Clinical and Patient-centered Outcomes of Nonsurgical Root Canal Retreatment in First Molars Using Contemporary Techniques

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Abstract

Introduction: There have been many recent technical advances in modern endodontics that have the potential to affect treatment outcomes. Reports on treatment outcomes using contemporary techniques are relatively scarce, especially in the field of nonsurgical retreatment. The purpose of this study was to determine the success of nonsurgical root canal retreatment in molars using contemporary endodontic techniques. **Methods:** Sixty-three patients referred for retreatment in first molars were enrolled in the study. The retreatment procedures were performed by endodontic residents using a semistandardized treatment protocol. Patients were followed-up at 6, 12, and 24 months. Treatment outcomes were categorized into healed, healing, or nonhealing based on clinical and radiographic criteria. Healed and healing were considered as successes, and nonhealing was considered a failure. Outcomes were also evaluated using patient-centered criteria that included oral health–related quality of life scores and subjective chewing ability. **Results:** Fifty-two of the 63 patients were available for final analysis. Five cases (9.6%) were determined to be nonhealing at the last follow-up with new or persistent periapical lesions. Thirty-seven (71.2%) patients had complete resolution of apical periodontitis, and the remaining 10 (19.2%) remained asymptomatic and showed radiographic evidence of healing. Oral health–related quality of life scores and chewing ability improved significantly over time ($P < .05$), with the biggest increase observed within the first week of treatment completion. **Conclusions:** This study showed that endodontic retreatment using contemporary techniques significantly improved patients' quality of life and chewing ability over time, with a success rate of 90.4% after 2 years. *(J Endod 2017;43:231–237)*

Key Words

Chewing ability, outcome, quality of life, retreatment, root canal

Significance

This prospective cohort study showed that endodontic retreatment using contemporary techniques significantly improved patients' quality of life and chewing ability over time, with a success rate of 90.4% after 2 years.

Retaining a pulpally involved tooth typically requires endodontic treatment followed by a permanent coronal restoration. Root canal treatment has a high success rate, with a reported survival rate of greater than 97% (1–3). When original root canal treatment fails, retreatment or apical surgery is often indicated. Prognosis generally becomes less favorable with repeated procedures (4, 5). The survival rate of retreatment cases at 5 years is reported to be 89% (6).

According to 2 recent meta-analyses, the pooled weighted success rate for nonsurgical retreatment was 76.6% (7) and 78% (8), with a range of 62%–86% in the reported literature (8). The large range of variation can be attributed to patient population, operator skill level, treatment protocol, assessment criteria, and preoperative apical diagnosis. The most important predictors for retreatment success identified in these meta-analyses include preoperative periapical status, size of lesion, apical extent of the root filling, and quality of coronal restoration (9). Other potential predictors include the presence of preoperative complications such as perforation and intraoperative complications such as pain and swelling (5, 7).

The majority of outcome studies on retreatment have been retrospective in nature, with only 8 prospective studies published between 1995 and 2016 (7, 10–16). Among these prospective studies, only 3 were published after 2005. One investigated the outcome of retreatment after failed apicoectomy (14). The other study with a large sample size and a 2-year follow-up reported a success rate of 85.6% when both "healed" and "healing" were pooled and considered successful (7). The techniques used in endodontic retreatment have evolved rapidly in recent years. The use of surgical operating microscopes has enhanced the operators' ability to locate missed canals, visualize root canal obstructions, and improve manual dexterity (17, 18). The incorporation of ultrasonic instruments into the endodontic armamentarium has drastically improved the efficiency in removing canal obstruction and the effectiveness of irrigation (19, 20). These new advancements have improved the efficiency and technical outcomes of endodontic retreatment; however, whether these improvements can translate into improved clinical outcomes has not been determined.

In addition to the clinical and radiographic criteria, patient-centered outcome measurements are also important in evaluating the effectiveness of a treatment. Oral

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health–related quality of life (OHQOL) is a multidimensional concept that captures how oral health and dental treatment affect the person's ability to function (chewing and speech), psychological states, social factors, and pain or discomfort (21). A modified version of the Oral Health Impact Profile has been previously validated and can be used to measure OHQOL among endodontic patients (22). Because 1 one of the most important functions of the dentition is mastication, patients' subjective ability to chew is a good measurement to determine how a treatment can help restore function (23).

