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Review Article

Factors Influencing Apical Extrusion Of Debris, Irrigating Solution And Microorganisms: A Literature Review

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ABSTRACT

Aim: aim of this review paper is to discuss the factors that influence the apical extrusion of debris, irrigating solution and microorganisms.

Background: Periapical extrusion is major concern in endodontic practice especially during chemo-mechanical preparation of root canal system. This periapical expulsion results in humoral or cell-mediated immunological reaction such as pain and/or, swelling, causing apical periodontitis and resulting in flare-up. The flare-up may arise due to irritation towards periapical tissue by instrumentation, irrigation and microorganisms which should be minimized even though it may not be avoided. To minimize these periapical expulsions, related factors should be scrutinizing evaluated and discussed. There are several factors that influence apical extrusion of debris, irrigating solution and microorganisms like root length, root curvature and so on.

Review result: Among the hand instrumentation techniques step-back produced more apical extrusion than others. Rotary instrumentation generally produced less apical extrusion than hand instrumentation. Cervical preflaring reduced the apical extrusion comparatively. EndoVac irrigation system expelled less irrigating solution than other systems/techniques.

Conclusion: step-back hand instrumentation showed more apical extrusion so it should be chosen carefully. Over hand instrumentation, rotary instrumentation should be preferred. Cervical preflaring showed less apical extrusion so it should be followed routinely.

Clinical significance: This review article discusses various factors responsible for periapical expulsion in detail. This also focuses on how periapical expulsions can be minimized even though it cannot be avoided for successful endodontic treatment with least patient discomfort.

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INTRODUCTION

Contemporary dental practice evolved in each and every aspect of dentistry like endodontic diagnosis, access preparation, cleaning and shaping and obturation of entire root canal system. Nowadays, various rotary systems available for cleaning and shaping of root canal system. But still, all existing chemo-mechanical systems fail to prevent apical extrusion of debris, irrigant and microorganisms into peri-radicular tissue. Siqueira and Barnett concluded that physical or chemical injury to periradicular tissues during cleaning and shaping of the root canal system can cause degranulation of mast cells, with consequent release of histamine into the periradicular tissues . Periapical expulsions may result in severe cell-mediated or humoral immunological phenomenon causing pain, swelling or both resulting in flare-up . Chapman et al (1968) were the first to report extrusion of infective debris from the root canal system beyond periapical foramen during endodontic preparation.

The aim of this review discusses on etiological and contributing factors that influences apical extrusion of debris during endodontic instrumentation. The search for articles were conducted in google scholar, PubMed, Ovid, MEDLINE, research gate using keywords “apical extrusion in endodontics” and “periapical extrusion”. More than three hundred articles were displayed. Studies related to Root canal retreatment were excluded from the search. Then for the analyzing and scrutinizing purpose 75 articles were selected for discussion. Influencing factors for apical expulsion were identified and analysed.

BACKGROUND:

Most common etiological factor of endodontic flare up is presence of virulent microorganism but non-contaminated dentinal chips and pulp tissue may also have potential to initiate an inflammatory reaction. This has been observed by Torneck (1967) and Seltzer et al (1968). The presence of immunoglobulins formed against altered tissue proteins acting as antigens. Mast cells had also been demonstrated capable of degranulation to release vasoactive amines. {(Seltzer & Naidorf 1985), Torabinejad et al (1985)}

All these aforementioned reports indicate that any types of periapical irritation which potential to initiate a periapical reaction. It appears that the confinement of canal preparation within the root canal space is of critical value from multiple perspectives, amongst which prevention of the initiation of an inflammatory and immunological reaction is the most important. So the causative factors or/and etiological factors should be identified and eliminated. In case of infective periapical extrusion etiological factors depend upon number and virulence of microorganism. The qualitative factors (virulence) cannot be controlled by operator but quantitative factors (number) of microorganisms can be measured and controlled by different techniques.

Methodologies And Experimental Designs Used In Apical Extrusion Studies

One of the primary reasons of flare-ups in endodontic cases are periapical expulsion of debris, irrigant and bacteria. So with the intention of quantitatively examining debris, irrigant and bacteria that might be extruded into periapical tissues during root canal shaping, laboratory experimental set-ups have been designed. Several experiments were conducted using model as described by Myers & Montgomery (1991) . Eppendorf tubes are commonly used means for debris collection (Tanalp et al 2006). To quantify irrigant and extruded debris following method was followed:

The method comprises of weighing the collecting tubes prior to and after instrumentation using a precise microbalance and calculation of the extruded debris by subtracting the initial weight from the postinstrumentation weight. A calibrated injector (e.g. injector used for insulin measure) can be used to collect and measure the amount of extruded irrigant. (Er et al. 2005 Tinaz et al.

2005 , Kustarci et al. 2008 , Mohammadi 2009). Lyophilization (dry freezing) prevent variation in room temperature and moisture by providing closed environment used for some studies. (Tanalp et al. 200610). Weighing procedures were repeated 3 times and an average value was taken for more precision.

