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Factors Affecting Apically Extrusion Debris During Root Canal Treatment -A Literature Review

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Abstract: *The problem of the ejection of intracanal debris and irrigants during root canal therapy has not yet been solved by an instrument or a method. A technique of shaping or irrigation should be designed to minimise the risk of apical extrusion to the greatest extent possible, even if doing so is not always possible. This is due to the possibility that any irritation of the periapical tissues might produce flare-ups. During the previous decade, there was a rapid development of root canal instruments and irrigation systems; several of these instruments and systems have been evaluated for their propensity to extrude debris. This research was conducted to locate literature that discusses the assessment extrusion of debris, bacteria, and irrigant during root canal therapy. The terms "apical extrusion," "debris extrusion," and "endodontic treatment" were entered into the search engines PubMed, Ovid, and MEDLINE, respectively. The search through the relevant literature spanned more than 35 years, up to 2021. This study's focus was limited to the apical extrusion of debris and irrigants the extrusion of fluids produced by irrigation systems, and the extrusion of microorganisms. In the publications that were retrieved, further searching in the reference sections provided information on issues that were relevant to apical extrusion. This study offers an update on the most recent developments concerning apical extrusion.*

Keywords*: *Debris extrusion, flare up, Ni–Ti file, postoperative pain, Rotary Instrumentation, root canal treatment.

1. Introduction

An intra-radicular microbial infection is the main source of a periapical lesion [1]. Apical periodontitis can be avoided and treated with proper endodontic therapy [2]. Endodontic therapy's objectives include periapical tissue preservation, enhancement of health, and prevention of periapical diseases. Root canal treatment is a process that consists of mechanically instrumenting the root canal, followed by irrigation and obturation using biocompatable material [3].

Technically, instrumentation and irrigation are used to remove sick tissue from the root canal fully, debride the canals, and shape the canals into a consistent conical shape. This makes it easier to supply the canals with medications and ensures they are properly obturated [4].

Microbiologically, instrumentation and irrigation work to remove microbes, decrease the probability of the bacteria surviving in the root canal, and eliminate any antigenic potential they may still have [5].

Clinical relevance of debris extrusion

As part of the chemomechanical preparation process, chips of dentin, pulp fragments, irrigations, and microorganisms may accidentally be pushed into the periapical tissues from the root canal [6], leading to post-treatment complications like inflammation, post-treatment pain, and slow healing [7].

When using an instrumentation technique, one of the primary concerns is the amount of substance pushed through the foramen [8]. It is believed that post-treatment flare-ups and, more significantly, root canal treatment failures are caused by the periapical extrusion of debris, dentine muck, or bacteria [9].

It has been observed that the occurrence rate of these problems ranges between 1.4% and 16%. [7] Therefore, preventing debris extrusion in root canal treatment is essential [10]. All files and instrumentation techniques incorporate apical debris extrusion; the quantity of ejected debris may vary depending on the preparation method used [11].

The kinematics selected and rotary file design help to move dentin debris coronally towards the canal orifice and accumulate it in the flutes of the preparation instruments, reducing apical compaction of debris [12]. Therefore, selecting a technique to reduce apical debris extrusion can result in a more favourable postoperative course [13].

According to Nair *et al*., [14]. all instrumentation techniques produce apically extruded debris, even when the preparation is retained at the apex.

Techniques of instrumentation

Manual

The crown-down technique and step-back instrumentation in plastic blocks were compared by Ruiz-Hubard et al. [15]. in both straight and curved canals. Instead of using step-back instrumentation, the authors found that using the crown-down pressure-less approach resulted in less debris being extruded apically. McKendry [16] reported that utilizing a balanced forced technique resulted in less apical debris extrusion than step-back procedures.

Similar findings were discovered by Al-Omari and Dummer [17], who concluded that step-back instrumentation combined with circumferential filing leads to the amount of apical extrusion at the same time, balanced force and crown-down techniques result in the smallest quantity of debris.