The purpose of the current study was to determine the outcomes of nonsurgical endodontic retreatment in first molars using contemporary techniques. Success was measured using clinical and radiographic criteria as well as patient-centered criteria including OHQOL and subjective chewing ability.

Materials and Methods

This was a prospective cohort study. The research protocol was approved by the Institutional Review Board at Texas A&M University Baylor College of Dentistry, Dallas, TX. Informed consent was obtained from all study subjects.

Patient Population

Sixty-three patients referred to the graduate endodontic clinic at Baylor College of Dentistry for retreatment were recruited to participate in the study. The inclusion criteria were as follows:

1. Adult patients 18–80 years of age
2. Generally healthy without any immunocompromising systemic diseases such as uncontrolled diabetes, AIDS, and so on
3. Teeth requiring treatment were either previously endodontically treated maxillary or mandibular first molars with opposing dentition

Exclusion criteria included:

1. Vertical root fracture
2. Advanced periodontal disease
3. Nonrestorable teeth
4. Major malocclusion. Restorability was determined jointly by the supervising endodontic faculty and the attending restorative faculty.

The preoperative diagnosis was determined based on clinical and radiographic findings using the American Association of Endodontists Consensus Conference–recommended diagnostic terminology. Teeth included in the study had a pulpal diagnosis of previously treated and a periapical diagnosis of normal, symptomatic apical periodontitis, asymptomatic apical periodontitis, or chronic apical abscess.

Treatment Protocol

All treatments were performed by second- or third-year endodontic residents using a predetermined treatment protocol between 2008 and 2013. Patients were anesthetized, and a dental dam was placed according to standard practice. Caries and defective restorations were removed, and an access cavity was made to establish straight-line access. Previous obturation materials and root canal obstructions were removed using a combination of heat, solvent, hand files, rotary files, and ultrasonic instruments. The working length was determined using an electronic apex locator and confirmed with digital radiographs. Root canal instrumentation was accomplished using hand files and nickel-titanium rotary files in a crown-down approach and in combination with chemical irrigation using 20 mL 5.25% sodium hypochlorite (NaOCl) and 5 mL 17% EDTA. Mesial canals in the mandibular molars and buccal canals in the maxillary molars were prepared to an apical size of #35 to 40 with a taper of 0.04 or 0.06; distal canals in the mandibular molars and palatal canals in the maxillary molars were prepared to an apical size of #40 to 60 with a taper of 0.04 or 0.06 depending on the original canal size and anatomy. Passive ultrasonic irrigation with NaOCl was performed for approximately 15 seconds in each canal using a #15 stainless steel file with an NSK ultrasonic unit (NSK America, Hoffman Estates, IL) to aid in the cleaning of the canal system. All treatments were performed under surgical operating microscopes.

Treatment was completed in 2 to 3 visits. An intracanal calcium hydroxide dressing (UltraCal; Ultradent, South Jordan, UT) was placed between visits; and IRM (Dentsply International, York, PA) was used as the interim filling material.

At the obturation visit, calcium hydroxide was removed with copious irrigation with 5.25% NaOCl combined with nickel-titanium rotary instrumentation. Passive ultrasonic irrigation was again used with NaOCl to ensure thorough removal of the medicament. The smear layer was removed with 5 mL 17% EDTA. Canals were subsequently dried with paper points and obturated with gutta-percha (GP) and AH Plus sealer (Dentsply, Tulsa, OK) or Resilon (RS) (Pentron Clinical Technologies, Wallingford, CT) and RealSeal SE (SybronEndo, Orange, CA) with the warm vertical compaction technique using System B (SybronEndo) and Obtura (Obtura Spartan, Algonquin, IL). An IRM temporary restoration was placed. Patients were subsequently referred back to their general dentists for a permanent coronal restoration. Permanent buildup was placed if it was requested by the referring dentist.

