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In Vivo Evaluation of Painful Symptomatology after Endodontic Treatment Performed Using Two Different Irrigation Needle Insertion Depths

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Abstract

Objective The main purpose of this study was to evaluate pain symptoms in patients after endodontic treatment performed in a single session in teeth with vitality or pulp necrosis, comparing two depths of insertion of the NaviTip irrigation needle.

Materials and Methods One-hundred upper uniradicular teeth were selected and divided into four groups (n = 25), namely Bio group 1 (live pulp/1 mm from the foramen), Bio group 3 (live pulp/3 mm from the foramen), Necro group 1 (pulp necrosis/1 mm from the foramen), and Necro group 3 (pulp necrosis/3 mm from the foramen). All canals were instrumented with Wave One Gold System. Irrigation was performed using 2.5% NaOCl. The teeth were filled using the single-cone technique with AH Plus sealer using a McSpadden compactor. After treatment, patients answered a questionnaire with a visual analog scale scored from 0 to 10 at 1, 3, and 7 days after treatment.

Statistical Analysis Data were analyzed using Mann–Whitney U, Wilcoxon, and Friedman tests.

Results There was a decrease in average pain levels at the three time points for both vital and necrotic teeth ($p < 0.05$). There were no significant differences in postoperative pain levels comparing needle depth, or vitality and pulp necrosis ($p > 0.05$). The percentage of mild pain increased over time and moderate pain decreased, regardless of pulp condition. There was no incidence of acute pain at any time.

Conclusions Post-treatment endodontic pain levels in upper uniradicular teeth with or without pulp vitality resulted in similar pain scores, regardless of the depth of insertion of the irrigation needle in relation to the apical foramen.

Keywords
- postoperative pain
- insertion
- needle
- irrigation
- single session

Introduction

Postoperative pain may be a concern after endodontic treatment. It is defined as an unpleasant sensation of varying degrees that can occur after root canal treatment, and has been reported in 3 to 58% of patients undergoing endodontic treatment, including those with vital and nonvital pulp.[1-3]

Common factors that influence the occurrence of pain after endodontic treatment include inadequate instrumentation, irrigant extrusion, and apical extrusion debris on instrumentation and filling.[4] Microbial effects, chemical mediators, immune response, cyclic nucleotide changes, psychological factors, and changes in local adaptation and periapical tissue pressure may also interfere with postoperative pain.[5]

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Root canal irrigation is a vital component of endodontic treatment and needs to be effective because instrumentation alone is insufficient to reduce viable microorganisms; moreover, improper preparation can lead to a decrease in successful outcomes. Irrigation aims to remove bacteria, debris, and necrotic tissue, especially from root canal areas untouched by mechanical instruments.[6-9]

The most common method used to continuously distribute irrigating solutions in the root canal system (RCS) during mechanical–chemical preparation is with a syringe and needle.[10,11] To increase the efficiency of syringe irrigation, some factors are important and may influence the effectiveness of the technique. Although different types of needles have been proposed,[12-15] the needle position in relation to the apical foramen—also described as "needle insertion depth or penetration"—has an important role, and has been highlighted in some *in vitro*[16] and *ex vivo*[17,18] studies.

It is assumed that positioning the needle close to the working length could, in fact, improve debridement (cleaning) and irrigation replacement.[19-22] However, irrigating agents in periapical tissue have been suggested to be an important source of postoperative pain. It was reported that irrigation methods and devices have an effect on apical extrusion of debris and/or irrigators.[23,24]

There are few *in vivo* studies that have correlated postoperative pain with the depth of needle penetration within the RCS during irrigation. Thus, this study aimed to evaluate pain symptoms of patients who underwent endodontic treatment of vital or necrotic teeth, comparing two different depths of irrigation needle insertion. The null hypothesis was that there would be no significant differences in postoperative pain between the groups studied.

Materials and Methods

After approval by the local ethics committee (3.267.557), all volunteers invited to participate in the present clinical study were informed of the procedures, risks and benefits, and their right to choose to participate. Written consent was obtained and a copy was provided to all volunteers.

Sample Calculation

SPSS version 20 (IBM Corporation; Armonk, New York, United States) was used to obtain the appropriate minimum sample size. A 95% confidence level and an error margin of 0.1 were considered. To obtain a more adequate sample size, $p = 0.5$ was considered.