Manual vs. rotary techniques

Compared to instrumentation procedures that include a rotating force, push-and-pull canal enlargement actions, such as filing, generate a greater number of apical debris. This is one of the findings consistent throughout the aforementioned researchconsistent throughout the researchresearch above above. This led to the formation of a hypothesis that engine-driven rotary devices using the balanced force technique would generate less debris than hand-filing operations, hence lowering the risk of periradicular tissue irritation and postoperative sequelae [18].

Del Fabbro *et al.*, [19] advocate using nickel-titanium [NiTi) instrumentation for root canal treatment to lessen the quantity of apical extrusion of debris. Similar studies show that using the rotation technique for canal preparation causes less post-treatment pain than K-files [20].

However, Içek *et al*., [21] found different outcomes and concluded that the rotational and reciprocal preparation techniques produced more pain over 48 hours than the modified step-back technique. When comparing K-file hand instrumentation to Mtwo rotary instrumentation (VDW, Munich, Germany), Kashefinejad *et al.*, [22] discovered a statistically significant difference in the pain experienced after therapy. Only 13.3% of patients in the rotary group needed analgesics, compared with 56.7% in the manual group.

Continuous vs. reciprocating single-file systems

When continuous rotating systems and reciprocating systems are utilised, the outcomes of previous researches on postoperative pain have been variable [23].

The One Shape (Micro-Mega, Besancon, France) file was selected as the preferred file for the rotating single-file group in examining postoperative pain by three distinct researchers. When compared to various single-file reciprocating instruments [24].

Mollashahi et al. [25] and Jain et al. [24] found no discernible differences in the severity of postoperative pain across the three relevant papers. Reciprocal single-file groups and single-file rotation on the other hand, in research by Neelakantan and Sharma [26], both the reciprocating single-file group and the One Shape rotary group reported much less intense postoperative pain.

Multi-file vs. single-file systems

A meta-analysis on the effects of engine-driven rotary and reciprocating tools on patients' post-treatment pain was carried out by Sun *et al.* [27]. The researchers looked at a total of 12 separate investigations. The researchers found multiple rotary-file systems resulted in much reduced postoperative discomfort compared to reciprocating single-file systems.

According to the findings of research conducted by Robinson et al. [28], multiple rotary-file systems produced cleaner canals than reciprocating files because they prevented the buildup of debris still present within the root canal.

In Robinson et al. study, the mesial roots of mandibular molars were instrumented, and the three-dimensional distribution, amount, and density of the unremoved inorganic debris were examined. It was found that utilising a single-file reciprocating technique left an average of 19.5% debris in the canal, but using a multi-file rotational approach left only 10.6% debris in the canal. This finding demonstrates that more material accumulates in the canal due to the velocity when using the reciprocating method.

Rotary kinematics

Three distinct categories of instruments may be used during root canal preparation. Instruments operated manually, instruments driven by engines to rotate, and instrumentsoperated manually, instruments driven by engines to rotate, and instruments driven by engines to reciprocate are included in these categories [29].

Most rotational NiTi root canal instruments on the market now rotate constantly around a single axis (Figure 1) [30].

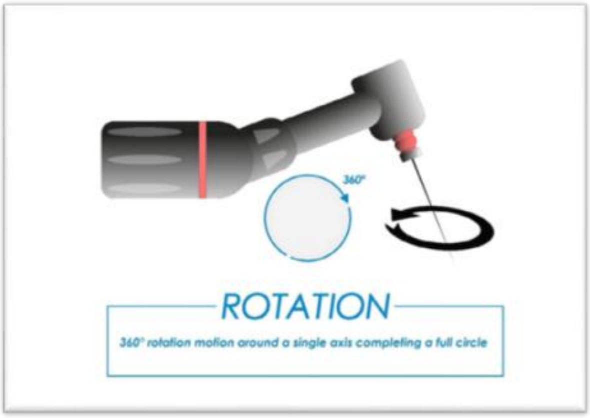

Figure (1). Engine-driven continuous rotation.

