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Influence of intraoperative factors on the outcome of root canal treatment (Part 2): A retrospective clinical study

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A B S T R A C T

Aim: to assess how intraoperative prognostic variables (Treatment session, apical preparation size, Root canal filling length, Obstruction, Type of irrigant, Acute flare up) affect the outcome of the initial endodontic therapy. **Methodology**: Out of 109 treated patients, 91 had completed medical and dental data. A total of 146 received endodontic treatment with 408 Canals. All procedures were carried out in 2018 and 2019, in a private dental clinic in Sirte, Libya. The criteria of the European Society of Endodontology were used to assess the treatment outcome. The level of significance was set at p-value < 0.05%. **Results**: three factors, namely, the Apical preparation size (Chi-square = 49.7, p-value = 0.0001), the type of irrigant (Chi-square = 18.7, p-value = 0.001) and the root filling extension (Chi-square = 15.6, p-value = 0.016) were found to have a significant effect on the success rate at < 0.05 level of significance. **Conclusion**: Quantitative results lead to the conclusion that three intraoperative factors, namely, the apical preparation size, the type of irrigant and the length of root filling were found to have a significant effect on the success rate of root canal treatment.

1 Introduction

Defining the outcome – success versus failure

There is no set definition for success or failure of endodontic treatment. Success in endodontic may depend on individual preferences, e.g. for a patient the disappearance of symptoms [1], restoration of functionality [2] and quality of life index [3] is success, while for a clinician the resolution of symptoms, and the disappearance or reduction of size of lesion are essential for success [4]. Insurance companies and health authorities may be more concerned about tooth retention or survival [5, 6].

In histological terms, endodontic success assumes that there has been a complete repair of the periapical tissues without the presence of inflammatory cells [7]. However, this goal is difficult to achieve as shown by previous studies [8]. Thus, we rely upon radiographic and clinical indicators to evaluate the outcome.

In the literature, various terms have been set to describe the outcome of non-surgical root canal treatment. Friedman and Mor (2004) [4] reported that success is a vague term and may confuse the patient, therefore healed / healing / diseased are more adequate. Wu et al. (2011) [9] have used new terms like effective & ineffective lately. 'Effective' includes 'healed' & 'healing' and does not require further intervention, while 'ineffective' at 1 year means the presence of sign and symptom or increase the periapical radiolucency size that will need treatment. However, a 1-year follow-up period is not

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enough to judge a tooth as 'diseased' [10] and for this reason this term has not been included in the literature yet. According to European Society of Endodontology 2006, the outcome assessment divided into three categories, which is followed in this study (Table 1). The primary goal of this study is to assess how intraoperative prognostic variables (apical preparation size, root canal filling length, obstruction, type of irrigant, the number of treatment sessions, and acute of flare up) affect the root canal treatment outcome.

2 Materials and Methods

2.1 Patients Sample:

Ninety-one patients with complete medical and dental records were included out of 109 treated patients. Patient with no follow-up recall (n=18) were excluded from the study. All treatments were performed through 2018 and 2019, in private Dental Clinic in Sirte, Libya. After informing all patients of the results of their treatment, verbal and written agreement was obtained for ethical reasons. All patients were over 15 years of age when treatment commenced and all teeth examined clinically and radiographically. The effectiveness of the treatment was evaluated using criteria from the European Society of Endodontology (Table 1).

Table 1: Root canal treatment assessment categories

Outcome	Clinical findings	Radiographic findings		Recall period
		Initial	Recall	
Favorable	- Absence of pain, - swelling, - sinus tract, - loss of function, - other symptoms	- Normal period ontal space around the root - Radiolucent area	- Periodontal space unchanged - Healing of the lesion with normal periodontal space around the root	At least one year
Uncertain		- Radiolucent area	- No changes in the size of the initial lesion	At least after 4 years
Unfavorable	- Presence of pain, swelling, sinus tract, loss of function, and other symptoms - Presence of signs of root resorption	Period ontal space remained normal after endodontic treatment - Radiolucent area	- Radiolucent area - Absence of healing: radiolucent area remained the same, increased, or diminished in size during the 4-year assessment period	Further treatments are required

Treatment Protocol:

Under rubber dam isolation, all canals were mechanically prepared using the Protaper NiTi rotary file system (Dentsply Maillefer, Ballaigues, Switzerland) using the crown down technique, to a minimum apical size of 20, 25, or 30 wherever possible, dependent on the canal diameter before instrumentation. Canal patency was succeeded and preserved with a size 10 k-file (Dentsply Maillefer, Ballaigues, Switzerland). Irrigation was carried out using 5% NaOCl associated with 17% EDTA (PD Co., Switzerland) in narrow or calcified canals and using 30 gauge close end, double side vent irrigation needle (irriflex®). The irrigating solutions were frequently agitated in the canal system by ultrasonic. Ultrasonic (Ultramint pro ultrasonic, eighteeth Co.,China) were used to remove pulp stones when present. The working length was determined by a combination of using an apex locator (Rootmini ZX®, J. Morita Co., Kyoto, Japan) and periapical radiography.

A total of two or more visits were required to treat every tooth with a periapical lesion. Calcium hydroxide (Metapaste, Meta Biomed Co., LTD, Korea) was used as an intracanal medicament for at least 7 days. The interappointment temporary dressing routinely used was ZOE (PD Co., Switzerland). At the obturation appointment, the canals were dried with paper points (Meta Biomed). MTA (Pro-Root MTA, Dentsply Tulsa Dental Co; USA) was placed to seal perforations or create an apical plug for immature necrotic teeth. Root canal fillings were performed using vertical compaction of guttapercha (System B, SybronEndo.) and back-filling with the thermoplasticized injectable gutta-percha technique (ObturaII Spartan, Earth City, Mo.). After obturation, the access cavity was sealed with composite (Dentsply Ltd., Weybridge, United Kingdom) or light cure GIC. In cases in which crown or bridgework had been removed, the restoration was recemented with GIC luting cement (Medicem, promedica Co. Germany).

Patients' Recall.
Patients were either called or had appointments set up in advance for clinical and radiological control. Recall period, either the presence or absence of clinical and radiographic signs or symptoms, and presence and determined the kind of restoration were all documented postoperatively.

Assessment of treatment outcome

The effectiveness of the treatment was judged based on the clinical observations made at the follow-up visit and a comparison of the radiographs taken at the postobturation and the follow-up appointments. The clinical criteria for treatment success were (1) absence of pain, (2) absence of tenderness to percussion, (3) tooth mobility of Grade 1 or less, (4) absence of associated soft tissue swelling or tenderness to palpation, and (5) attachment loss of less than 5 mm. The radiographic criteria for judging treatment outcome at the follow-up examination were as follows: 1. complete healing-periodontal ligament space was normal. 2. Incomplete healing: the lesion's size diminished, but the periodontal ligament space returned to its previous size. 3. Uncertain healing—it was unable to determine the extent of postoperative healing from radiographs. 4. Failure to heal: an existing periapical radiolucent area persisted or grew larger, or a periodontal ligament space that was once normal widened or transformed into a new radiolucent area.

Radiographic Method and Evaluation
Periapical radiographs were either digital or scanned conventional radiographs. Two independent endodontists, who have analyzed all preoperative and postoperative radiographs. Photoshop software (Adobe Photoshop.CS, Version 8.0, USA) was utilized to see the periapical region with three times magnification.
The PAI technique was used to score all potential teeth [11]. For teeth with apical area that were healthy or diseased, a score of ≤2 or ≥2 was assigned, respectively.

Statistical Analysis

The medical data were analyzed statistically using factor description and association analysis. The factor description was performed *via* percentage success rate, whereas factor association was discovered through two-way cross tabulation rate and intra-operative factors against the success rate. Chi-square Pearson test was applied. Furthermore, the percentage success rate was also considered for different categories as well as overall.

3 Results

Table 2 shows that among the six intra-operative factors, three factors, namely, the apical preparation size (Chi-square = 49.7, p-value = 0.0001), the type of irrigant (Chi-square = 18.7, p-value = 0.001) and the extension of root filling (Chi-square = 15.6, p-value = 0.016) were found to have significant effects on the success rate at 0, 05 level of significance. No significant effect is observed for the obstruction, acute flare up and the number of treatment visits. Table 3, shows the percentage of success rate for different factor categories and as an overall rate. The registered overall success rate was 89.7%.