The appropriate calculated sample size was at least 97 patients. However, because the patients present in the study were divided into two groups, 49 individuals per group were considered, and rounded up to 50. Furthermore, because subgroup analysis was also performed, a total of four groups ($n = 25$ each) were defined.

Patient Selection

One-hundred volunteer patients of both sex were included in this study according to defined criteria. All treatments were performed in a single session by a single endodontic specialist into a private office. Only upper uniradicular teeth with a single canal, diagnosed with vital pulp or pulpal necrosis, and without spontaneous pain symptoms were selected. Patients with systemic diseases that prevented endodontic treatment requiring prophylactic medication, those taking analgesic medication 12 hours before treatment, and individuals allergic to ibuprofen, or those who exhibited swelling in the region, were treated but excluded from analysis.

Individual diagnosis was confirmed by obtaining dental histories, and performing periradicular radiography, vertical and horizontal percussion, and thermal tests (EndoIce; Coltene/Whaledent Inc., Cuyahoga Falls, Ohio, United States). Teeth that did not respond positively to pulp sensibility tests and presented radiographic evidence of apical periodontitis with a minimum lesion size of 2 × 2 mm, were considered teeth with pulp necrosis.[23] Patients were randomly grouped according to pulp condition: teeth with pulp vitality in the Bio group and teeth without pulp vitality in the Necro group. The groups were then further subdivided by raffle according to the depth of insertion of the irrigation needle before treatment, resulting in four groups: Bio 1, Bio 3, Necro 1, and Necro 3.

Treatment Protocol

After local anesthesia using 3.6 mL 2% lidocaine and 1:100,000 epinephrine (Alphacaine; DFL Indústria e Comércio Ltda., Rio de Janeiro, RJ, Brazil), the access cavity was formed using sterile spherical drills numbers 2, 3, or 4, and the pulp chamber was removed using tapered diamond tips (Dentsply-Maillefer; Ballaigues, Switzerland). An initial exploration of the root canal was performed using Kerr #10 or #15 files (Dentsply-Maillefer) under constant irrigation, according to the apparent root canal length determined with radiographic aid. The choice of automated file was made according to the manual file that fit to the tooth foramen according to manufacturer's recommendations, using medium (35/.06) and/or large (45/.05) files.

Instrumentation was performed using the electric motor X Smart Plus (Dentsply-Maillefer). Initially, to clean the cervical region of the canal, instrumentation of the cervical third was performed. Thereafter, odontometry was performed with aid of the Root ZX Mini apex locator (J. Morita; Darmstadt, Germany). For all groups, the working length was set at 1 mm short of the apical foramen. The automatic file was introduced into the canal with gentle movements of light apical pressure at the entrance and brush removal at three stages (cervical, middle, and apical third) until reaching the total working length.

Root canal irrigation was gradually performed using 2.5% sodium hypochlorite between each third, using a 10 mL plastic disposable syringe and NaviTip irrigation tip (30-gauge,

25 mm; UltraDent Products Inc, South Jordan, Utah, United States), with a total of 30 mL per experimental unit, according to the instrumentation. The final irrigation procedure involved agitation using the Easy Clean (Easy Dental Equipment; Belo Horizonte, Brazil) instrument at working length with 2 mL 17% EDTA for 20 seconds three times and 2 mL 2.5% sodium hypochlorite for 20 second three times, for a total of 3 mL and 6 mL, respectively.

After final irrigation and cone testing, the root canals were dried using absorbent paper cones (Dentsply-Maillefer; Ballaigues, Switzerland) and filled with gutta-percha with the caliber equivalent to the Medium #35 or Large #40 final file, encased in AH Plus sealer (Dentsply Ind. e Com. Ltda.; Ballaigues, Switzerland), using the McSpadden #50 (Dentsply-Maillefer) technique. The cervical excess portion of the cone was cut at the level of the cementoenamel junction and compacted. The coronal portion of the canal was cleaned and, finally, the dental element was sealed using photo-activated composite. All patients received postoperative instructions to take analgesics (600 mg ibuprofen, 6/6 hours) in case of pain. The number of tablets used was recorded.

Postoperative Pain Analysis and Statistical Analysis

On completion of endodontic treatment, the volunteers were asked to complete a visual analog scale (VAS) form, with pain perception scored from 0 to 10. Pain sensation was recorded at 24, 48, and 72 hours intervals, and at 1 week. Pain perception was classified as none, mild (VAS score, 1–2), moderate (score, 3–7), or severe (score, 8–10). Patients were instructed to return their cards after 1 week and to contact the provider if further consultations were needed for pain relief.