The chance of a NiTi instrument breaking during conventional continuous rotation is higher because of torsional and flexural strains [31]. One of the file terminals on a metal shaft that has undergone torsional fatigue twists along its longitudinal axis, whereas the other terminal is intact (Figure 2) [32].

A torsion fracture occurs when any part of the instrument, including the tip, locks and binds to canal walls as the rest of the file rotates. More torsional stress is produced when shaping smaller-diameter root canals than when shaping larger-diameter canals. When a metal is repeatedly put under tension and compression, it develops cyclic fatigue, which weakens the structure of the metal (Figure 3) [33].

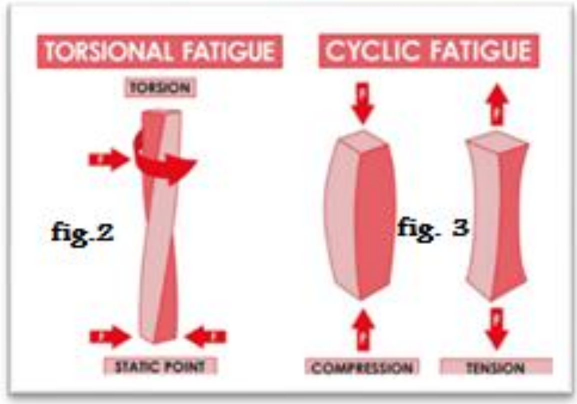

Figure (2). Schematic presentation of forces contributing to torsional fatigue.
Figure 3. Schematic presentation of forces resulting in material cyclic fatigue.

Flexural fatigue may cause an instrument to fracture if it is subjected to extra force after being worn down by metal fatigue. When it breaks at the point of maximal flexure, the tool rotates freely and does not bind to the walls of the root canal [33].
Cyclic fatigue is more likely to occur in a canal with a strong curve and a limited radius of curvature, according to findings from studie [31]. Whereas straight canals may experience torsional stress [34].
The main factor for NiTi instrument separation is thought to be cyclic fatigue [35]. M anufactureranufactureranufactureranufacturera nufactureranufacturers have used modern design and manufacturing methods have used modern design and manufacturing methods have used modern design and manufacturing methods have used modern design and manufacturing methods have used modern design and manufacturing methods have used modern design and manufacturing methods to improve safety while increasing resistance to file breakage in the newest NiTi rotary instruments [36]. Reciprocal movement was created to reduce endodontic tool breakage caused by flexural fatigue [37].
The cycle fatigue resistance of NiTi instruments could be improved, as suggested by a recent assessment of the relevant published literature, by using a reciprocating motion for an extended period rather than continuous rotation [37]. Reciprocation was first used in endodontics in 1958 and is defined as any repetitive backward [upward or downward) or forward (forward and reverse) movement [24].

Early reciprocating systems alternated 90° angles in equal motion; more current systems employ a 30° angle. None of which could finish a complete cycle of rotation [38].

Most recent developments have enabled the development of systems that depend on a new mechanical rotation a multiple reciprocation movement that completes 360° cycles (Figure 4).

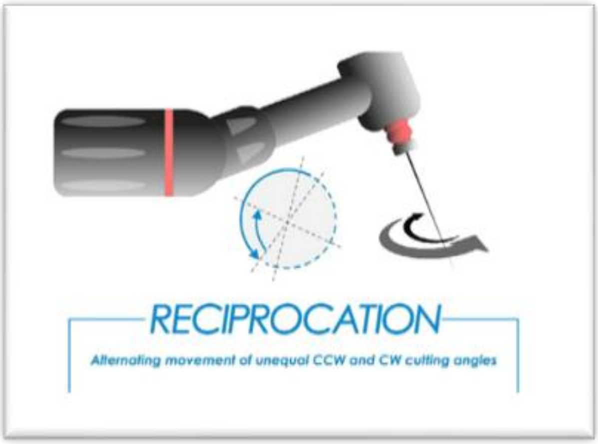

Figure (4.) Engine-driven reciprocation.

