REVIEW PAPER

CAUSES OF POST-OPERATIVE PAIN RELATED TO ROOT CANAL TREATMENT

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ABSTRACT

Post-operative pain is a common complication during root canal treatment (RCT). Its' prevalence ranges from 25% to 72% in the first 24 hours after treatment. There are several factors that affect post-operative pain occurrence. They are associated with the patient, canal preparation technique, and parameters of applied files. The apical foramen widening and apical extrusion of debris are the most important direct causes of post-operative pain. Clockwise or counterclockwise motion of the file may support the extraction of dentinal chips and extrusion of debris in the periapical area. Both incidence and intensity of pain are significantly lower after preparation with rotary instruments in comparison to reciprocating systems and hand files. Cross-section and taper of the instrument affect the amount of space for debris and efficiency of its' removal. Moreover, reduction of cross-section area and number of cutting edges are advantageous. Preparation of the apical part of root canal determines the risk of physiological foramen transportation or widening (over-preparation), resulting in increased incidence of post-operative pain. There are significant discrepancies related to the number of visits on treatment and its' influence on discussed ailment occurrence. Single-visit RCT provides both higher healing rate and more often discussed ailment occurrence than multi-visit one.

Key words: post-operative pain, apical extrusion of debris, reciprocating motion, rotary motion.

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INTRODUCTION

Root canal treatment (RCT) aims to prevent periapical tissue from pulp inflammatory process propagation and heal periapical lesions that already exist. It comprises disinfection of root canals by chemo-mechanical preparation and medicaments applied between visits.

Post-operative pain related to RCT usually occurs in response to apical extrusion of debris (AED) or over-preparation of apical area [1, 2]. Other causes of post-operative pain include incomplete pulp removal, apical extrusion of obturating material, chemical irritation, root fracture, and improper adjustment of a filling [3].

AED is defined as periapical displacement of dentinal chips with micro-organisms, necrotic tissues, irrigation solution, and pulpal fragments [1, 4-6]. It contributes to symptomatic periodontitis resulting in early or late failure of endodontic treatment [4]. This phenomenon is related to the imbalance between root canal microbiota and host's immune response, leading to episodes of acute periodontitis or exacerbation of chronic periodontitis [1, 6, 7]. Therefore, removal of debris is an essential condition for therapeutic success [8]. Gambarini *et al.* [6] reported that improper irrigation, over-instrumentation, and lack of recapitulation may result in an increase of AED. Type of tooth, structure of root canal system, working length

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(WL), instrumentation technique, foraminal enlargement as well as amount and type of irrigation solution, and method of irrigation affect the extent of AED [4].

Each canal preparation technique involves the formation of dentinal chips and their extrusion to periapical tissues despite maintaining proper working length [1, 2, 4, 7]. Endodontic treatment methods differ in the scale of this phenomenon [2].

The aim of the study was to review the causes of post-operative pain after root canal treatment, in particular the impact of the technique of root canal instrumentation and file system used.

INCIDENCE OF POST-OPERATIVE PAIN

Pak and White [9] claimed that the frequency of post-operative pain amounts up to 40% in the first 24 hours after procedure, and decreases to 11% two days after treatment, and then remain constant for a week. It is supported by a previous study [10], showing the incidence of post-operative pain of 72% in the first 24 hours and of 39% after 6 days. Other authors [11] reported the incidence of post-operative pain of 25-40% in the first 48 hours, regardless of the pulp and periapical tissue diseases. After a week, the value decreased to 11%.

In contrast to these results, a study by Torabinejad *et al.* showed that the incidence of post-operative pain in the first 96 hours after procedure was low regardless of instrumentation technique and analgesics intake [12].

INTENSITY OF POST-OPERATIVE PAIN VARIATIONS

The highest post-operative pain intensity is observed at an early stage after endodontic treatment [9]. It may originate from inflammation activity, preparation of apical area, anesthetic injection, rubber dam clamp pressure, and staying with an open mouth for a long time [3].

Gambarini *et al.* used visual analogue scale to divide post-operative ailments into 4 groups (1 = no pain, 2 = mild pain, 3 = moderate pain, and 4 = severe pain) depending on symptoms intensity. Table 1 presents the comparison of occurrence frequency and post-operative pain intensity in the first 12, 24, and 72 hours after RCT [3, 6, 13].

Research comparing post-operative pain after RCT with hand, rotary, and reciprocating files reported that WaveOne (WO) preparation caused lower pain sensations after 6, 12, and 18 hours post-operatively than both hand and rotary files. Also, in ProTaper Universal (PTU) group ailments, pain was less noticeable after 6 and 12 hours post-operatively in comparison to hand files ($p < 0.05$) [3].