Data were recorded for statistical evaluation using SPSS version 20 software (IBM Corporation; Armonk, New York, United States). Mann–Whitney U, chi-squared, Wilcoxon, and Friedman tests were used to determine significant differences assuming an $\alpha < 5\%$.

Results

Investigating the primary objective of the research, there were no statistical differences in the mean incidence of pain comparing the two depths of needle insertion in relation to the root apex in the Bio and Necro groups (i.e., 1 and 3 mm) at all evaluated time points ($p > 0.05$) (►**Table 1**).

A secondary analysis was performed to determine whether pulp condition influenced the incidence of postoperative pain. When considering only depth and having the pulp condition as a variable, no statistical differences between the groups at all evaluated time points were observed ($p > 0.05$) (►**Table 2**).

The *p*-values of the two-by-two comparisons between days are shown in ►**Table 3**. In the Bio group, there was a statistical difference in both needle insertion depth and among the time points: 1 to 3 days ($p = 0.042$), 1 to 7 days ($p = 0.041$) at 1 mm; 1 to 3 days ($p = 0.048$), 1 to 7 days ($p = 0.049$) at 3 mm; and 1 to 3 days ($p = 0.07$), 1 to 7 days ($p = 0.08$) ($p < 0.05$). However, this difference was not evident when comparing days 3 to 7 at depths of 1, 3 mm, and both ($p > 0.05$).

The same analysis was performed in the Necro group. There were statistical differences between 1 and 3 days ($p = 0.041$), 1 and 7 days ($p = 0.042$) at 1 mm; 1 and 7 days ($p = 0.024$) at 3 mm; and 1 and 3 days ($p = 0.015$), 1 and 7 days ($p = 0.03$) ($p < 0.05$). These results were not evident in the comparison at 1 to 3 days ($p = 0.143$) at 3 mm and 3 to 7 days at depths of 1 and 3 mm, and both ($p > 0.05$).

In relation to pain evolution comparing the three time points, a statistical difference was evident at each of the two depths in both groups (►**Tables 4** and **5**).

In relation with Bio and Necro groups collectively, it is noteworthy that over the 3 days, there was a statistically significant reduction in the average pain at each depth of needle insertion. The averages were 0.72, 0.18, 0.00 ($p < 0.001$) at 1 mm; 0.37, 0.10, 0.02 ($p < 0.001$) at 3 mm; and 0.55, 0.14, 0.01 ($p < 0.001$) in both (►**Table 4**).

Analysis of pain evolution in relation to VAS classification (►**Table 5**) revealed that the percentage of mild pain increased over time as moderate pain decreased. Observing the Bio group on day 1 at a depth of 1 mm, moderate pain was 20%, versus 4% at 3 mm. On the same day in the 1 mm Necro group, moderate pain was at 8% versus 4% at 3 mm.

On the day 3, 8% of patients with vital teeth reported moderate pain at 1 mm, none experienced moderate pain at 3 mm, as 100% reported mild pain. In the Necro group, 100% reported mild pain at both depths. On day 7, all patients reported mild pain regardless of needle insertion depth and pulp condition. There was no incidence of acute pain.

Table 1 Comparison of pain in relation to needle insertion depths in all groups

Bio + Necro		Mean	Median	Standard deviation	Min	Max	*n*	IC	*p*-Value
1 d	1 mm	0.72	0	1.67	0	7	50	0.46	0.822
	3 mm	0.37	0	0.93	0	5	50	0.26	
3 d	1 mm	0.18	0	0.72	0	4	50	0.20	0.705
	3 mm	0.10	0	0.42	0	2	50	0.12	
7 d	1 mm	0.00	0	0.00	0	0	50	- x -	0.312
	3 mm	0.02	0	0.14	0	1	50	0.04	

Table 2 Comparison of pain at 1 and 3 mm depth

1 mm		Mean	Median	Standard deviation	Min	Max	*n*	IC	*p*-Value
1 d	Bio	1.00	0	2.10	0	7	25	0.82	0.749
	Necro	0.44	0	1.04	0	4	25	0.41	
3 d	Bio	0.28	0	0.98	0	4	25	0.38	0.934
	Necro	0.08	0	0.28	0	1	25	0.11	
7 d	Bio	0.00	0	0.00	0	0	25	- x -	1.000
	Necro	0.00	0	0.00	0	0	25	- x -	
3 mm									
1 d	Bio	0.29	0	0.75	0	3	25	0.30	0.560
	Necro	0.44	0	1.08	0	5	25	0.42	
3 d	Bio	0.04	0	0.20	0	1	25	0.08	0.547
	Necro	0.16	0	0.55	0	2	25	0.22	
7 d	Bio	0.00	0	0.00	0	0	25	- x -	0.327
	Necro	0.04	0	0.20	0	1	25	0.08	