Table 2: Prognostic factors related to success rate

Factor	Category	No. of teeth	Success rate		P-value
			Categorical%	Overall%	
Apical Preparation Size	20/0.4	9	44.4%	02.7 %	0.0001[2]
	20/0.6	2	100%	01.4 %	
	25/0.4	73	95.9%	47.9 %	
	25/0.4, 25/0.6	13	92.3%	08.2 %	
	25/0.4,25/0.6 ,30/0.4	4	100%	2.7%	
	25/0.4, 30/0.4	1	100%	1.0%	
	25/0.6	35	85.7%	22.6 %	
	30/0.4	7	42.9%	2.0%	
	Total 90.5%	146			
Type of irrigant	Naocl 5%	91	92.3%	57.5 %	0.001[2]
	Naol 5%,EDTA17 %	50	90.0%	30.8 %	
	Naol 5%,EDTA17 %,CHX	05	40.0%	1.4%	
	Total 89.7%	146			
Extension of root filling	Good	138	89.5%	84.9 %	0.016[2]
	Over 1 mm	2	100%	1.7%	
	Over 2 mm	3	66.7%	1.7%	
	Flashed	3	100%	2.1%	
	Total 90.4%	146			

Number of treatment visit	Single visit	50	86.0%	29.5 %	0.064
	Two visit	85	94.1%	54.8 %	
	Three visit	11	72.7%	5.5%	
	Total 40.8%	146			
Obstruction	No	132	89.4%	80.8 %	0.972
	Pulp stone	12	91.7%	7.5%	
	Broken File	02	100%	1.4%	
	Total 89.7%	146			
Acute flare up	Yes	13	15.8%	8.2%	0.857
	No	133	89.4%	81.5 %	
	Total 89.7%	146			

4 Discussion

Retrospective studies have been extensively explored in the literature to assess the extent to which specific factors may have an influence on periapical lesion healing after RCT. In the present study, some intra-operative variables selected for the evaluation of root canal treatment outcome. This makes it possible to evaluate how well endodontic clinical practice is working.

The number of treatment visits for root canal therapy was one aspect that was considered. Traditionally, therapy has been spread out over two or more appointments to give medications time to work and to improve root canal disinfection, boost patient comfort, and track the healing process[12]. However, recent data favor single-visit treatments more and more because they attempt to render any remaining germs harmless or eradicate them by encasing them in a full root filling during a single appointment, restricting them of food and the space they need to survive and grow [13-15]. According to additional research, healing rates are comparable irrespective of the number of visits [16-19]. In the present investigation, there was no statistically significant link among the number of treatment visits and periapical lesion healing.

Regarding how intraoperative issues like instrument fractures, perforations, and apical stops affect the results of root canal therapy various studies fail to find a clear association. [17, 20, 21]. However, some claim they have a negative impact on the outcome of RCTs [22, 23]. According to a university study on Saudi Arabian participants, perforations were the problems that had the least negative effects on healing (5.5%) and fractured instruments (6.6%) [24]. Only 1.4% of the cases in the current study involved broken instruments, and no correlation between bypassed broken files and apical lesion healing was discovered.

Numerous studies have been conducted on the effectiveness and length of the root canal filling. The gutta percha filling is typically regarded as "adequate" if it extends 0 to 2 millimeters from the radiographic apex. According to the literature currently available, a proper root canal filling will result in a good long-term prognosis in terms of extension and compaction [5, 25, 26]. Short filling has a better likelihood of succeeding in terms of extension than overfilling among "inadequate" filling [5]. The extrusion of debris, intracanal medicaments or root filling materials beyond the apical foramen into the periapical tissues might consequence in delayed healing or even treatment failure because of a foreign body reaction [27-30]. From the results of the current study, the proportion of healing for teeth with adequate root filling extension was (89.5%), while in the teeth with flashed or 1mm overfilling record higher success rate (100%) than teeth with 2mm overfilling (66.7%), the difference was significant. However, from a therapeutic perspective, a correct root canal filling may promote apical healing than other extensions.

