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CLINICAL RESEARCH

Impact of Case Difficulty, Endodontic Mishaps, and Instrumentation Method on Endodontic Treatment Outcome and Quality of Life: A Four-Year Follow-up Study

ABSTRACT

Introduction: Root canal treatment (RCT) is often considered a difficult procedure for both the patient and treatment provider. The American Association of Endodontists case difficulty assessment form categorizes cases as minimal, moderate, and high difficulty level. We recently showed that endodontic mishaps occur frequently during treatment of teeth in high difficulty category. The aims were to investigate the clinical and radiographic outcome at least 4 years after RCT and to evaluate patients' perceived oral health-related quality of life (OHRQoL). **Methods:** Two hundred thirty-four patients (257 endodontically treated teeth) who were previously included in a quality assurance study were offered a recall appointment at the Department of Clinical Dentistry, University of Bergen, Norway. Patients were given a thorough clinical, radiographic examination and asked to fill out the Oral Health Impact Profile-14 questionnaire. **Results:** A total of 149 patients (160 teeth) attended the 4-year (range, 4–6 years) recall appointment. An unchanged or lower Periapical Index (PAI) score at recall visit was registered on 153 teeth (95.6%) ($P < .001$). Radiographic success rate (PAI score ≤ 2) was 87.5%, and clinical success (absence of clinical signs and symptoms) was 88.8%. Both radiographic and clinical success was observed in 78.8% of teeth. Teeth in high difficulty category, instrumented with engine-driven files, and molars presented with significantly more clinical signs and symptoms but not high PAI score (PAI score ≥ 3) ($P < .05$). Endodontic mishaps such as overinstrumentation and overfill with gutta-percha resulted in significantly high PAI score ($P < .05$). Patients with no clinical signs and symptoms after RCT and elderly had a significantly better OHRQoL ($P < .05$). **Conclusions:** Presence of clinical signs and symptoms rather than PAI score affected patients' OHRQoL. *(J Endod 2023;49:382–389.)*

KEY WORDS

AAE case difficulty assessment; coronal restorations; OHIP-14; procedural errors; reciprocating WaveOne files

Primary nonsurgical root canal treatment (RCT) is performed to save teeth that otherwise will be extracted when the dental pulp is inflamed (pulpitis), infected (pulp necrosis), or when there is an indication for elective treatment. People generally want to keep their natural teeth for life[1]. Teeth needing RCT present with various levels of difficulty for the operator. It has been proposed that achieving a predictable treatment outcome can be challenging even for an experienced practitioner when treating a case in high difficulty category[2].

We recently reported that case difficulty had an impact on the occurrence of endodontic mishaps in an undergraduate student clinic[3]. Teeth that were categorized as highly difficult according to the American Association of Endodontists case difficulty assessment form were shown to need significantly more dental treatment visits to complete RCT and resulted in significantly more endodontic mishaps such

SIGNIFICANCE

This study addresses gaps in knowledge on clinical, radiographic, and patient-centered oral health-related quality of life outcome on cases in high difficulty category 4 years after root canal treatment.

as instrument separation, canal transportation, loss of working length, short obturation, and overfill with gutta-percha[3].

It is documented that endodontic treatment outcome is influenced by preoperative periapical diagnosis and operative factors such as use of rubber dam, endodontic mishaps, technical quality of the obturation, and postoperative coronal restorations[4-8]. Technological advances, for example, use of engine-driven files, are meant to improve the technical quality of root fillings and thereby increase the success rate of RCT[9]. Our previous study indicated that use of engine-driven reciprocating files did not significantly reduce occurrence of endodontic mishaps[3]. However, the use of engine-driven files on long-term outcome has not been reported.

The main goal of endodontic treatment is to maintain healthy periradicular tissue and the functionality of the tooth without patient discomfort[10]. A successful outcome after RCT is often based on absence or reduction of periapical lesion radiographically, no clinical signs or symptoms, and no patient discomfort. In addition, an improved oral health-related quality of life (OHRQoL) after RCT is desired.