Another methodology used by Ruiz-Hubard et al (1987). They used the filter column suction system which contain standardized acrylic endodontic teaching models. There were certain advantages and disadvantage of using simulated root canals in acrylic models. But heat generation with rotary instruments might have soften the resin material and could adversely affect the reliability of the experimental system as mentioned by Kum et al. 2000 . Other criticism as the pulpal status as well as the condition of the periapical tissues cannot be mimicked. This has well been demonstrated by Salzgeber & Brilliant (1977) who used a radiopaque material to delineate apical penetration in vivo. The pressure at the periapex cannot be simulated either. Hachmeister et al (2002) suggested the use of floral foam to simulate the resistance of the periapical tissues to pressure exerted from within the root canal space. On the other hand, this methodology had also been criticized as foam may absorb irrigant and debris.

REVIEW AND DISCUSSION:

Effect Of Influencing Factors:

Influencing factors are classified as: A) tooth related, B) instrumentation related, C) irrigation related

A) Tooth related influencing factors:

Influence of assessing apical patency on apical extrusion:

Achieving apical patency of the root canal is the first step of cleaning and shaping of root canal system. The smallest instrument is used to assess the patency of the canal by negotiating it till the major diameter of the canal. It may be associated with the apical extrusion of debris . Camoes et al (2009) evaluated the effect of apical patency on the expulsion of material (irrigating solution) beyond the apical foramen with or without apical patency. Authors concluded that probability of extrusion of irrigating solution was more when apical patency was established as also observed by Souza RA (2006).

Periapical lesion and disruption of apical constriction:

Apical extrusion of debris depends on several factors. One of the important factors is the apical constriction of the root canal . Tinaz et al (2005) studied the effect of apical diameter disruption on periapical extrusion in single-rooted teeth. The authors reported that the apical extrusion of debris increased with the increase in the diameter of the apical constriction (within experimental limit) this study also supported by Lambrianidis et al (2001). On the contrary Psimma et al (2013) observed that as the apical preparation size increases (within experimental limit) expulsion of irrigating solution decreases.

Influence of root length:

VandeVisse and Brilliant (1975) measured quantitatively, for the first time, the amount of debris extruded during root canal preparation using irrigating solution. They observed that as the length of the root canal increased, the amount of debris also increased this is in correlation with Myers and Montgomery (1991). But another study by Hinrichs et al (1998) reported that debris expulsion did not depend upon canal length with no statistically significant difference.

Influence of vitality of tooth:

Cleaning and shaping of vital teeth differ from nonvital teeth as Salzgeber and Brilliant (1977) reported that canal preparation in vital teeth produced less extrusion of irrigant than nonvital teeth in this vivo study. Samples selected for this study were mandibular molars. Presence of vital tissue remnant in lateral canals in case of vital teeth might have probably resisted the expulsion of irrigant into the periapical tissue.

Root curvature and step-back, crown-down, balanced force technique of instrumentation:

Riuz-Hubard et al (1987) compared the step-back technique with crown-down pressureless

technique in simulated straight and curved canals to determine apical extrusion. Result showed that a significantly greater amount of debris forced periapically in both simulated straight and curved canal when the step-back technique was used than crown-down pressureless technique. They also mentioned that apical extrusion is more in straight canal than in curved one in crown-down pressureless technique. This findings in correlation with Mckendry (1990), Al-Omari and Dummer (1995), Vansan et al (1997). All these studies interpreted that step-back technique might have caused screwing in-effect, thus showed more amount of apical extrusion comparatively. On the contrary, the straight canals showed less apical extrusion compared to curved one as reported by Morgan and Montgomery . There may some discrepancy occurred during canal preparation in curved canals as with risk of ledging, zipping and perforation of the canal.

Influence of cervical preflaring on apical extrusion:

Fairbourn et al (1987) compared the effect of cervical preflaring on the apical extrusion. Researcher observed that cervical preflaring caused less apical extrusion than conventional filing technique. This observation was also correlated by the Borges et al (2016). Preflaring technique facilitated better irrigation of the root canal system so allowed flushing of debris out of the canal from apical region. (Barbizam JV et al 2002, Fornari VJ et al 2010, Schneider SW 1971). This resulted in less packaging of debris periapically.

B) Instrumentation Related Influencing Factors:

Cleaning of root canal preparation were done following proper principles as per given by Young GR et al (2007).

Type of instrumentation (Hand and engine driven):

Many researcher compared hand and engine driven instrumentation to assess periapical expulsion of debris: Beeson et al (1998) were the first to compare traditional hand filing and engine-driven rotary instrumentation methods and observed that the rotary profile produced less debris extrusion than conventional filing. Many studies showed that engine-driven instrumentation showed less apical extrusion than hand instrumentation like Reddy and Hicks (1998) , Hinrichs et al (1998), Ferraz et al (2001), Mangalam et al (2002), Bidar et al (2004), Azer et al (2005), Zarrabi et al (2006), Kustarci et al (2008), Kustarchi et al (2008), Adl et al (2009), Madhusudhana et al (2010), Ghivari et al (2011) and Reyhani and Ghesami (2016). As compared to hand files, rotary files design feature serve to minimize contact between file and dentin so as to decrease taper lock and screw effect, thus reduces apical extrusion {Mohammadi et al (2009)}.