Outcome Assessment

Patients were recalled at 6, 12, and 24 months after the placement of a permanent coronal restoration. At each follow-up, standard clinical examinations were performed to determine the integrity of the coronal restoration and the presence of signs and symptoms. The presence of any pain or discomfort to palpation, percussion, or biting with a Tooth Slooth (Professional Results Inc, Laguna Niguel, CA) was recorded. Six-point periodontal probing was also performed and recorded. The presence of any sinus tract was also noted. Digital periapical radiographs were exposed and evaluated by 3 calibrated observers to determine the periapical status. The treatment outcomes were classified into 3 categories according to the following definitions:

1. Healed: the absence of any clinical signs or symptoms and normal periapical tissue with an intact periodontal ligament space and lamina dura or a slightly widened periodontal ligament around extruded material
2. Healing: the absence of any clinical signs or symptoms and periapical radiolucency still present but reduced in size
3. Nonhealing: the presence of signs or symptoms and/or the emergence of new periapical radiolucency or unchanged or enlarged periapical radiolucency

"Nonhealing" was considered "failure," and "success" was the combination of the "healing" and "healed" groups.

At the preoperative visit and all the subsequent follow-up visits, patients were presented with the modified OHQOL questionnaire and the chewing ability questionnaire (Figures 1 and 2). Responses were marked on a Likert scale of 1 through 5, with 1 being "never" and 5 being "all the time."

Statistical Analysis

The rate of "healed," "healing," and "nonhealing" is expressed as a percentage. The influence of various preoperative and treatment factors on the outcomes was evaluated using the Fisher exact test using GraphPad Prism 6 (GraphPad Software, La Jolla, CA). A P value $<.05$ was considered statistically significant.

1. Are you ordinarily or would you be able to chew or bite fresh carrot or celery sticks?
2. Are you ordinarily or would you be able to chew or bite fresh lettuce or spinach?
3. Are you ordinarily or would you be able to chew or bite steaks, chops, or firm meat (eg, beef jerky)?
4. Are you ordinarily or would you be able to chew or bite boiled peas, carrots, or green or yellow beans?
5. Are you ordinarily or would you be able to chew or bite a whole fresh apple without cutting?

Figure 1. Subjective masticatory ability questionnaire.

The changes in the OHQOL score and the subjective chewing ability score were evaluated with 1-way analysis of variance. Bonferroni post hoc analysis was used to analyze the differences between time points.

Results

Demographic Information

Fifty-four of the 63 patients returned for follow-ups. Two teeth were extracted before the 12-month follow-up. One was extracted because of a perforation created during post placement, and the other was extracted because of a vertical root fracture. Because these 2 early failures were excluded from the study, only 52 patients were available for the final analysis.

Demographic information is summarized in Table 1. The final study population included 33 women and 19 men between the ages of 28 and 80 years, with a mean age of 48.6 years. There were 35 mandibular first molars and 17 maxillary first molars. Twenty-two cases were obturated with GP, and 30 cases were obturated with RS.

1. Have you had trouble pronouncing words because of your teeth or mouth?
2. Have you felt that your sense of taste has worsened because of your teeth or mouth?
3. Have you had painful aching in your mouth?
4. Have you found it uncomfortable to eat any foods because of your teeth or mouth?
5. Have you had to alter the temperature of the foods that you eat because of your teeth or mouth?
6. Have you been self-conscious because of your teeth or mouth?
7. Have you felt tense because of your teeth or mouth?
8. Has your diet been unsatisfactory because of your teeth or mouth?
9. Have you had to interrupt meals because of your teeth or mouth?
10. Have you found it difficult to relax because of your teeth or mouth?
11. Have you found it difficult to fall asleep because of your teeth or mouth?
12. Have you ever been awakened by problems with your teeth or mouth?
13. Have you been embarrassed because of your teeth or mouth?
14. Have you been irritable with other people because of your teeth or mouth?
15. Have you had difficulty doing your usual jobs because of problems with your teeth or mouth?
16. Have you felt that life in general was less satisfying because of your teeth or mouth?
17. Have you been totally unable to function because of your teeth or mouth?

Figure 2. Modified quality of life questionnaire.