According to the World Health Organization, quality of life (QoL) refers to individual's perceptions of their positions in life within the context of the culture and value systems as well as their goals, expectations, and beliefs[11]. Oral Health Impact Profile (OHIP) is a frequently used instrument consisting of 49 items to assess OHRQoL[12]. To simplify, it has been adapted into a short form containing 14 items (OHIP-14)[13]. OHIP is based on Locker's conceptual framework and the World Health Organization International Classification of Impairments, Disabilities, and Handicaps testing the following 7 dimensions of impact: functional limitation, pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap[14].

The aim of this study was to investigate the treatment outcome 4 years after primary nonsurgical RCT performed in an undergraduate student clinic with case difficulty, instrumentation method, endodontic mishaps, and coronal restoration as variables. A clinical examination and radiographic assessment were performed, followed by an evaluation of patient's OHRQOL using an OHIP-14 instrument.

MATERIALS AND METHODS

Patients (*n* = 234) from a previous quality assurance study were invited to a recall appointment at the Department of Clinical Dentistry, Faculty of Medicine, University of Bergen, Norway[3]. Briefly, 234 patients had received primary nonsurgical RCT on 257 teeth 4–6 years previously. The treatment was performed by 2 consecutive classes of fourth-year dental students using hand files and reciprocating WaveOne files (Dentsply Sirona, Charlotte, NC) for instrumentation. Teeth were categorized using the American Association of Endodontists case difficulty assessment form. Endodontic mishaps such as instrument separation, canal transportation, overinstrumentation, loss of working length, lateral or strip perforation, short obturation, and overfill with gutta-percha that occurred during treatment were registered.

To evaluate the 4-year treatment outcome and assess its influencing factors, data stored in electronic journal system (Version 7.1; Opus Systemer AS, Planmeca Group, Helsinki, Finland) and recall data were analyzed. Teeth that were missing, extracted, re-treated surgically, or nonsurgically were recorded as early failures and excluded from further statistical analysis.

Clinical Examination

Patients' chief complaint regarding treated tooth was registered. If the patient reported pain sensation, a numeric rating score (NRS) in which 0 is zero pain and 10 is highest imaginable possible pain was used for quantification. All clinical examinations were performed by one examiner (IJ) under the supervision of an endodontist (SRH/AB). A palpation and percussion test were performed. Periodontal probing depth and mobility were registered. Type of coronal restoration, presence of post and core, and if the tooth was used as an abutment for fixed or removable partial denture were recorded. If a sinus tract was detected, it was traced with gutta-percha to register origin of infection with a radiograph.

Radiographic Assessment

For radiographic examination a periapical radiograph was taken with phosphorplates (Digora Optime; Soredex, Milwaukee, WI). Additional radiographs were taken when necessary. One observer (IJ) interpreted all radiographs using the Periapical Index (PAI) scoring system as described by Ørstavik et al[15]. Before the PAI scoring, the observer was calibrated scoring a set of 100 reference radiographs until reaching a calculated Cohen's κ = 0.72, which was considered acceptable. For the intraobserver agreement a Cohen's κ = 0.80 was accomplished.

Evaluation of the Endodontic Treatment Outcome

Clinical success was defined as absence of clinical signs and symptoms such as pain (NRS = 0), percussion tenderness, palpation tenderness, sinus tract, and endodontic pocket to apex. Presence of at least one of these clinical signs and symptoms was evaluated as a clinical failure. PAI scores 1 and 2 were considered as radiographic success, whereas PAI scores 3, 4, and 5 were registered as radiographic failure. The overall endodontic treatment outcome was evaluated in accordance with the definition provided by the European Society of Endodontology's quality guidelines for evaluation of the endodontic treatment outcome[10]. Combined or total treatment outcome in this study was defined as successful if the tooth presented with absence of clinical signs and symptoms and a radiographic PAI score ≤ 2.