Mangalam et al (2002) compared hand and rotary instrumentation along with time consumption. They observed that hand instrumentation showed more apical extrusion with greater time consumption. As machine operated rotary files required less time for canal preparation than hand file. However, Logani and Shah (2008) found different result when researchers compared nickel-titanium made files. They compared hand protaper, universal protaper rotary and profile rotary instrumentation systems and observed that hand protaper produced less amount of apical debris than protaper rotary and the least with profile rotary. Researcher explained that protaper systems have greater cutting efficiency and aggressive taper causing more apical extrusion than profile. Between the hand and rotary protaper system, hand protaper showed less apical extrusion as balanced force permits control pressure of the instrument inside the canal allowing better removal of debris adhering to its debris. Luci et al (2010) also obtained contrast result when author studied apical extrusion of debris with three different instrumentation techniques - hand (crown–down), engine-driven reciprocating system (crown-down) (M-4 system) and engine-driven continuous rotary (Protaper) system. They observed that continuous rotary (Protaper) system produced greater apical extrusion than others. Author claimed that rotary protaper

promotes greater dentin wear in shorter time because of its greater cutting capacity and taper.

Effect of various rotary instrumentations:

After having confirmed the superior efficacy of rotary instrumentation over hand instrumentation in terms of debris expulsion, further research studies were conducted to the type of rotary instrumentations which was better in terms of reduced debris and irrigant extrusion beyond the apical foramen. Tanalp et al9 (2006) compared the protaper, profile, and HERO shaper rotary instrumentation systems for apical expulsion and observed that the profile system showed the least debris while protaper showed the most. Another study by Tasdemir et al (2010) compared the apical extrusion of debris using three nickel-titanium rotary systems - protaper, Mtwo and BioRaCe and observed that the BioRaCe system produced the least whereas the protaper system produced the most. Comparatively, rotary protaper have progressive taper and simultaneous dentin cutting at apical and coronal region can cause more extrusion . Kocak et al (2015) assessed different generations of rotary protaper system like universal protaper and protaper next for the apical extrusion of debris during instrumentation. They concluded that protaper next instrumentation resulted in less apical extrusion than universal protaper. Explanation for this is given by Ruddle et al (2013) as protaper next is fifth generation rotary file that has been designed such that its centre of mass and centre of rotation are offset. In rotation, this offset design with rectangular cross section design produces mechanical wave of motion that travel along the active length of file which minimizes the engagement between file and dentin. In addition, this offset design enhances debris pushing out of canal in coronal direction. That's cause of less apical extrusion with respect to protaper next file compared with universal rotary protaper as similar observation were noted by Caper et al (2014) . Froughreyhani et al (2011) assessed the amount of extruded debris using Mtwo and RaCe instrumentation systems, and reported that the Mtwo system produced more debris than RaCe instrumentation. This observation explained by author as Mtwo files was used in "single-length technique with brushing movement" while RaCe system was used in crown-down manner with pecking motion causing less apical extrusion. Nagaveni et al (2013) compared the amount of apically extruded debris and volume of irrigating solution using Universal Protaper, Hero-shaper, RaCe and K3 rotary instrumentation systems. They concluded that K3 showed the least amount of extruded debris and irrigating solution while Protaper showed the most. RaCe exhibited extrusion of less volume of irrigating solution compared to Hero shaper instrumentation system. Er et al (2005) assessed the apical extrusion of bacteria using engine driven Ni-Ti instrumentation systems universal protaper rotary and system GT. The researcher observed that although system GT showed more amount of bacterial extrusion than universal protaper rotary system with no statistically significant difference.

The effect of full sequence and reciprocating file systems on apical extrusion:

Burklein and Schafer (2012) compared the apical extrusion of debris using two reciprocating-single file systems (Reciproc and Wave one) and that using two full-sequence multiple file rotary systems (Mtwo and Protaper). They observed that the reciprocating systems produced more apical debris than the full-sequence rotary systems like Burklein et al (2014), Surakanti et al (2014), KÜÇÜKYILMAZ et al (2014), Nevares et al (2015), Borges et al19 (2016), Vivekanandan et al (2016), Nayak et al (2014) and Vivekanandan et al (2016). Reciprocating file has clockwise (CW) and counter-clockwise (CCW) rotation of file movement with more CW rotation than CCW rotation. When instrument was rotated CW, it will screw in the canal and when rotated CCW, it will unscrew out of the canal. As the CW rotation was greater than CCW, the end result was screwing in effect causing debris pushed apically.

Lu Yan et al (2015) reported the apical as well as coronal extrusion of debris using two reciprocating single file system, Reciproc and Waveone, and two full-sequence rotary BLX and Protaper instruments. The researcher concluded that reciprocating single file system produced less extrusion of debris compared with full-sequence rotary instrumentation. Authors have explained this observation as there was difference in diameter after instrumentation compared with Burklein and Schafer (2012). Author had followed manufacturer's instruction for canal preparation. Another study by Ustun et al (2015) showed the less amount of apical debris with reciprocating file (waveone) compared with Universal Protaper and twisted file. Similar observations mentioned by others as De-Deus G et al (2015), and Tinoco et al (2014) observed reciprocating rotary systems showed less apical extrusion than continuous rotary instrumentations. The taper of the Protaper instruments favor the preparation of the apical third in early stages, thus, wear occurs early throughout the whole root canal because the instruments reach the working length in the beginning of the preparation, causing greater apical extrusion of bacteria. Literatures don't mention any obvious reason for these findings.

Effect of different pitch of instrument in relation to apical extrusion of debris:

Elmsallati et al (2009) compared the amount of apically extruded debris from curved canals when using rotary Ni-Ti files with different pitches and sequences of use under the same preparation technique. The researchers concluded that short pitch design resulted in less amount of apical extrusion than medium and long pitch design. Author explained as short pitch files have more threads and more grooves between cutting edges to entrap more debris along the same length than medium and long threads. This might have reduced the quantity of debris extruded with short pitch files.