TABLE 1. Demographic Information of the Study Subjects

Factors	No.
Sex	
Male	19
Female	33
Tooth type	
Maxillary first molar	17
Mandibular first molar	35
Preoperative apical diagnosis	
Normal	7
Symptomatic apical periodontitis	28
Asymptomatic apical periodontitis	12
Chronic apical abscess	5

Treatment Outcome

All teeth received full-coverage crowns; these full-coverage crowns were determined to be adequate based on clinical and radiographic evaluation. Thirty-seven (71.2%) patients showed complete healing at the last follow-up visit. Ten (19.2%) patients remained asymptomatic throughout the follow-up period and showed a reduction in their periapical lesion size; however, lesions that were not completely resolved at the last follow-up visit were considered as "healing." Five (9.6%) patients had a persistent (3) or new (2) periapical lesion. Three were asymptomatic, and 2 reported "occasional discomfort" or "sensation" on the treated tooth. The overall success rate, combining "healed" and "healing" cases, was 90.4%. All teeth remained functional. Examples of cases in each healing category are shown in Figure 3*A–F*.

Prognostic Factors

Healed and successful (a combination of healed and healing) rates are reported in Table 2.

Patient Factors

When patient factors such as age, sex, and tooth location are considered, no statistically significant differences were noted.

Preoperative Diagnosis

Fourteen cases had no preoperative periapical lesion, and 12 (85.7%) remained lesion-free after 2 years and were considered healed; however, new lesions developed in 2 cases. Of the cases with a preoperative lesion, 65.8% (25/38) completely healed by the last follow-up visit, and 92.1% (35/38) of the cases had a reduction in the lesion size and were considered successful. The difference between the 2 diagnostic groups in "healed" and "successful" rates was not statistically significant.

In regard to the preoperative pain level, 24 cases presented with no preoperative pain and were diagnosed as "normal," "asymptomatic apical periodontitis," or "chronic apical abscess"; 60.9% (15/24) of these cases healed completely, and 82.6% (20/24) were considered successful. Of the cases with preoperative pain (symptomatic apical periodontitis), 79.3% (22/28) healed, and 96.5% (27/28) were considered successful. There was no significant difference between the 2 groups.

Obturation Material

Twenty-two cases were obturated with GP, and 30 were obturated with RS. Three failures were noted in the RS group and 2 in the GP