Oral Health Impact Factor

To assess OHRQoL within the last 6 months, an oral health impact factor form with 14 questions (OHIP-14) was used. The OHIP-14 questionnaire was originally translated into
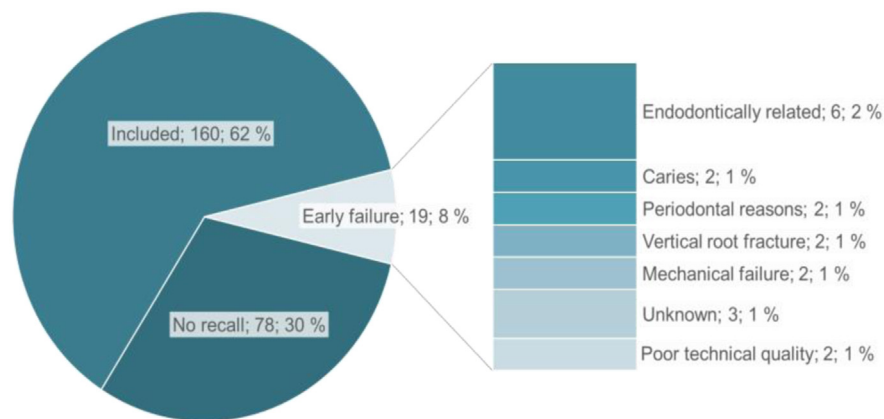

FIGURE 1 – Pie chart showing status of the 257 teeth that were included in our previous study.

TABLE 1 - Demographic Data on 160 Teeth at Recall Appointment

Treatment factors	Number [n (%)]	Clinical signs and symptoms (n)	PAI ≥ 3 (n)	Total failures (n)
Diagnosis				
Vital pulp	62 (38.8)	7	2	8
Pulp necrosis	98 (61.3)	11	18**	26*
Pulpal necrosis without AP	18 (11.3)	2	1	2
Pulpal necrosis with AP	70 (43.8)	8	15	21
Pulpal necrosis sinus tract	10 (6.3)	1	2	3
Case difficulty				
Minimal	6 (3.8)	0	1	1
Moderate	59 (36.9)	2	5	6
Difficult	95 (59.4)	16*	14	27*
Tooth type				
Anterior	27 (16.9)	0	3	3
Premolar	34 (21.3)	1	3	4
Molar	99 (61.9)	17**	14	27*
Dental arch				
Maxilla	89 (55.6)	10	14	22
Mandible	71 (44.4)	8	6	12
Instrumentation method				
Hand files	85 (53.1)	5	9	14
Engine-driven files	75 (46.9)	13*	11	20
No. of treatment visits				
1–3	108 (67.5)	10	14	21
4	52 (32.6)	8	6	13
Coronal restoration				
Permanent direct	105 (65.6)	13	12	22
Permanent indirect	52 (32.5)	5	7	11
None	3 (1.9)	0	1	1
Gender				
Male	83 (51.9)	9	11	17
Female	77 (48.1)	9	9	17
Age at follow-up (y)				
Elderly (≥65)	50 (31.3)	6	8	11
Adults (<65)	110 (68.8)	12	12	23

Columns with (n) refer to number of teeth.
Significant differences between categories are marked as *P < .05 and **P < .01.

Norwegian by an experienced researcher and was back-translated into English independently by 2 dental researchers who had English as their first language. The translated version of the original OHIP-14 questionnaire is widely used in epidemiologic studies[16]. Each question was assessed on the basis of the following response scale: 0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, and 4 = very often in the last 6 months. Individual domain score is derived by summing up responses of the 2 items within a particular domain where scores can range from 0 to 8. A total OHIP-14 summary score is derived by summating responses to all items, and scores can range from 0 to 56. A high score indicated poorer OHRQoL.

Ethical Considerations

Ethical approval was granted by the Regional Committees for Medical and Health Research Ethics (REK-Vest) with reference number 2018/2117. All participants signed a written consent form approving use of their personal data for research purposes.

Statistics

SPSS version 26 (IBM Corporation, Armonk, NY) was used for descriptive and inferential statistical analysis. Variables were dichotomized for statistical purposes. Pearson's χ^2 test was used to determine differences between groups on treatment outcome and correlations. The internal consistency of the OHIP-14 questionnaire was examined by computing Cronbach's alpha coefficients. Only one OHIP form was registered per patient because several patients had more than one tooth that was included in this study. A Student t test was used to compare the 7 domains and total OHIP-14 scores separately for each evaluation. A P value ≤ .05 was considered significant.