Apical size preparation is one of the effective factors on the healing of periapical lesion. It has been suggested that the apical area be enlarged to allow sufficient irrigant penetration depth for improved cleansing [31]. However, there is disagreement over the necessity of apical enlargement. The most effective method of cleaning and disinfecting the canals, according to its proponents, is preparation to larger apical size. Greater apical preparations enable more effective dentin removal [32], considerably decrease the bacterial load in the root canal system [33-36], and improve irrigant flushing activity in the apical area [37]. Enlargement to different apical sizes, including #30 [38] and #40 [39], has been recommended for the effective elimination of debris from the canal. Correspondingly, various preparation sizes of #45 [39, 40] and #60 to #80 [37] have been revealed to significantly decrease the microorganism load during endodontic treatment. Contrary to these findings, Yared and Dagher [41] have stated a #25 file to be as effective as a #40 file for decreasing remaining microorganisms.

Our findings differ from those of other researches that assessed the impact of the apical size of canal preparation on treatment outcomes [42-44]. According

to Strindberg [42] , when apical size preparation increased, the success percentage of endodontic treatment dropped. Hoskinson et al [44] additionally stated that small (ISO 20-30) apical preparations had a success rate of 77% compared to large (ISO 35-90) preparations' (70%) success rate. However, the study did not appear any significant effect of the master apical file (MAF) size on the course of treatment. On the other hand, Kerekes and Tronstad [43] found no difference in healing between roots prepared to sizes 20 to 40 and those prepared up to sizes 45 to 100 where success rates of 90% and 91% were recorded. Equally, these findings must be taken with caution because the tooth type in the 2 groups were definitely different; the first involved mostly of roots with 2 canals as well as the buccal roots of maxillary premolars and molars, while canals with only 1 root were involved in the second group [43]. In contrast, a randomized clinical study conducted by Saini et al. 2012 [45], which has the highest level of evidence (level 1), concluded that the preparation of the canal to 3 sizes larger than the initial apical binding file is sufficient, and further enlargement does not offer any extra benefits during endodontic therapy. Although the statistical outcome of this study indicates a significant relationship between apical preparation size and success rate (P= 0.0001), this relationship may be explained by the different numbers of teeth used in each preparation group. For instance, the success rate for 73 teeth prepared up to size 25.04 and 7 cases prepared up to size 30.04 was 48% and 2%, respectively.

In chemical preparation of root canal treatment, the sodium hypochlorite (NaOCl) is the most widely used solution, due to its antimicrobial effects and ability to dissolve necrotic pulp [46-49]. NaOCl's characteristics are influenced by time and concentration, but it also damages apical tissues. In other words, higher volume, frequency, and contact times with lower concentrations of NaOCl have been suggested for root canal disinfection. [46, 47]. Cvek et al. (1976) [50]found that after a 3-month canal dressing with Ca(OH)2, using 0.5% sodium hypochlorite solution was correlated with greater healing than using 5% solution, although the difference was not statistically significant. The efficacy of irrigation can be augmented by adding ethylene-di-amine-tetra-acetic acid (EDTA) for smear layer removal. Following EDTA irrigation, NaOCl enters the dentin and the canal wall more deeply [51]. According to a clinical microbiological investigation, individuals who received both NaOCl and EDTA had less bacterial infection than those who received only NaOCl. [52]. The results of their cases divided into different canal disinfection techniques over the long term (2 years) did not match their microbiological test results [53]. In comparison to irrigation using saline (91%), 5% NaOCl (86%) or 0.5% NaOCl (92%) the percentage of teeth with periapical healing was low (67%) after additional irrigation with NaOCl and EDTA solutions. [53]. Their outcome findings were unexpected as pre-obturation. In the present study, the teeth irrigated with sodium hypochlorite only has the highest success rate in comparsion with the teeth irrigated with sodium hypochlorite and EDTA. The cause behind that could be as a result of the fact that EDTA can reduce up to 80%–88% of available chlorine from NaOCl solutions [54, 55].

5 Conclusions

Three elements has a significant effect on the outcome of primary root canal therapy: the size of the apical preparation, the type of irrigant, and root filling extension. Therefore, when performing chemo-mechanical debridement, root canal therapy should focus on using sodium hypochlorite as the main irrigant, gaining and maintaining access to the apical anatomy with enough apical enlargement. In addition, obturating the canal with tightly packed material without extrusion into the periapical tissues.

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