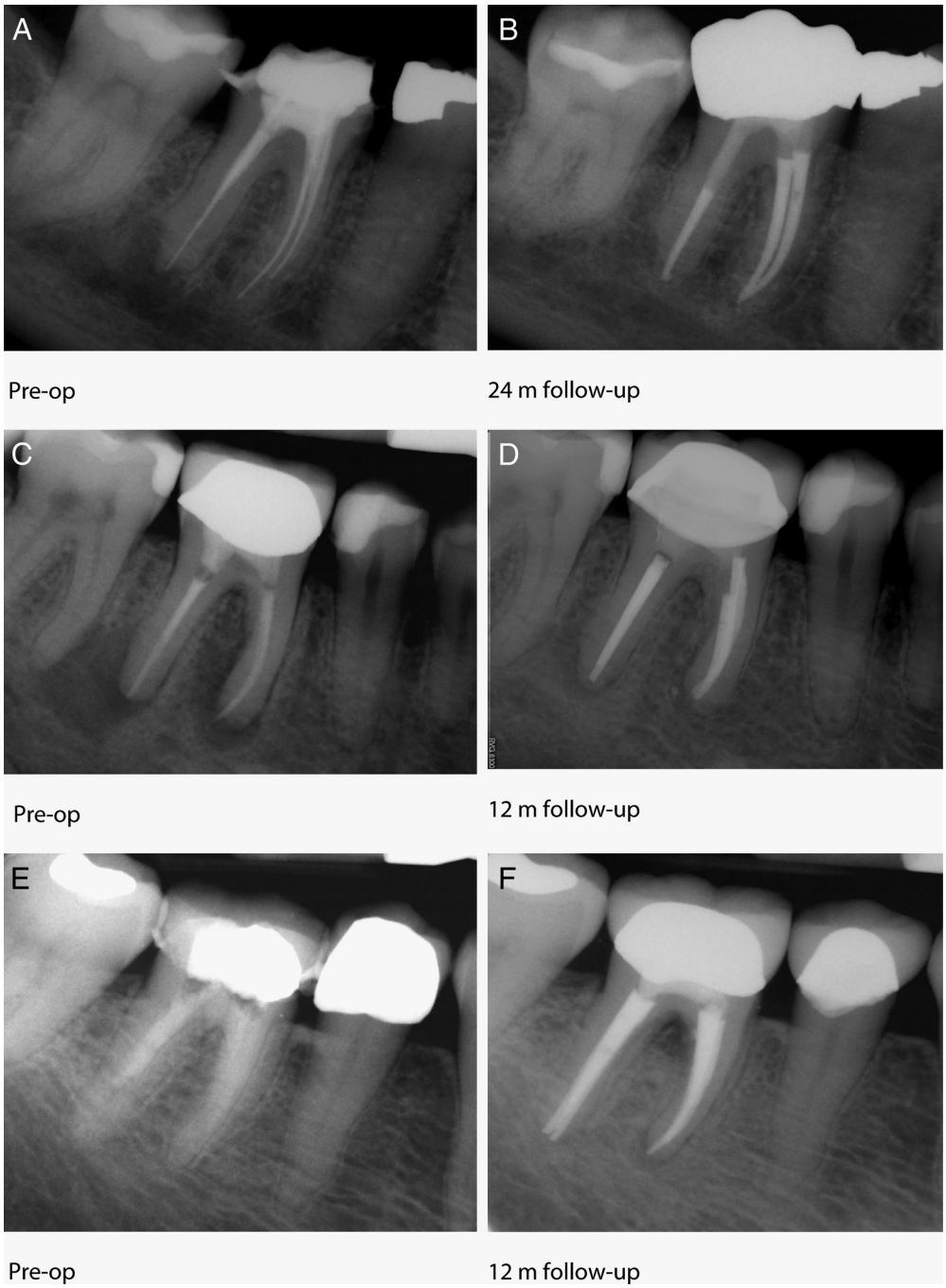

Figure 3. Representative periapical radiographs of (*A* and *B*) healed, (*C* and *D*) healing, and (*E* and *F*) nonhealing cases. (*A*) Preoperative and (*B*) 24-month follow-up showing complete resolution of the periapical radiolucency; case was considered "healed." (*C*) Preoperative and (*D*) 12-month follow-up showing reduced periapical radiolucency; case was considered "healing." (*E*) Preoperative and (*F*) 12-month follow-up showing new periapical radiolucency developed around the M root; case was considered "nonhealing."

group, resulting in a success rate of 90.0% and 90.9%, respectively. Nineteen of 30 (63.3%) in the RS group and 18 of 22 (81.8%) in the GP group showed complete healing.

OHQOL and Chewing Ability

Both OHQOL and subjective chewing ability significantly improved over time ($P < .05$). A lower OHQOL score indicates better quality of life, whereas a higher chewing ability score indicates better perceived chewing function. The biggest improvement for both measurements occurred within the first week (Table 3 and Fig. 4*A* and *B*). Both scores continued to improve at a slower pace after 1 week over the 2-year period.

Discussion

Nonsurgical root canal retreatment is indicated when the initial root canal treatment fails. Failure of the initial treatment is often manifested by symptoms experienced by the patient and/or a persistent periapical lesion detected by the dentist. The cause of failure is often

TABLE 2. Treatment Outcome by Patient, Preoperative, and Treatment Factors

Factors	No. of successful cases	Success rate (%)	*P* value	No. of healed cases	Healed rate (%)	*P* value
Sex			.3419			.3589
Male	16/19	84.2		12/19	63.1	
Female	31/33	93.9		25/33	75.8	
Age			1.000			.7325
<60	35/39	89.7		27/39	69.2	
>60	12/13	92.3		10/13	76.9	
Location of tooth			1.000			.1012
Mandibular	31/35	88.6		22/35	62.9	
Maxillary	16/17	94.1		15/17	88.2	
Presence of lesion			.6024			.3001
No lesion	12/14	85.7		12/14	85.7	
Lesion	35/38	92.1		25/38	65.8	
Size of lesion			1			.7288
<5 mm	14/15	93.3		11/15	73.3	
≥5 mm	21/23	91.3		14/23	60.1	
Preoperative pain			.1686			.2337
No pain	20/24	82.6		15/24	60.9	
Pain	27/28	96.5		22/28	79.3	
Obturation material			1			.2172
Gutta-percha	20/22	90.9		18/22	81.8	
Resilon	27/30	90.0		19/30	63.3	