RESULTS

Data for the 257 root-filled teeth were analyzed from the patient journal record. Of these, 19 teeth were registered as early failures and were excluded from this study (Fig. 1). Seventy-eight teeth were not included in this study because the subjects declined to participate (n = 53), could not be contacted (n = 18), or were deceased (n = 7). A total of 149 patients (160 teeth) attended a 4-year (range, 4–6 years) recall appointment where clinical, radiographic, and OHRQoL assessments were performed (Table 1). The mean age was 55.6 years (range, 28–91 years, standard deviation, 15.6).

Radiographic Assessment

Of 160 teeth, 153 teeth (95.6%) had a lower or unchanged PAI score at recall visit (P < .001) (Table 2). A PAI score ≥ 3 was registered in 20 teeth, resulting in a radiographic success of 87.5% (Table 2). Of these 20 teeth, only 4 teeth presented with clinical signs and symptoms. Teeth with pulp necrosis as diagnosis at treatment onset had significantly higher PAI score (≥3) (P < .01) at 4-year recall, resulting in an RCT success rate of 82% for non-vital pulp. Two teeth with vital pulp resulted in PAI score > 3, resulting in a success rate of 96.8% for pulpectomy cases.

Clinical Findings

Clinical signs and symptoms were registered in 18 teeth, resulting in clinical success of 88.8% (Table 1). The most frequent symptom was tenderness to percussion (n = 10), followed by tenderness to palpation (n = 7) and pain (n = 4; NRS of 1, 5, 6, and 8). Several teeth presented with more than one symptom. All teeth with pain symptoms had periodontal pocket ≥ 4 mm, but pathologic mobility was only registered in one of them. All teeth presenting with pain, sinus tract, tenderness to percussion and palpation were molars. The 2 teeth with endodontic pockets to the apex were diagnosed to have vertical root fracture and referred for extraction. Teeth in high difficulty category that were treated with engine-driven instrumentation and molars presented with significantly more clinical signs and symptoms (P < .05). Additional complaints during clinical examination were registered on 19 teeth. The most common complaint was food impaction (n = 6), followed by dissatisfaction with tooth color, subjective fear of tooth loss, and mobility problem. Singular issues related with periodontal disease were also reported.

Total Failures

A combination of clinical signs and symptoms with PAI score ≥ 3, registered as total failures,

TABLE 2 - Cross-Tabulation of PAI Score Registered Preoperatively and at Four-Year Recall

		PAI score at recall after 4 years					Total
		1	**2***	**3***	**4***	**5***	
Preoperative PAI score	1	68	5	1*	0*	1*	75
	2	14	0	0	0*	0*	14
	3	13	2	3	0	0*	18
	4	24	3	11	1	0	39
	5	9	2	1	2	0	14
Total		128	12	16	3	1	160

*Number of teeth where PAI scores were higher than preoperative score.

occurred in 34 teeth, resulting in an overall success of 78.8%.

Case Difficulty
Teeth in high difficulty category had significantly more clinical signs and symptoms and total failures compared with teeth in minimal and moderate difficulty category ($P < .05$).

Type of Tooth, Dental Arch, Instrumentation Method
Significantly more molars presented with clinical signs and symptoms ($P < .01$) and had total failure ($P < .05$). However, significant numbers of molars were also in the high difficulty category ($P < .05$). Teeth instrumented with engine-driven files resulted in significantly more clinical signs and symptoms ($P < .05$).

Coronal Restorations
About two thirds of the root-filled teeth (65.6%) were restored with direct composite restorations, 53 teeth (32.6%) had indirect restorations (crown or bridge abutment), and 3 teeth lacked coronal restorations. Of the 53 teeth with indirect restoration, post and core were placed on 23 teeth (43.4%). There were no significant differences between direct and indirect restoration on the treatment outcome. A total of 18 teeth were used as bridge

abutment. When comparing these 18 bridge abutments with other coronal restorations (direct restorations and single crowns), significantly more teeth serving as bridge abutments had a PAI score ≥ 3 ($P < .05$). Similarly, when bridge abutments were compared with single crowns, a significantly higher PAI score was found on bridge abutments ($P < .05$).