Self-adjusting files and apical extrusion:

A self-adjusting file is a hollow, nickel-titanium file, designed as a compressible thin-walled pointed cylinder. It is 1.5-2.0 mm in diameter and composed of a 120mm thick Ni-Ti lattice. Several studies reported that instrumentation with self-adjusting file (SAF) produced less apical extrusion like Ozsu et al (2014), De-Deus et al (2014), Karatas et al (2015), Pawar et al (2015), Vyavahare et al (2016). The difference in apical extrusion attributed to the file design and kinematics of SAF system and other system's files. The SAF files allow continuous irrigation throughout the scraping of dentin. This could facilitate the augering of debris out of the canal and decrease in amount of apically extruded debris (2016). On the contrary Kirchhoff et al (2015) found more amount of apical expulsion with self-adjusting systems than twisted file, waveone, protaper system. Author had explained the observation as cleaning and shaping of flat-oval shaped canal was difficult to reach with all rotary and reciprocating files while self-adjusting file (SAF) adapt well in original shape of flat-oval canals. This could produce more debris along the motion applied to the file and file design. That must have caused apical extrusion of debris.

Influence Of Hand Instrumentation On Apical Extrusion Of Bacteria. Hedge M.et al (2011) assessed the apical extrusion of bacteria using step-back and crown down hand instrumentation technique. They reported that step-back produced more bacterial extrusion than crown down technique

Influence of continuous wave and different angle of reciprocation on apical extrusion of debris and bacteria:

Supremacy of continuous rotary instrumentation over reciprocating instrumentation in relation to apical extrusion of debris was observed by different authors. However, some authors had done experiment with different reciprocating angulation on apical extrusion as Karatas et al (2015) and Arslan et al (2016). Karatas et al (2015) evaluated the influence of movement kinematics of twisted file (TF) adaptive

movements (continuous rotation) with 90° clock-wise (cw)-30° counter clock-wise (ccw), 150° cw-30° ccw. The study reported that 90° cw-30°ccw motion produced more amount of apical extrusion than continuous rotation. 150° cw-30˚ccw motion produced results similar to continuous rotation.

These conflict results might be because of different instrument design and different files and root canal anatomy. Arslan et al (2016) compared the apical extrusion of debris using one system with different angulation. Reciproc instrumentation with different kinematics - 150° counter clockwise (ccw)-30° clock-wise (cw), 270° ccw-30° cw, 360° ccw-30° cw and continuous rotation. All instrument movements were associated with apical extrusion. Reciprocating motions 150° ccw-30° cw and 270° ccw-30°cw were associated with less extrusion than continuous motion.

Effect of different rotary instrumentation on apical extrusion of bacteria

- Garlapati et al (2013) observed apical bacterial extrusion using four different NiTi rotary systems K3, Mtwo, RaCe and Protaper instrumentation systems. The authors concluded that least bacterial extrusion in K3 group while most in Mtwo group. This may be attributed to its Standardized length preparation technique for Mtwo instrumentation (Single-length technique) where all the Ni-Ti instruments are taken to full working length and also to the double cutting-edge geometry of Mtwo instruments whose cross-section resembles an S-Instrument, an instrument with a similar geometry and a smaller cross-section surface than a triple cutting edge instrument with convex geometry (compared with K3, RaCe and Protaper). Because of its specific design characteristics, cutting efficiency, and its standardized length preparation technique Mtwo Rotary Ni-Ti instruments remove adequate amount of dentin in a short period of time thereby unable to displace the debris coronally, leading to significantly greater amount of apical extrusion of bacteria.
- Ghogre P et al (2015) assessed Protaper, K3XF , twisted files and hand files for bacterial extrusion. Hand preparation produced significantly more extrusion than rotary instrumentation. Among the rotary systems K3XF showed least bacterial extrusion.
- Mohammed N et al (2016) used two different rotary instrumentations for assessment of bacterial extrusion namely Protaper and twisted file with Xsmart and Xsmart dual group. They observed that twisted files group showed less bacterial extrusion than protaper. Similar finding were observed by Taneja S. et al (2015) where protaper, Hyflex and GTx were used.
- Teixeira JM et al (2015) assessed an influence of working length and apical preparation size on apical bacterial extrusion using reciprocating instrumentation. They observed that working length and apical preparation size had not any significant effect on bacterial extrusion.
- Turker SA et al (2015) evaluated the apical bacterial extrusion with different instrumentation systems like Protaper next , twisted file and One shape. One shape produced least bacterial extrusion than protaper next and twisted file.

c) Irrigation Related Influencing Factors

Influence of Irrigation protocol and Irrigation system

- Hulsmann et al (2007) reviewed the complications arising during root canal irrigation and found that the efficacy of root canal irrigation in terms of debris removal and eradication of bacteria.