Table 3 Comparison between days and depth in the both groups

Bio		1 d	3 d
1 mm	3 d	0.042	
	7 d	0.041	0.180
3 mm	3 d	0.048	
	7 d	0.049	0.317
Both	3 d	0.007	
	7 d	0.008	0.109
Necro			
1 mm	3 d	0.041	
	7 d	0.042	0.157
3 mm	3 d	0.143	
	7 d	0.024	0.180
Both	3 d	0.015	
	7 d	0.003	0.059

Table 4 Pain evolution at different depth of needle insertion in all groups

Bio + Necro		Mean	Median	Standard deviation	Min	Max	*n*	IC	*p*-Value
1 mm	1 d	0.72	0	1.67	0	7	50	0.46	<0.001
	3 d	0.18	0	0.72	0	4	50	0.20	
	7 d	0.00	0	0.00	0	0	50	- x -	
3 mm	1 d	0.37	0	0.93	0	5	50	0.26	<0.001
	3 d	0.10	0	0.42	0	2	50	0.12	
	7 d	0.02	0	0.14	0	1	50	0.04	
Both	1 d	0.55	0	1.36	0	7	100	0.27	<0.001
	3 d	0.14	0	0.59	0	4	100	0.12	
	7 d	0.01	0	0.10	0	1	100	0.02	

Table 5 Classification of pain level following visual analog scale (VAS) scale

			1 d		3 d		7 d	
			n	%	*n*	%	*n*	%
Bio	1 mm	Mild	20	80.0%	23	92.0%	25	100%
		Moderate	5	20.0%	2	8.0%	0	0.0%
	3 mm	Mild	24	96%	25	100%	25	100%
		Moderate	1	4.0%	0	0.0%	0	0.0%
	Both	Mild	44	88.0%	48	96.0%	50	100%
		Moderate	6	12.0%	2	4.0%	0	0.0%
Necro	1 mm	Mild	23	92.0%	25	100%	25	100%
		Moderate	2	8.0%	0	0.0%	0	0.0%
	3 mm	Mild	24	96.0%	25	100%	25	100%
		Moderate	1	4.0%	0	0.0%	0	0.0%
	Both	Mild	47	94.0%	50	100%	50	100%
		Moderate	3	6.0%	0	0.0%	0	0.0%
General	1 mm	Mild	43	86.0%	48	96.0%	50	100%
		Moderate	7	14.0%	2	4.0%	0	0.0%
	3 mm	Mild	48	96.0%	50	100%	50	100%
		Moderate	2	4.0%	0	0.0%	0	0.0%
	Both	Mild	91	91.0%	98	98.0%	100	100%
		Moderate	9	9.0%	2	2.0%	0	0.0%

Discussion

Postoperative pain in periapical tissues[25,26] may involve mechanical, chemical, or microbial etiologies, which may result in acute inflammation.[27] In a clinical investigation, however, it is difficult to determine whether one or more factors cause pain. Therefore, the present study was careful to exclude pre-existing factors that could mask the main research objective, that is, to analyze whether the depth of insertion of the irrigation needle had any influence on the incidence of pain after endodontic treatment.

Failure in the cleaning and shaping stages and extrusion of infected debris are elements that influence the occurrence of post-treatment pain.[28] The system chosen in the present study was a single-file alternative M-Wire instrumentation with potential advantages including a reduced number of instruments, which reduces cross-contamination, is less expensive, has lower instrument fatigue,[29,30] better centering capability, and taper lock reduction.[31] In addition, other studies[25,26] concluded that this system carried fewer apical bacteria than rotatory multifile systems.

The most conventional method of continuously dispensing irrigating solution(s) is with a syringe and needle. When analyzing the type of needle used, one study[32] compared different needle designs and concluded that open-end needles improve irrigant change near the apical third, near the tip of the needle, and highlight that chamfered needles are associated with risks for significant injury to both patient and dentist, combined with an increased possibility of perforation within the root canal.