The use of analgesics was significantly higher in the group treated with hand files, especially within the first 18 hours, when compared to rotary and reciprocating files [3]. On the other hand, there was no significant difference in painkillers intake between patients treated with ProTaper Next (PTN) and WO [13]. Patients suffering from post-operative pain were given 400 mg of ibuprofen [3].

CAUSES OF POST-OPERATIVE PAIN

The occurrence of post-operative pain depends on host-dependent and operator-dependent factors. The former group involves a history of pre-operative pain and occlusal trauma. The latter group entails mechanical, chemical, and bacterial injury during root canal preparation resulting from AED. AED is one of the main reasons of post-operative pain [5, 6]. Moreover, temporarily applied antiseptics and final filling materials may be extruded to periapical tissues, which would result in acute periapical inflammation. In some

TABLE 1. Incidence and intensity of post-operative pain depending on file system used [3, 6, 13]

Study	Shokraneh *et al.* (2017) after 12 h				Gambarini *et al.* (2013) after 72 h				Kurnaz (2020) after 24 h			
File system	Lack of pain	Mild pain	Moderate pain	Severe pain	Lack of pain	Mild pain	Moderate pain	Severe pain	Lack of pain	Mild pain	Moderate pain	Severe pain
K-file (Dentsply Maillefer)	40.00%	26.67%	16.67%	16.67%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ProTaper Universal (Dentsply Maillefer)	54.84%	25.81%	9.68%	9.68%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ProTaper Next (Dentsply Maillefer)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60.00%	26.67%	13.33%	–
WaveOne (Dentsply Maillefer)	62.50%	18.75%	12.5%	6.25%	30.00%	16.67%	26.67%	26.67%	36.67%	36.67%	26.67%	–
TwistedFile Adaptive (Kerr Dental)	N/A	N/A	N/A	N/A	46.67%	26.67%	20.00%	6.67%	N/A	N/A	N/A	N/A

N/A – not available

TABLE 2. Pre-, intra-, and post-operative factors associated with pain after RCT

Pre-operative	Intra-operative	Post-operative
Acute exacerbation of chronic lesion	Apical extrusion of filling materials and instruments	Leaky temporary materials
Non-vital tooth	Irritating canal medications	Effect of occlusion
Unusual root canal anatomy	Irrigation procedural complications	
Periapical cyst and inflammation	Missed canals	
	Working without rubber dam isolation	

cases, this phenomenon can result in delayed or inhibited healing [2].

Additionally, root canal instrumentation technique and applied file system impact post-operative pain occurrence [14]. Authors indicated factors related to the tooth, which are the number of roots and tissue condition [11]. Moreover, treatment of asymptomatic periodontitis with periapical lesions predispose the appearance of post-operative pain [6]. A proper root canal chemo-mechanical preparation is the key factor in avoiding this complication. Table 2 shows the factors that may influence incidence of post-operative pain after RCT.

TYPE OF FILES MOTION

NiTi files may use continuous rotation (CR), reciprocal motion (RP), or combine motion (CM). Their movement can also be clockwise or counterclockwise. Systems using CR rotate in one direction and complete a full rotary cycle [15]. This motion is used by PTU and PTN (Dentsply Maillefer), Mtwo (VDW), Hyflex (Coltene), and ProDesign Logic (Easy Equipamentos Odontológicos). RP is an oscillating motion; an instrument rotates in one direction and then reverses direction before completing a full rotary cycle [3]. File systems, such as WO and WaveOne Gold (Dentsply Maillefer), Reciproc (VDW), and ProDesign R (Easy Equipamentos Odontológicos) use this type of movement.

The applied system may significantly influence the amount of AED and thus, occurrence of post-operative pain [5]. Hand files produce the greatest AED [5, 7], which may result from an extended period of apical area instrumentation as well as from variable, operator-dependent factors [7]. The employment of balanced forces technique or usage of NiTi instruments reduce this adverse phenomenon due to a better control of pressure that a file exerts on the root canal wall [5, 7]. The number of used files poorly affects the inflammation caused by AED, while kinematic parameters, such as type of motion, shape of a file, and angle of rotation exacerbate the inflammation significantly [7, 14].

Surakanti *et al.* showed that root canal preparation with Hyflex files produced significantly less AED than WO and PT due to continuous rotary motion [5]. It was supported by another study comparing rotary and reciprocating systems, and reporting that lower debris rate was found after root canal preparation to the size 25/ 05 in ProDesign Logic group comparing with ProDesign R group (4.20% and 12.21%, respectively) [16]. Application of PTN and WO systems leads to periapical displacement of debris, but PTN allows for minimizing this phenomenon. However, the difference was not statistically significant [4, 5]. On the other hand, Twisted File Adaptive was found to have a beneficial ability of cutting dentine and removing debris because of predominance of clockwise motion [6]. A few studies reported no statistically significant differences in AED between rotating and reciprocating systems [17-19].