The effect of irrigating device on apical extrusion

- Mitchell et al (2010) compared the 27-g needle irrigation with EndoVac irrigation system for extrusion of irrigants. They concluded that significantly less extrusion risk using EndoVac system compared with needle irrigation. Author observed that

EndoVac system has safe way of irrigation as it pulled irrigant within canal and removed by negative pressure at the working length. Similar observation noted by Tambe et al (2013), Nielsen BA and Baumgartner JC (2007). Altundasar et al (2011) evaluated the debris and irrigant extrusion potential of two rotary systems (protaper and RaCe system) with the combination of conventional /side-vented irrigation needles. It was observed that RaCe system in combination with side-vented needle showed the least apical debris expulsion. This is also supported by Psimma et al (2013), Yeter et al (2013). They reported that open-ended needle showed more amount of extrusion than close-ended needle. Open-ended needle caused direct pressure on irrigating solution causing expulsion of debris compared with close-ended needle.

Effect of different irrigation solution on apical extrusion:

- Parirokh et al (2012) compared the effect of 2% chlorhexidine, 5.25% sodium hypochlorite and 2.5% sodium hypochlorite, used as irrigants. It was observed that irrigation with 5.25% sodium hypochlorite was associated with more amount of apical extrusion compared to the other irrigants. Higher concentration of sodium hypochlorite better dissolve organic tissue than other irrigants. The authors concluded that the type of irrigant affected the amount of apically extruded debris.

CONCLUSION:

It is concluded that apical extrusion of debris, irrigant and microorganisms is not avoidable sequel in endodontic treatment. But, these periapical expulsions cause humoral or cell-mediated immunological reaction resulting in pain and /or swelling, apical periodontitis, periapical bone resorption. There are several factors responsible for periapical expulsion as root length, root curvature, cervical preflaring, and so on. Among the hand instrumentation technique step-back produced more apical extrusion than other hand instrumentation techniques. Rotary instrumentation generally produced less apical extrusion as well as less time consumption than hand instrumentation. Cervical preflaring reduced the apical extrusion comparatively. EndoVac irrigation system is recommended irrigation device than side-vented/closed-ended needle irrigation in relation to expulsion of debris. It would seem logical to use technique which minimizes periapical expulsion.

CLINICAL SIGNIFICANCE:

This review article discusses on various factors responsible for periapical expulsion like root length, root curvature and so on. This also focuses on how periapical expulsions can be minimized so as to minimize periapical expulsion for successful endodontic treatment with least patient discomfort.

REFERENCES:

1 Siqueria JF, Jr, Barnett F. Interappointment pain: Mechanisms, diagnosis, and treatment. Endod Topics. 2004;7:93–109.

2 Siqueira JF Jr. Microbial causes of endodontic flare ups. Int Endod J 2003;36:453-63.

3 Chapman CE, Collee GJ and Beagrie GS. A preliminary report on the correlation between apical infection and instrumentation in endodontics. J Brit Endod soci. 1968;12, 7-11.

4 Torneck CD Reaction of rat connective tissue to polyethylene tube implants, Part II. Oral Surgery 1967; 24, 674–683.

5 Seltzer S, Soltanoff W, Sinai I. Biologic aspects of endodontics. 3. Periapical tissue reactions to root canal instrumentation. Oral Surgery 1968;26, 534–46.

6 Seltzer S, Naidorf IJ. Flare-ups in endodontics. Etiological factors. J Endod 1985;11,472-478.

7 Torabinejad M, Eby WC, Naidorf IJ. Inflammatory and immunological aspects of the pathogenesis of human periapical lesions. Journal of Endodontics 1985;11, 479–488.

