear. One of the most decisive factors in the choice of a post system is related to the post length.²¹ Santos Filho et al. reported that the length of metallic posts is directly related to the fracture resistance of endodontically treated teeth.²⁰

The result of the study presented by Evren et al showed that post space preparation had a significant effect on apical crack propagation. This might be caused by reduced residual dentin thickness and excessive forces caused by stiff drills. It has been shown that an increased diameter of a post does not increase its retention. In a finite elemental analysis, Santos Filho et al showed that ferrule presence promoted more satisfactory stress distribution to the roots. Thus, it is unnecessary to enlarge the canal space beyond the size of the smallest post.

ROOT CANAL RE TREATMENT

Orthograde retreatment procedures are performed when initial root canal treatments fail. Although the outcome of these re treatments is favorable, it was frequently associated with a lower healing rate than that of initial treatment. Procedural errors like perforations and inadequate root filling length were shown to be the most significant factors to influence the outcome, as well as a presence of the periapical lesion and good coronal restoration. When orthograde retreatment is indicated, efficient removal of the filling material from the root canal system is essential to ensure a favorable outcome. However, the complete removal of endodontic fillings is difficult or impossible. Several techniques can be used for this purpose, including stainless steel files, nickel-titanium (NiTi) rotary instruments, heat-bearing instruments, ultrasonics, and solvents. Novel techniques seek improved results through NiTi rotary instruments and the operating microscope. One example of a dedicated rotary system for the removal of gutta-percha is the ProTaper Universal system for retreatment (Dentsply Maillefer, Ballaigues, Switzerland). It consists of 3 instruments: D1 with tip 30 and taper 0.09, D2 with tip 25 and taper 0.08, and D3 with tip 20 and taper 0.07. Defects in the root canal wall were shown to appear after root canal preparation and filling. Nonetheless, the appearance of defects was only checked after initial endodontic treatment. Because re treatment requires more mechanical manipulations in the canal and further preparation of the root canal, it could be that more damage to the root canal wall is caused after this procedures. The removal of gutta-percha by using hand files can be a tedious, time-consuming process, especially when the root filling material is well-condensed. Therefore, the use of rotary NiTi instruments in root canal retreatment might decrease patient and operator fatigue. The results of the current experiment support this finding. Chloroform is known to be most efficient is

dissolving gutta-percha and was used in the current experiment to facilitate filling removal in both the hand files and NiTi groups. Chloroform can cause significant softening of dentin after 5 minutes and could thus affect the microhardness of dentin.²¹

CONCLUSION

During various endodontic procedure such as biomechanical preparation, canal obturation, post space preparation and re treatment can causes dentinal defects. Care should be taken during endodontic procedure by using appropriate technique, material and instruments which creates less or no dentinal defects.

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