Endodontic Mishaps
Presence of endodontic mishaps was not associated with clinical signs and symptoms. Teeth that were overinstrumented or overfilled with gutta-percha had a significantly higher PAI score (≥ 3) ($P < .01$) and total failures ($P < .001$) (Table 3). Sinus tract ($P < .05$), endodontic pocket ($P < .01$), and pain ($P < .01$) occurred more frequently in overinstrumented cases. Overfilled with gutta-percha was found to be correlated with endodontic pocket ($P = .05$), whereas canal transportation was correlated with pain ($P = .05$).

Oral Health-Related Quality of Life
Internal consistency for OHIP-14 as measured by Cronbach's alpha was 0.89, which is considered good. This indicates the extent to which participants who respond positively to one item also respond positively to other items, validating high internal reliability.

Patients with clinical signs and symptoms had a significantly poorer OHRQoL in several domains compared with patients with no clinical signs and symptoms (Table 4). On the other hand, a high PAI score did not result in a poorer OHRQoL. Young adult patients reported a significantly poorer OHRQoL in several domains and total score compared with the elderly (65 years and older). There were no significant differences within case difficulty, instrumentation method, or gender with respect to OHRQoL.

DISCUSSION
The main findings in this study are that clinical signs and symptoms but not periapical lesions caused a significantly poorer OHRQoL. Teeth in high difficulty category, instrumentation with engine-driven files, and molars resulted in more clinical signs and symptoms but not higher PAI score. Presence of endodontic mishaps did not cause clinical signs and symptoms.

Periapical Index
There was an overall significant reduction in PAI score after RCT at 95.6%. Results from this study are in agreement with Sjøgren et al[7] (1990), where 96.8% of vital teeth and 81.6% of teeth with necrotic pulp were successful radiographically (PAI score of 1 or 2). This confirms that endodontic treatment outcome has not changed over the years. However, because more people choose to retain their natural teeth, there is a need to perform RCT on teeth that are difficult to treat[17]. For the first time, we report teeth in high difficulty category have a radiographic success of 85.3%. The existence of a periapical lesion 4 years after RCT can be interpreted as healing with scar tissue formation or persistence of disease. However, an outcome based only on radiographic examination is inadequate. Therefore, clinical signs and symptoms and OHRQoL assessment were included in this study.

Clinical Signs and Symptoms
Approximately 1 in 10 teeth (11.25%) had clinical signs and symptoms after RCT. The most common clinical symptom experienced by patients was tenderness to percussion. In a recent clinical study, 5% of patients experienced persistent pain (pain, tenderness to percussion and palpation) after endodontic treatment[18]. In this study, clinical signs and symptoms were higher because fistula and endodontic pocket to the apex were included as a sign of disease. The origin of tenderness to percussion was unclear because these teeth also presented with periodontal pocket

TABLE 3 - Frequency of Teeth with Endodontic Mishaps

Endodontic mishaps	Number [n (%)]	Clinical signs and symptoms (n)	PAI ≥ 3 (n)	Total failures (n)
Overinstrumentation	28 (17.5)	6	10**	15**
Loss of working length	10 (6.3)	1	2	3
Short obturation	15 (9.4)	1	1	2
Overfill with gutta-percha	12 (7.5)	2	6**	7**
Canal transportation	6 (3.8)	1	1	2
Instrument separation	4 (2.5)	0	0	0
Lateral or strip perforation	3 (1.9)	0	1	1

Columns with (n) refer to number of teeth.
Significant differences between categories are marked as **$P < .01$.

TABLE 4 - Variations in OHQoL (OHIP-14) with Variables Associated with Tooth and Patient-Related Factors (*n* = 149) (Mean ± Standard Deviation)