Reciprocating instrumentation has complicated kinematics. Instead of spinning continuously, the files move back and forth with a reverse balancing force [39].
As an alternative to full-sequence continuous rotation files, reciprocal file systems use the alternating movement of unequal cutting angles in both the clockwise and anticlockwise directions. This helps to avoid torsional fractures. The reciprocational movement aims to reduce the risk of damage by, first, engaging the file in a cutting action and then, as fast as possible, disengaging it in a motion that does not include cutting [40].
Numerous investigations have compared the apical extruded debris of reciprocating systems

and continuous rotation systems. According to several authors, rotary files produced less apical debris than reciprocating files did [41].

In contrast, several authors discovered that rotary instrumentation caused more apical debris extrusion than reciprocating instrumentation did [42]. Numerous studies also revealed no significant distinction between the two systems [43].

In a recent study, a comparison was made between the quantity of apical extrusion debris generated with the continuous rotation files HyFlex EDM (Coltene, Altstatten, Switzerland) and XP Shaper (FKG Dentaire) and the reciprocation file Reciproc Blue (VDW) in canal preparation At the same time, the temperature was set to body temperature. There was no noticeable difference between the HyFlex EDM files and the other NiTi files that were evaluated; however, the XP-endo Shaper group extruded a substantially lower number of debris than the Reciproc blue group [44].

TheThe different findings may be due to differences in file design, the total number of files utilized, and even the anatomical structure of the canals across the studies [45].

Apical patency

During canal instrumentation, dentinal and pulpal debris can create errors in the root canal's procedure and obstruct the apical region [17]. Apical debris accumulation is reported to be prevented by maintaining the apical orifice open and the space between it and the periodontal ligament clean [46]. The first phase of root canal treatment consists of establishing apical patency.

A tiny hand file must be able to pass through a little constriction of the apical foramen with ease and consistency to be considered apical patency. Glide path preparation comes next, followed by starting root canal enlargement [47]. To keep the root canal clean and preserve apical patency, it is necessary to regularly recapitulate through the apical constriction using a tiny K-file [47].

They concluded that less material was extruded via the foramen when the apical constriction was enlarged. To support this conclusion, Tinaz et al. study [48] demonstrated that when the apical patency's diameter increased, the amount of apically extruded material increased as well.

The study design is responsible for the conflicting findings. In the work by Lambrianidis et al. [49], a step-back approach was used to instrument the canal in two stages. The initial instrumentation was only performed up to the point when the root canals were apically constricted. The apical constriction was visibly expanded when the second phase of canal preparation was performed. The canals had been previously widened in phase one, which would have made it simpler to clear away debris since the coronal section of the canal area was widened in phase two. In phase two, the canal area was also expanded.

Use a patency file carefully since it can drive collected debris apically, potentially introducing microorganisms to the periapical area [50]. On the other hand, recent studies demonstrate that maintaining apical patency does not enhance the levels of postoperative pain or the incidence of flare-ups.

Glide path

A further preparatory step performed before canal instrumentation is glide path preparation [47]. A usual description of it is "a smooth radicular tunnel from the canal orifice to the physiologic terminal (foraminal constriction)" [51]. A repeatable glide path should be constructed before beginning the procedure of preparing the canal. This will help decrease procedural errors and increase the shaping capabilities of the final canal shaping system [52].

Initial glide path development minimises the time needed for preparation while maintaining the natural architecture with minimal changes and variations in the curve of the root canal [53]. Enhancing the results of root canal treatment therapy [5] As a result of the fact that manual and rotary glide path instruments first have to negotiate their way through root canal systems that are calcified and blocked, these instruments are exposed to a significant amount of torsional stress [31].

If the cross-section of the instrument tip is bigger than the width of the canal, there is a possibility that the instrument blades may get locked in the root canal walls. Taper locking is the term for this. A gliding path is created, which minimises the contact area between the shaping file and the root canal walls to minimise the possibility of taper locking and lower torsional stress [54].