8 Bernett F. Tronstad L. The incidence of flare-up during endodontic treatment. J of Rent Res. 1989:68:1253.

9 Myers GL, Montomery S. Comparison of weights of debris extruded apically by conventional filing and canal master techniques. J Endod 1991;17, 275-279.
10 Tanalp J, Kaptan F, Sert S, Kayahan B and Bayirl G. Quantitative evaluation of the amount of apically extruded debris using three different rotary instrumentation systems. Oral Surg Oral Med Oral Path Oral Radiol Endod 2006;101(2):250-257.
11 Er, K., Z. Sümer, and K. E. Akpınar. Apical extrusion of intracanal bacteria following use of two engine driven instrumentation techniques."Int Endod j 2005;38.12: 871-876.
12 Tinaz AC, Alacam T, Uzun O, Maden M and Kayaoglu G. The effect of disruption of apical constriction on periapical extrusion. J Endod 2005; 31 (7):533-535.
13 Kustarci A, Akdemier N, Siso SH, Altunbas D. Apical extrusion of intracanal debris using two engine driven and step-back instrumentation technique: an in vitro study. Eur J Dent 2008;2:233-239.
14 Mohammadi Z (2009). In vitro evaluation of apical extrusion of bacteria following use of new rotary instrumentation system. The New York state dental journal:75 (3):28-30.
15 Ruiz-Hubard EE, Gutmann JL, Wagner MJ. A quantitative assessment of canal debris forced periapically during root canal instrumentation using two different techniques. J Endod 1987;1;13 (12):554-8.
16 Kum K, Spangberg L, Cha BY, Il-Young J, Seung-Jong L, Chan-Young L. Shaping ability of three ProFile rotary instrumentation techniques in simulated resin root canals. J Endod 2000: 26, 716–723.
17 Salzgeber RM, Brilliant JD. An in vivo evaluation of the penetration of an irrigating solution in root canals. J Endod 1977;3: 394–398.
18 Hachmeister DR, Schindler WG, Walker WA, Thomas DD (2002) The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. Journal of Endodontics 28, 386–90.
19 Borges MFAe, Miranda CES, Silva SRC, Marchesan M. Influence of Apical Enlargement in Cleaning and extrusion in Canals with Mild and Moderate curvatures. Braz Dent J (2011) 22(3): 212-217.
20 Camoes IC, Salles MR, Fernando MVM, Freitas LF and Gomes CC. Relationship between the size of patency file and apical extrusion of sodium hypochlorite. Indian J Dent Res 2009;20(4):426-430.
21 SOUZA, Ronaldo Araújo. The importance of apical patency and cleaning of the apical foramen on root canal preparation. Braz. Dent. J. [online]. 2006, vol.17, n.1 [cited 2018-03-26], pp.6-9. Availablefrom:<http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-64402006000100002&lng=en&nrm=iso>. ISSN 0103-6440. http://dx.doi.org/10.1590/S0103-64402006000100002.
22 JG Cailleteau, TP Mullaney. Prevalence of teaching apical patency and various instrumentation and obturation techniques in united states dental schools.J of Endod 1997;23:394-396.
23 Lambrianidis T, Tosounidou E, Tzoanopoulou M. The effect of maintaining apical patency on periapical extrusion. J Endod 2001;27: 696–698.
24 Psimma, Z., Boutsioukis, C., Vasiliadis, L. and Kastrinakis, E. A new method for real time quantification of irrigant extrusion during root canal irrigation ex vivo. Int Endod J 2013; 46(7): 619-631.
25 VandeVisse I, Brilliant JD. Effect of irrigation on the production of extruded material at the root apex during instrumentation. J Endod 1975;1,243-246.
26 Hinrichs RE, Walker WA and Schindler WG.A comparison of amounts of apically extruded debris using handpiece-driven nickel-titanium instrumentation system. J Endod 1998;24(2):102-106.
27 Mckendry DJ. Comparison of balance forces, endosonic and step-back filing instrumentation techniques: quantification of extruded apical debris. J Endod 1990;16(1):24-27.
28 Al-Omari MAO, Dummer PMH. Canal blockage and debris extrusion with eight

preparation techniques. J Endod 1995;21 (3):154-158.

29 Vansan, L.P., Pécora, J.D., da COSTA, W.F., Silva, R.G. and Savioli, R.N. Comparative in vitro study of apically extruded material after four different root canal instrumentation techniques. Braz Dent J, 1997;8 (2), :79-83.

30 Morgan LF, Montgomery S. An evaluation of the crown-down pressureless technique. J Endod 1984;10:491-8.

31 Fairbourn DR, McWalter GM, Montgomery S. The effect of four preparation techniques on the amount of apically extruded debris. J Endod 1987;13:102-108.

32 Borges AH, Pereira AM, Porto AN, Estrela CRDA, Pedro FLM, Aranha AMF and Guedes OA. The influence of cervical preflaring on the amount of apically extruded debris after root canal preparation using different instrumentation systems. J Endod 2016;42(3):465-469.

33 Barbizam JV, Fariniuk LF, Marchesan MA, Pecora, JD, Sousa-Neto, MD. Effectiveness of manual and rotary instrumentation techniques for cleaning flattened root canals. J Endod 2002;28:365-366.

34 Fornari VJ, Silva-Souza YTC, Vanni JR, Pécora DJ, Versiani MA, Souza-Neto MD. Histological evaluation of the effetiveness of increased apical enlargement for cleaning the apical third of curved canals. Int Endod J 2010;43:988-994.

35 Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271-275.

36 Young GR, Parashos P, Messer HH. The principles of techniques for cleaning root canals. Aust Dent J 2007;52:52-63.

37 Beeson TJ, Hartwell GR, Thornton JD and Gunsolley JC. Comparison of debris extruded in straight canal: conventional filing versus profile .04 taper series 29. J Endod 1998;24(1):18-22.

38 Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod 1998;24: 180-183.

39 Ferraz CCR, Gomes NV, Gomes BPFA, Zaia AA, Teixeira FB and Souza-Filho FJ. Apical extrusion of debris and irrigants using two hand and three engine-driven instrumentation techniques. Int Endod J 2001;34(5):354-358.

40 Mangalam S, Rao CVN, Laxminarayanan L. Evaluation of apical extrusion and irrigant using three instrumentation techniques. Endod J 2002; 14:19-23.

41 Bidar, Maryam, et al. Evaluation of apically extruded debris in conventional and rotary instrumentation techniques. J Calif Dent Assoc 2004;32.9: 665-671.

42 Azar NG, Ebrahimi G. Apically-extruded debris using the protaper system. Aust Endod J 2005;31(1):21-23.

43 Zarrabi MH, Bidar M and Jafarzadeh H. An in vitro comparative study of apically extruded debris resulting from conventional and three rotary (profile, RaCe and Flexmaster) instrumentation system. J Oral sci 2006;48(2):85-88.

44 Kustarchi A, Akpinar KE, Kursat Er. Apical extrusion of intracanal debris and irrigant following use of various instrumentation techniques. Oral Pathol Oral Radiol Endod J 2008;105:257-262.

45 Adl A, Sahebi, S, Moazami F and Niknam M. Comparison of apical debris extrusion using a conventional and two rotary techniques. Iran Endod J 2009;4(4):135-138.