Interestingly, instrumentation technique might be the most important factor affecting the prevalence of post-operative pain [6]. Its' frequency and analgesics intake were greater in a group of patients treated with reciprocal systems (WO) [6, 13, 20]. However, these findings were not supported by Kherlakian *et al.*, who found no difference in the incidence of post-operative pain and the usage of analgesics between rotary and reciprocal file systems [21]. The counterclockwise motion may indicate higher AED for reciprocating systems [2]. However, studies results should be considered in a clinical aspect since the irrigation and presence of periapical resistance may cause a greater introduction of debris into periapical tissue [3].

SHAPE OF THE INSTRUMENT

The cross-section and taper of an instrument have a significant impact on dentin cutting ability and debris removal. AED after preparation was found statistically lower in WaveOne Gold than WO [1]. Changing the triangular cross-section into equilateral one and the taper from 0.08 to 0.07, provides improvement of an increasement of dentinal space and working efficiency. Instrumentation with self-adjusting file (SAF) introduces less debris into periapical tissues than WO. The reason for that is a better adaptation of SAF to the canal wall, lack of positive pressure, continuous irrigation, and additional activation of the solution. Additionally, SAF produces less AED than hand files due to an advantageous file shape [7].

Interestingly, the file cross-section is thought to be the most important factor contributing to a smaller amount of AED in multi-file rotary systems in comparison to single-file reciprocating ones [5, 14]. The bigger the cross-section of an instrument, the smaller its' debris area and debris removal ability [22]. S-shaped Reciproc files have greater area for removing debris than triangular PT files, because they enhance the effectiveness of dentine cutting [14]. Moreover, both WO and PT have three cutting edges, which affect slightly cutting effectiveness, leaving a little space for debris evacuation. It results in a troublesome removal of dentinal chips in reciprocating motion. On the other hand, the rotary motion may contribute to coronal shift of debris that counteract AED phenomenon [23].

APICAL SHAPING

Two main methods of root canal shaping, namely foraminal enlargement (FE), which is the preparation of 0.0 mm from apex after establishment with apex locator, and non-foraminal enlargement (NFE), which prepares the canal 1.0 mm shorter after indication APEX on apex locator, were described [24].

The level of post-operative pain after FE and NFE preparation with hand files was found to be comparable [25]. However, FE preparation with NiTi rotary and reciprocating instrument systems resulted in greater post-operative pain comparing with NFE [24]. Moreover, the application of FE method caused higher ailment intensity for rotary systems in comparison with reciprocating ones [26].

Apical preparation is a consequence of chosen files' type and size. It is a key factor of AED limitation and thus adequate RCT effect [4, 5]. File control during apical area instrumentation may be improved by prior canal orifice preparation [5].

Furthermore, setting the working length to 1 mm in relation to physiological foramen significantly allows reduction of AED [4]. Additionally, accurate control of the working length minimizes the amount of AED [5].

The risk of post-operative pain may be reduced by performing apical patency and glide path prior to root canal instrumentation. Glide path preparation with rotary files (e.g., ProGlider [PG]), reciprocal files (e.g., Reciproc), or hand files (e.g., K-file) must meet velocity and security requirements. It helps maintaining natural canal curvature [11]. Apical dentine plug evaluation should be performed as a prevention of apical third over-preparation [27]. Creating apical patency always results in the introduction of NaOCl into the periapical tissues and less debris extrusion [27]. Moreover, the use of 5.25% NaOCl in irrigation protocol directly affects periodontal ligament response [14].

OTHER FACTORS

Number of visits during RCT appears to be an important factor for prognosis. Sathorn *et al.* reported that the healing rate of single-visit treatment amounted to 77.2%, while multi-visit treatment to 71.6% [28]. Post-operative pain after single-visit and multi-visit treatment was found comparable [29]. However, higher post-operative pain incidence and analgesics intake was observed after single-visit treatment [30, 31].

Factors, such as roots number, pre-operative pulp, and periapical tissue condition, also affect the intensity of post-operative pain [2, 32]. A higher incidence of post-operative pain in the group of multi-root teeth comparing with single-root group was revealed [2]. Pulp condition significantly affects post-operative pain prevalence in reciprocating files cases. However, such a relationship does not appear in rotary files group. Moreover, age and gender of patient did not impact the occurrence of this complication [3, 13].

CONCLUSIONS

AED seems to be the most important etiological factor of post-operative pain. Intensity of this phenomenon depends on the applied instrument system and the type of motion used. Other factors presumably influencing the frequency and intensity of pain occurrence are less significant.

Differences in presented studies may arise from subjectivity of a patient's pain sensation. Further research on this issue should be conducted.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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