The incidence of instrument breakage has been thought to be significantly reduced by a gliding path because it decreases the torsional and flexural stress on the root canal instrument [55]. Since it produces a reproducible tunnel in which rotary preparation instruments can work with fewer occurrences of instrument breakage or canal aberrations, glide path preparation increases the efficacy of root canal preparation [55].

During preenlargement procedures, a significant amount of the pulp, bacteria, and related irritants are removed, which lowers the risk of problems after treatment. More irritants are pushed beyond the apex, and more postoperative symptoms are caused by coronally passing files viainadequately prepared canals. A cleansed preenlarged preparation, on the other hand, results in less detritus being unintentionally infected periapically when files are processed through it [18].

However, there were no noticeable differences in apical debris extrusion between the K-files and the other rotational glide path files. [56] These outcomes could be related to Tinaz et al.'s [48] finding that more apically extruded debris was generated in teeth with higher apical patency during manual K-file instrumentation and engine-driven rotary instrumentation utilising the ProFile.04 Taper Series (Dentsply Sirona).

Regardless of the methods utilised, apically extruded debris tended to rise as the apical patency diameter increased. Generally, the main shaping process produces more debris than the glide path preparation process.

Instrument design

Removing damaged radicular dentine, bacteria, and microbial toxins from the root canal system are the primary objectives of the biomechanical preparation process [57]. Most of the mechanical root canal instrumentation devices now in use suggest multiple or single file systems to reduce canal dimensions [57]. An ISO tip size of 25 and either a continuous 6% taper or a variable 6% taper are often used in root canal enlargements that are considered standard [4].

The flutes of rotary files gather dentinal debris and transfer it coronally towards the canal opening, preventing debris from compaction in the root canal. It's moved coronally towards the canal orifice. This is achieved using rotary files [12]. It is believed that apical debris extrusion is caused by variations in the cross-section and cutting blade design, taper, tip type, configuration, flexibility, alloy, number of files utilised, kinematics, and cutting efficiency [58].

Manufacturers have experimented with innovative manufacturing procedures, thermal treatments after production, and varied cross-sectional designs to improve NiTi alloy properties. Endodontic files constructed of NiTi alloy are either martensite (CM wire, gold, and blue heat-treated NiTi) or austenite (ordinary NiTi, M-Wire, and R-Phase) [59].

NiTi alloys M-Wire, R-Phase, and CM-Wire have been heat treated. M-wire contains martensite, R-phase, and austenite. Compared to NiTi files, M-Wire and R-Phase instruments are more flexible and cycle fatigue-resistant. CM-Wire uses stable martensite because the austenite finishing temperature exceeds the operating temperature. CM-Wire recovers after autoclaving or heat [60].

Clockwise/forward/right-cutting reciprocation

The reciprocating motion technique improves the balanced force approach, which lowers mistakes during root canal instrumentation [61]. Alternating changes in rotational direction decrease the number of cycles and cyclic fatigue on instruments. This is in comparison to when instruments rotate continuously. Reciprocating root canal shape has increased fracture resistance in several studies [62]. The Espir [63] study showed that canal preparation is effective with CW reciprocation motion with Mtwo (VDW). All continuous rotation systems cut clockwise, often known as right-cutting. The rotating CW cutting tool cannot pierce or cut canal walls in a CCW reciprocating motion. The CCW angle of motion is larger than the CW angle in reciprocating file systems that cut left [64].

In 2016, two studies examined how kinematics affected the ejection of apical debris. The same instruments, used in the same order, were evaluated in these trials. The only difference between groups was in movement kinematics, eliminating other factors like instrumentation sequence, metallergy, and design of instrument. The researchers discovered that movement kinematics significantly impacted the quantity of debris extruded apically [7, 65].

Solutions and extruded debris

A necessary part of the debridement process is irrigation. When endodontic instruments are used during preparation, dentine debris and the smear layer that adheres to the canal walls are produced. They should be removed from the root canal system to increase the chance of an effective outcome [66]. While irrigation is the most important step for clearing away debris and the smear layer, In the canal system, it is impossible to remove around half of the debris created when instrumentation is performed [67].