Treatment factors	No. of teeth	Functional limitation	Physical pain	Psychological discomfort	Physical disability	Psychological disability	Social disability	Handicapped	Total OHIP score
Case difficulty category	Minimal and moderate (*n* = 58)	0.69 ± 1.43	1.38 ± 1.85	1.19 ± 1.72	0.69 ± 1.52	0.93 ± 1.73	0.76 ± 1.59	0.69 ± 1.61	6.33 ± 9.03
	High (*n* = 91)	0.30 ± 0.73	1.36 ± 1.10	1.25 ± 2.01	0.70 ± 1.23	1.00 ± 1.55	0.55 ± 1.11	0.59 ± 1.54	5.76 ± 6.89
	P value	NS	NS	NS	NS	NS	NS	NS	NS
Instrumentation method	Hand (*n* = 85)	0.43 ± 0.99	1.35 ± 2.01	1.01 ± 1.64	0.65 ± 1.25	0.94 ± 1.65	0.70 ± 1.36	0.57 ± 1.31	5.65 ± 6.85
	Engine-driven (*n* = 75)	0.47 ± 1.15	1.39 ± 1.74	1.43 ± 2.13	0.75 ± 1.46	1.01 ± 1.60	0.56 ± 1.28	0.69 ± 1.64	6.33 ± 8.68
	P value	NS	NS	NS	NS	NS	NS	NS	NS
Clinical symptoms	Yes (*n* = 17)	0.76 ± 1.09	2.41 ± 1.87	2.41 ± 2.50	1.59 ± 1.50	1.94 ± 1.75	1.06 ± 1.20	1.24 ± 1.25	11.41 ± 7.69
	No (n = l32)	0.41 ± 1.06	1.23 ± 1.85	1.08 ± 1.76	0.58 ± 1.29	0.85 ± 1.57	0.58 ± 1.33	0.55 ± 1.34	5.28 ± 7.53
	P value	NS	*P < .05	*P < .05	**P < .01	**P < .01	NS	*P < .05	**P < .01
PAI score	<3 (*n* = 130)	0.48 ± 1.11	1.41 ± 1.94	1.30 ± 1.98	0.75 ± 1.42	1.02 ± 1.66	0.64 ± 1.36	0.67 ± 1.41	6.26 ± 8.14
	>3 (*n* = 19)	0.21 ± 0.71	1.11 ± 1.41	0.74 ± 1.01	0.37 ± 0.68	0.68 ± 1.29	0.58 ± 0.96	0.37 ± 0.83	4.05 ± 4.09
	P value	NS	NS	NS	NS	NS	NS	NS	NS
Age (y)	≥65 (*n* = 50)	0.52 ± 1.15	0.58 ± 0.91	0.36 ± 0.94	0.22 ± 0.55	0.60 ± 1.40	0.40 ± 0.83	0.34 ± 0.75	3.02 ± 4.45
	<65 (*n* = 99)	0.41 ± 1.03	1.77 ± 2.11	1.67 ± 2.10	0.94 ± 1.56	1.16 ± 1.69	0.75 ± 1.49	0.78 ± 1.55	7.47 ± 8.63
	P value	NS	**P < .01	**P < .0 l	**P < .01	*P < .05	NS	*P < .05	**P < .01
Gender	Women (*n* = 72)	0.50 ± 1.13	1.68 ± 2.10	1.54 ± 2.15	0.81 ± 1.58	1.15 ± 1.78	0.64 ± 1.41	0.82 ± 1.52	7.14 ± 9.44
	Men (*n* = 77)	0.40 ± 1.01	1.08 ± 1.60	0.94 ± 1.59	0.60 ± 1.10	0.81 ± 1.44	0.62 ± 1.24	0.45 ± 1.14	4.90 ± 5.64
	P value	NS	NS	NS	NS	NS	NS	NS	NS
Total outcome	Total failure (*n* = 32)	0.44 ± 0.88	1.72 ± 1.82	1.59 ± 2.12	0.97 ± 1.33	1.41 ± 1.68	0.88 ± 1.13	0.84 ± 1.17	7.84 ± 7.27
	Clinical and radiographic success (*n* = 117)	0.45 ± 1.12	1.27 ± 1.89	1.13 ± 1.83	0.62 ± 1.36	0.85 ± 1.59	0.56 ± 1.36	0.57 ± 1.39	5.57 ± 7.85
	P value	NS	NS	NS	NS	NS	NS	NS	NS

Significant differences are marked as *P < .05 and **P < .01.

and in some instances, bleeding on probing from the periodontium. Interestingly, Vena et al[18] (2014) reported that persistent pain was reported more frequently in cases treated by specialists (9.3%) compared with general dentists (3.0%). Specialists often treat teeth in high difficulty category, and therefore our results corroborate this finding. It is unclear why teeth in high difficulty category and molars had significantly more clinical signs and symptoms. Other studies have indicated problems related to molars such as treatment completion and extractions[19,20]. In a general practice setting, pain experience 1–3 years after RCT has been reported to be as high as 50%, with a majority experiencing mild pain[20]. However, in this study, only about 11% of patients presented with clinical signs and symptoms 4 years after treatment, and this could be due to patients being treated in an educational institution with adherence to strict standard of care protocols during treatment procedures.