multifactorial and has been extensively reviewed. It is widely accepted that the presence of intraradicular or extraradicular infection is the most common cause of failed cases (24). Unresolved infections are often associated with incomplete cleaning during the initial treatment or coronal leakage. Other possible causes of persistent apical periodontitis include foreign body reaction, true cyst, vertical root fracture, and so on (25, 26). Bacteria recovered from previously treated cases are more dominated by gram-positive facultative anaerobes and often include *Enterococcus faecalis* and *Actinomyces* species, which show greater resistance to common root canal medicaments (27, 28).

There are several challenges faced during retreatment including the removal of the previous obturation material, correcting procedural errors generated during the initial treatment, locating missed canals, and eliminating potential therapy-resistant bacteria. The prognosis is generally reduced in retreatment compared with initial treatment because of these challenges. The most recent systematic review on retreatment outcomes reports a pooled weighted success rate of 76.7% assessed by complete healing and 77.2% assessed by incomplete healing (9). A majority of the studies included in the meta-analysis are retrospective and were conducted before many of the modern endodontic techniques became available. Therefore, the current study was performed to determine whether the latest technical advances have any impact on treatment outcome.

The success rate of 90.4% reported in the present study is consistent with and slightly higher than the 85.6% success rate reported by Ng et al (7) using similar criteria. The study by Ng et al had a large sample size of 750 teeth or 1314 roots with at least a 2-year follow-up. There are several main differences between these studies in addition to the sample size. One of these differences is the unit of evaluation; the present study used the tooth as the unit, whereas the study by Ng et al used the root. The success rate is expected to be higher if the root was used as the unit of evaluation because all teeth included in the current study are multirooted. Another difference is the protocol for retreatment. In the present study, a semistandardized contemporary treatment protocol was followed that represents the current standards in endodontic therapy including the use of surgical microscopes, rotary instrumentation, the use of ultrasonic instruments, and ultrasonic irrigation. There appears

TABLE 3. Oral Health–related Quality of Life (OHQOL) Score and Chewing Ability Score at Each Time Point

Time of follow-up	OHQOL score (mean ± standard error)	Chewing ability score (mean ± standard error)
At entry	30.8 ± 1.5	22.9 ± 0.9
1 week	24.0 ± 1.1	25.3 ± 0.6
1 month	22.1 ± 0.9	27.0 ± 3.7
6 months	21.0 ± 0.8	28.0 ± 0.4
12 months	20.7 ± 0.9	27.8 ± 0.5
24 months	19.8 ± 0.6	28.6 ± 0.4

A lower OHQOL score indicates better quality of life, whereas a higher chewing ability score indicates better perceived chewing function.

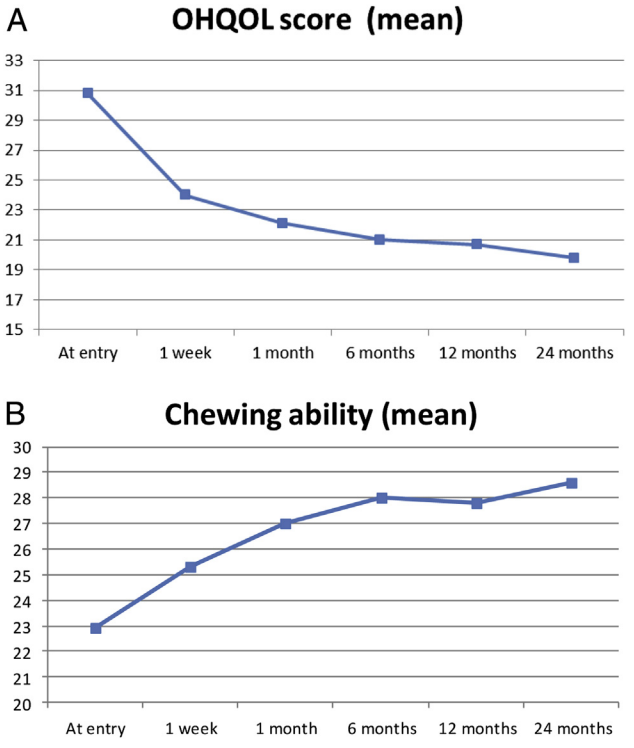

Figure 4. Changes in (*A*) OHQOL score and (*B*) chewing ability score over time. A lower score in OHQOL represents better quality of time; a higher score in chewing ability represents better chewing ability.