Irrigation must be delivered into the apical part of the canal so that it may be cleansed and maintained free of debris at all times. Decreasing thelikelihood of obstructions and the ejection of apical debris [68]. Due to the vapour lock effects, irrigation typically fails to reach the apical third of the canal. Agitating the irrigant may considerably increase the exchange and effectiveness of any chosen solution and create a powerful hydrodynamic effect [69].

In the results of recent research by Gupta and colleagues [70], apical ejection of debris and irrigant was seen when different irrigation agitation methods were used. Compared to the no-agitation control groups, the mean quantities of apical extruded debris and irrigant were higher in the agitation groups. This could result from increased turbulence brought on by enhanced irrigant displacement inside the canal. Regular and adequate irrigation is believed to improve the removal of dentine and pulpal debris [71].

Conflicting findings were discovered when examining the association between the quantity of debris extruded from the apex and the amount of irrigant used. Myers and Montgomery [72] and Tinaz et al. [73] did not discover any relationship between the two variables, while Hinrichs et al. [74] and Ferraz et al. [75] did discover a positive relationship between the two variables.

Since organic material can be dissolved by sodium hypochlorite (NaOCl) solution, It offers huge possibilities for removing the debris created during a chemo mechanical root canal preparation [76]. In addition, it has antimicrobial abilities, making it possible for the root canal system to be effectively cleaned [77].

In addition to the buildup of dentinal debris inside the canal, endodontic instrumentation techniques are responsible for producing the smear layer that accumulates on the walls of the root canal and cause obstruction dentinal tubule openings. The smear layercomprises various biological and inorganic components, including dentinal filings, microorganisms, and bits and pieces of odontoblastic processe [78].

The chelating agent ethylenediaminetetraacetic acid (EDTA) is utilised as a final irrigant because of its decalcifying characteristics to elminate the possibly infectious smear layer and unblock obstructed channels. Even though EDTA preparations are recommended for use as lubricants during canal instrumentation by producers of NiTi instruments, it is still possible for EDTA to come into contact with the periapical tissue. This is something that cannot be avoided [79].

During the process of cleaning and shaping the root canal, Cruz et al. [80] studied research to see whether or not EDTA-containing paste may aid in the removal of debris. Following the use of NaOCl for canal preparation in the first group, final irrigation was carried out using an EDTA solution at a concentration of 17 In the second group, in addition to the NaOCl that was used as the irrigation solution, Glyde Root Canal Conditioner (Dentsply Sirona) was also utilised with each instrument. Similarly, 17% liquid EDTA was used for final irrigation. The authors found that when mechanical instrumentation was performed using Glyde Root Canal Conditioner (Dentsply Sirona), more debris was deposited in the apical third of the root canals. This was a result of mechanical instrumentation.

Influence of irrigant needle type on extrusion

Typically, conventional needles of different gauges are used in studies on apical extrusion. Attention was drawn to the type of irrigation needles utilised by Altundasar et al. (2011) [81], The most irrigant was extruded when ProTaper and a conventional needle were used, while side-ventilated irrigation needles seemed to have a reducing effect.

Conclusion

Apical extrusion research is summarised in this review. The reported studies' clinical relevance and scientific reliability make it difficult to conclude. Apical extrusion alone shouldn't be the deciding factor when selecting a root canal treatment since other variables affect clinical outcomes.

In contrast, one of the most important and helpful duties a practitioner has is to minimise the risk of causing any kind of damage or irritation to the tissues in the surrounding area. Extreme caution is required when choosing and using instruments, and the clinical diagnosis must always be kept in mind.

Side-vented irrigation needles could restrict apical extrusion. Negative-pressure irrigation devices are interesting, but delivery tip obstruction must be avoided. Extrusion research designs that more closely resemble in vivo situations and incorporate other important parameters like apical pressure are on the rise.

Ethical approval:

All subjects involved in this study were informed, and the agreement will be obtained verbally from each one before collecting samples.

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