Endodontic Mishaps

We previously reported that cases in high difficulty category had significantly more endodontic mishaps such as loss of working length, short obturation, canal transportation, and overfill with gutta-percha[3]. Overinstrumentation and overfill with gutta-percha were the only 2 endodontic mishaps that resulted in high PAI score. Overfill with gutta-percha has been shown to result in endodontic failures[7], and therefore, this is not an unexpected finding. Interestingly, none of the endodontic mishaps in this study caused any clinical signs and symptoms. Other mishaps such as instrument separation, short obturation, canal transportation, and lateral or strip perforation did not affect the treatment outcome; however, the numbers in this study were too low to make a conclusion.

Instrumentation Methods

Engine-driven instrumentation resulted in significantly more clinical signs and symptoms. Our previous study[3] reported that significantly more molars were in the engine-driven group, and therefore the results here are more likely due to tooth factor rather than instrumentation method.

Coronal Restoration

Direct coronal composite restoration was the preferred form of coronal restoration, with two thirds of the teeth receiving composite restoration. A recent study showed no significant differences in outcome whether a direct or indirect restoration was placed after RCT[21]. However, indirect restoration that served as bridge abutments had significantly higher PAI score.

OHRQoL

Endodontic treatment improves OHRQoL[22-24]. We recently showed that patients experiencing pain, female, and younger adults who needed RCT had a poorer quality of life compared with patients without pain, male, and elderly (>65 years of age)[17]. In this study, we found that patients who presented with clinical signs and symptoms had a poorer quality of life in several domains, which is similar to another OHRQoL outcome study[18]. Our previous study showed that female patients undergoing RCT had a poorer OHRQoL[17]. Women are generally reported to be more anxious about RCT, which may have been reflected in the previous study[17,25]. Although the results in this study show that female patients had a tendency for poorer OHRQoL, this was not significant. In addition, compared with our previous study, which was undertaken during treatment performance[17], a 4-year recall indicates RCT improves quality of life among the female gender.

Interestingly, having a high PAI score (≥3) did not affect the patient's OHRQoL. This is in agreement with other studies that have shown that an individual patient who is generally unaware of the status of periapical tissue may perceive a tooth with periapical lesion as successful as long as the tooth is symptom free[19,20]. The lack of effect of PAI score on OHRQoL may elucidate why these patients did not receive further treatment such as retreatment or surgical treatment.

Our results show that endodontic treatment outcome has not changed over the years, even with technological advances in this field. One reason could be that we may be treating teeth that are technically demanding. In this study, dental operating microscope was used when indicated, electronic apex locators were commonly used for working length determination, root canals were irrigated with Dakins solution (0.5% buffered sodium hypochlorite solution), and smear layer was removed with 17% EDTA. An intracanal medicament, calcium hydroxide (Ultracal XS; Ultradent Products, Inc, South Jordan, UT),

was placed between treatment visits. The root-filling material and technique were gutta-percha with AH Plus Sealer (Dentsply DeTrey GmbH, Konstanz, Germany) and cold lateral condensation, respectively. In the future, case-controlled studies need to address the role of individual variables on treatment outcome, for example, use of different irrigation medium, protocols, ultrasonic agitation of irrigants, obturation with vertical condensation technique, and use of different types of sealers. Another limitation of this study is that treatment outcome from an educational institution may not always reflect treatment outcome in the general population[26-28]. It can be speculated that endodontic mishaps related to maintaining working length, such as overinstrumentation and overfill with gutta-percha, are due to shortcomings of novice undergraduate students with regard to dexterity skills. These mishaps are unlikely to occur when a treatment is performed by an endodontic specialist; therefore, it is possible to achieve a higher treatment success.

In conclusion, teeth in high difficulty category, molars, and teeth treated with engine-driven files presented with significantly more clinical signs and symptoms and not periapical lesions 4 years after treatment completion. Presence of clinical signs and symptoms rather than PAI score affected patients' OHRQOL.

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