to be a wider range of variations in the techniques used in the Ng study with a smaller apical preparation size and a greater number of visits; the use of magnification and ultrasonics was not specified. Whether technical advancement has any effects on treatment outcome or tooth survival is not clear. One recent study compared tooth survival using classic versus contemporary treatment techniques and showed no significant difference between these 2 groups (29). It is difficult to contribute the small difference in success rate to 1 specific factor, such as the treatment protocol and/or modern techniques. Future cohort studies or randomized controlled trials with sufficient sample sizes will be necessary to draw any definitive conclusion on the effects of different techniques on treatment outcome.

The current study included only first molars for analysis, whereas other studies typically include all tooth types. Tooth type has been identified as a factor that can potentially affect treatment outcome (30). We elected to include only first molars in this current study to eliminate the potential variations introduced by including multiple tooth types. First molars are the most common teeth to be affected by caries and become endodontically involved (31). They are also the most important teeth to carry out chewing function (32).

We examined several patient factors such as age and sex; preoperative factors including presence of pain, preoperative lesion, and size of lesion; and treatment factors such as obturation material. Several factors were found to be associated with a nearly 20% difference in the "healed" rate. These factors include tooth location (maxillary vs mandibular), presence of lesion, presence of preoperative pain, and obturation materials. These findings are in agreement with the majority of the literature on endodontic outcomes (5, 7, 30). However, these differences were not statistically significant, likely because of the small sample size, which limited the statistical power of the study.

Efforts were made to minimize the number of variables by including only the first molars and healthy patients and using semistandardized treatment protocols. Despite the limited number of cases included, the results from this preliminary study provide a meaningful and relevant estimated success rate for modern root canal retreatment, and the percentage of "successful" and "healed" cases can be useful in designing future clinical trials with a more accurate power analysis.

Another limitation of this study was the choice of obturation materials. At the time the study was designed, RS was emerging as a promising new obturation material with similar or superior physical and chemical characteristics compared with GP. One clinical study showed that teeth obturated with RS have a similar success rate to those obturated with GP (33). Including a second obturation material added another potential variable that may have influenced the outcome of treatment. Although the results show no significant difference in the "success" rate between the 2 materials, the "healed" rate was approximately 20% lower in the RS group than in the GP group. In addition, both of the cases that developed new lesions after treatment were obturated with RS. Further studies are necessary to provide more conclusive evidence on whether obturation with RS leads to a different clinical outcome compared with GP.

One of the recent advances in endodontics not used in this study was cone-beam computed tomographic (CBCT) imaging. It has been proposed that CBCT imaging should be examined before any retreatment to identify missed canals (34). CBCT scanning has also been shown to detect significantly more periapical lesions. A recent prospective study reported a 93% success rate of retreatment when the outcome was assessed by periapical radiographs and a 77% success rate when assessed by CBCT imaging (15). Although the impact of preoperative CBCT scanning on treatment outcome remains to be determined, the success rate of retreatment in this study would likely have been lower if CBCT imaging had been used to evaluate the outcome.

Mastication is 1 of the primary functions served by the dentition, especially the posterior teeth. The ability to chew has a significant impact on general health and quality of life. The modified OHQOL questionnaire uses 17 questions that are designed to gather information on functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. This questionnaire has been shown to be a valid and sensitive measure for endodontic treatment (22, 35). Additionally, a subjective chewing ability questionnaire was used to further explore the impact of treatment on patients' perceived chewing function. Both OHQOL and subjective chewing function scores showed a significant improvement over time, especially within the first week of treatment completion. These findings suggest that endodontic retreatment allows patients to quickly regain chewing function and restore quality of life.

In conclusion, endodontic retreatment using contemporary techniques significantly improved patients' quality of life and chewing ability and achieved a relatively high success rate (90.4%). This information will be beneficial in designing future larger-scale studies to determine the impact of various treatment factors on outcome.

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The authors deny any conflicts of interest related to this study.

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