46 Madhusudhana K, Mathew VB, Reddy NM. Apical extrusion of debris and irrgants using hand and three rotary instrumentation systems- an in vitro study. Contemp Clin Dent 2010;1(4):234-236.

47 Ghivari SB, Kubsad GC, Chandak MG and Akarte NR.Apical extrusion of debris and irrigant using hand and rotary systems: a comparative study. J Conserve Dent 2011;14(2):187-190.

48 Reyhani MF and Ghasemi N. Apically extruded debris: Mtwo vs BioRaCe and K-file. European international journal of science and technology 2016;5(2):54-59.

49 Logani A and Shah N. Apically extruded debris with three contemporary Ni-Ti instrumentation system :an ex vivo comparative study. Indian J Dent Res. 2008;19(3):182-185.

50 Luci SB, Zottis AC, Piffer CS, Vanzin AC, Ligabue RA. Apical extrusion of debris after

hand, engine driven reciprocating and continuous preparation. Rev Odonto Cienc 2010;25(3):288-291.

51 Tasdimer T, Er K, Celik D and Aydemir H. An in vitro comparison of apically extruded debris using three rotary nickel-titanium instrument. J Dent Sci 2010;5(3):121-125.

52 Ruddle CJ, Machtou P and West JD. The shaping movement 5th generation technology. Dentistry today J april 2013:1-8.

53 Kocak MM, Cicek E, Kocak S, Saglam BC and Yilmaz N. Apical extrusion of debris using protaper universal and protaper next rotary systems. Int Endod J 2015;48(3): 283-286.

54 Caper ID, Arslan H, Akcay M and Ertas H. An in vitro comparison of apically extruded debris and instrumentation times with protaper universal, protaper next, twisted file adaptive and Hyplex instruments. J Endod 2014;40(10):1638-1641.

55 Froughreyhani M, Lotfi M, Rahimi S, Shahi S, Milani AS and Mehanfar N. Evaluation of the amount of apically extruded debris using Mtwo and RaCe system. Afra J Biotechnol 2011;10(84): 19637-19640.

56 Nagaveni SA, Balakoti KR, Smita K, Ratnakar P, Satish SV and Aravind T. Quatitative evalution of apical extrusion of debris and irrigant using four rotary instrumentation system: an in vitro study. J Contemp Dent Pract 2013;14(6):1065-1069.

57 Burklein S and Scahfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod 2012;38(6):850-852.

58 Burklein S, Benten S and Schafer E. Quantitative evaluation of apically extruded debris with single file systems: Reciproc, F360 and OneShape versus Mtwo. Int Endod J 2014;47(5):405-409.

59 Surakanti JR, Venkata RP, Vemisetty HK, Dandulo RK, Jaya NM, Thota S. Comparative evaluation of apically extruded debris during root canal preparation using ProtaperTM, HyflexTM and WaveoneTM rotary system. J Conserve Dent 2014;17(2):129-132.

60 KÜÇÜKYILMAZ Ebru, SAVAS Selcuk, SAYGILI Gokhan, UYSAL Banu. Assessment of apically extruded debris and irrigant produced by different nickel-titanium instrument systems. Braz. oral Res J; 2015;29(1): 1-6.

61 Nevares G, Xavier F, Gominho L, Cavalcanti F, Cassimiro M, Romeiro K, Alvares P, Queiroz G, Sobral AP, Gerbi M, Silveria M and Albuquerque. Apical extrusion of debris produced during continuous rotating and reciprocating motion. Scientific World J 2015:1-5.

62 Vivekanandhan P, Subbiya A, Mitthra S, Karthick A (). Comparison of apical debris extrusion of two rotary systems and one reciprocating system. J Conserv Dent;2016;19:245-9.

63 Nayak, G., Singh, I., Shetty, S. and Dahiya, S. Evaluation of apical extrusion of debris and irrigant using two new reciprocating and one continuous rotation single file systems. J Dent (Tehran, Iran), 2014;11(3):302-309.

64 Vivekanandhan P, Subbiya A, Mitthra S, Karthick A (2016). Comparison of apical debris extrusion of two rotary systems and one reciprocating system. J Conserv Dent;19:245-9.

65 Lu, Y., Chen, M., Qiao, F., & Wu, L. (2015). Comparison of apical and coronal extrusions using reciprocating and rotary instrumentation systems. BMC Oral Health, 15, 92. http://doi.org/10.1186/s12903-015-0081-z.

66 Ustun Y, Canakci BC, Dincer AN, Er O and Duzgun S (2015). Evaluation of apically extruded debris associated with several Ni-Ti system. Int Endod J 48(7):701-704.

67 De-Deus G, Neves A, Silva EJ et al. Apically extruded dentin debris by reciprocating single-file and multi-file rotary system. Clin. Oral Investig. 2015:19, 357–61.

68 Tinoco JM, De Deus G, Tinoco EM, Saavedra F, Fidel RA, Sassone LM. Apical extrusion of bacteria when using reciprocating single file and rotary multifile instrumentation systems. Int Endod J. 2014:1;47 (6):560-6.

69 Elmsallati EA, Wadachi R, Suda H). Extrusion of debris after use of rotary nickel titanium files with different pitch: A pilot study. Aus Endod J 2009:1; 35 (2):65-69.

70 Ozsu, D., Karatas, E., Arslan, H. and Topcu, M.C., (). Quantitative evaluation of apically extruded debris during root canal instrumentation with ProTaper Universal, ProTaper Next, WaveOne, and self-adjusting file systems. Eur J Dent 2014: 8(4): 504-508.