The gauge of needle chosen is also important, with 27 to 30 G the most commonly used because they are of adequate thickness and enable the return of the solution in the socket.[33] A previous study that evaluated irrigant(s) flow[32] found that only detachment of the biofilm or debris could not guarantee its removal; therefore, it was necessary to have favorable irrigant flow to transport them toward the channel entrance (reverse flow). It is recommended that any needle, regardless of design, be passively positioned in the root canal and not get caught in the walls. Placing a needle too tightly within the canal would likely result in blockage of irrigant backflow, a situation that should be avoided. The needle used in this study met all these criteria.

Although this technique is simple, there is potential for complications,[34,35] including chemical solution extrusion, and the depth of needle insertion into the root canal appears to have significant influence. One study[36] analyzed irrigant flow using thermal imaging comparing different depths of needle insertion. The authors concluded that positioning the needle close to the apical foramen led to an increase in mean pressure at the root apex, suggesting an increased risk of irrigant extrusion and, although irrigation change was more extensive near its tip, when it was positioned at 1 and 2 mm. According to the authors, the apical output needles should not be placed 1 mm from the apex due to the high pressure developed. Irrigant extrusion may occur, resulting in postoperative pain. This did not occur in the present study.

In general, placing the needle closer to the working length resulted in a more efficient replacement of the irrigant in the apical region, a result that was consistent with previous studies,[14,36-38] although favoring its extravasation.[39] It cannot be stated that this did not occur in this study; nevertheless, if it did occur, it was not enough to cause a pain response in the

patient. This result suggests that in clinical situations there may be other factors influencing the occurrence of postoperative pain, and that the apical pressure exerted on the root apex may require other factors to cause pain.

Previous studies have focused mainly on the efficiency of debris and bacteria removal, and have provided little understanding regarding the occurrence of postoperative pain related to needle insertion depth. In the present *in vivo* study, it was found that there was no significant incidence of postoperative pain when the irrigation needle was inserted 3 mm from the root foramen. As such, together with previous studies, it was found that at this depth of needle penetration, there is a safety margin for irrigant leakage without losing quality of intra-radicular disinfection. However, other studies have reported that that this type of needle should not be placed 1 mm from the apex due to the high apical pressure that could develop.[32,36] This could cause postoperative pain in the patient, which is contrary to findings of this study, given that there was no incidence of acute pain at any of the analyzed time points when the needle was positioned 1 mm from the root apex.

In general, the pain levels that patients experienced in the present investigation were very low. The highest incidence of pain occurred in the first 24 hours after endodontic treatment, 14% moderate pain at 1 mm and 4% at 3 mm. On day 3, 100% of patients experienced mild or absent pain at 3 mm and 96% at 1 mm, according to VAS scores (i.e., 0–2). On day 7, all patients experienced mild or absent pain, regardless of pulp condition. There were no total reports exceeding moderate pain. No patient reported other symptoms or complications such as swelling or paresthesia, or had to use analgesic medication.

Although the focus of the present work was the action of irrigation needle depth, the volunteers were also grouped according to pulp condition. The objective was to determine whether this factor is important in the occurrence of postoperative pain. When analyzing pain at 1 mm from the root apex, having the pulp condition as a variable, it was found that there were no significant differences between the group means in all situations ($p > 0.05$); the same occurred at 3 mm of the root apex. In this study, pulp condition had no apparent important impact on the occurrence of pain after endodontic treatment.

There is no definitive evidence regarding the minimum pressure that leads to irrigation extrusion; it can only be estimated by comparing positions of different depths of needle insertion.[36]

The depth of the irrigation needle in relation to the apical foramen did not influence pain after endodontic treatment, regardless of pulp condition of the dental element; thus, the null hypothesis of this study was accepted. Although some studies have reported that 3 mm is a recommended depth, which provides efficiency in both RCS cleaning and safety in relation to irrigant leakage and debris, reducing the risk for postoperative pain, results of the present investigation suggest that positioning 1 mm needle of the apical foramen in the upper uniradicular teeth, "*in vivo*" also did not result in painful postoperative damage. Therefore, it is at the discretion of provider to decide which position is ideal, which makes him or her more comfortable and safe during treatment because at both depths studied, there was no incidence of acute pain.

Conclusions

Pain after endodontic treatment in upper uniradicular teeth with or without pulp vitality was similar regardless of the depth of penetration of the irrigation needle in relation to the apical foramen. There was, however, a decrease in the incidence of pain over time.

Conflict of Interest

None declared.

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