71 De-Deus GA, Silva EJNL, Moreira EJ, Neves ADA, Belladonna FG and Tameirao. Assessment of apically extruded debris by self-adjusting file system. J Endod 2014:40(4):526-529.

72 Karatas E, Ozsu D, Arslan H and Erdogan AS. Comparison of the effect of nonactivated self-adjusting file system, Vibringe, EndoVac ultrasonic and needle irrigation of apical extrusion of debris. Int Endod J 2015:48(4):317-322.

73 Pawar, A.M., Pawar, M.G., Metzger, Z. and Kokate, S.R). The self-adjusting file instrumentation results in less debris extrusion apically when compared to WaveOne and ProTaper NEXT. J Conserv Dent.,2015:18(2): 89-93.

74Vyavahare NK,Raghavendra SS, Desai NN. Comaparative evaluation of apical extrusion of debris with V-Taper, ProTaper Next and the self-adjusting file system. J Conserv Dent 2016;19:235-8.

75 Kirchhoff AL, Fariniuk LF and Mello I. Apical extrusion of debris in flat-oval root canals after using different instrumentation systems. J Endod 2015:41(2):237-241.

76 Mithra N. Hegde & Snehal Thatte. Comparison of the amount of apical extrusion of bacteria following the use of different instrumentation techniques – an in vitro study. NUJHS : 2011; I,(4):27-32.

77 Karataş, E., Arslan, H., Kırıcı, D.Ö., Alsancak, M. and Capar, I.D.,. Quantitative evaluation of apically extruded debris with Twisted File Adaptive instruments in straight root canals: reciprocation with different angles, adaptive motion and continuous rotation. Int Endod J 2015:49(4):382-385.

78 Arslan, H., Doğanay, E., Alsancak, M., Çapar, I.D., Karataş, E. and Gündüz, H.A). Comparison of apically extruded debris after root canal instrumentation using Reciproc® instruments with various kinematics. Int Endod J 2016:49(3):307-310.

79 Garlapati R, Venigalla BS, Patil JD, Raju RV, Rammohan C . Quantitative evaluation of apical extrusion of intracanal bacteria using K3, Mtwo, RaCe and protaper rotary systems: An in vitro study. J Conserv Dent 2013:1;16 (4):300.

80 Ghogre P, Chourasia HR, Agarwal M, Singh MP, Gurav S, Ghogre R. Quantitative evaluation of apical extrusion of intracanal bacteria using rotary ProTaper, K3XF, twisted and hand K-file system: An ex vivo study. Indian J Dent Res. 2015;26(4):406-410.

81 Mohammed N, Noushad MC, Balan B, Dhanesh N, Jayasheelan N, Revankar VD . Apical Extrusion of Intracanal Bacteria following use of Two Engine-driven Instrumentation Techniques: An in vitro Study. J contemp Dent Pract 2016 ;17(11):939-942.

82 Taneja S, Kumari M, Barua M, Dudeja C, Malik M. Apical extrusion of Enterococcus faecalis using three different rotary instrumentation techniques: an in vitro study. Indian J Dent Res. 2015 Jan-Feb;26(1):67-71.

83 Teixeira JM, Cunha FM, Jesus RO, Silva EJ, Fidel SR, Sassone LM. Influence of working length and apical preparation size on apical bacterial extrusion during reciprocating instrumentation. Int Endod J 2015;48(7):648-53.

84 Türker SA, Uzunoğlu E, Aslan MH. Evaluation of apically extruded bacteria associated with different nickel-titanium systems. J Endod 2015 ;41(6):953-5.

85 HÜLSMANN, M., RÖDIG, T. and Nordmeyer, S. Complications during root canal irrigation. Endod Topics, 2007;16(1):27-63.

86 Mitchell RP, Yang SE, Baumgarter JC. Comparison of apical extrusion of NaOCl using the EndoVac or needle irrigation of root canal. J Endod 2010; 36 (2):338-341.

87 Tambe, V.H., Nagmode, P.S., Vishwas, J.R., Saujanya, K.P., Angadi, P. and Ali, F.M.,. Evaluation of the amount of debris extruded apically by using conventional syringe, Endovac and ultrasonic irrigation technique: An in vitro study. J Int Oral Health, 2013;5(3):.63-66.

88 Nielsen BA and Baumgartner JC. Comparison of EndoVac system to needle irrigation of root canals. J Endod 2007;33(x) 1-5.

89 Altundasar E, Nagas E, Uyanik O and Serper A. Debris and irrigant extrusion potential of 2 rotary systems and irrigating needle. J Endod 2011;112(4): e31-e35.

90 Psimma, Z., Boutsioukis, C., Vasiliadis, L. and Kastrinakis, E., A new method for real time quantification of irrigant extrusion during root canal irrigation ex vivo. Int Endod J, 2013;46(7): 619-631.

91 Yeter KY, Evcil MC, Ayranci LB and Ersoy I. Weight of apically extruded debris following use of two canal instrumentation techniques and two designs irrigation needles. Int Endod J 2013;46(9):795-799.

92 Perirokh M, Jalali S, Haghdoost AA and Abbott PV. Comparison of the effect of various irrigants on apically extrusion of debris after root canal preparation. J Endod 2012;38(2):196-199.

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