2022

Outcome of Endodontic Microsurgery: Success and Survival Rates at Virginia Commonwealth University

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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May, 2022

Acknowledgements

I would like to thank everyone for taking the time to help me in this project. Special thanks to my wife, Sarah, for her wonderful contribution and support throughout the process. I would like to thank Dr. Myers and Dr. Jadhav for their guidance and insight with this thesis, as well as Dr. Carrico for all her help with the statistical aspects of the project.

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Abstract

OUTCOME OF ENDODONTIC MICROSURGERY: SUCCESS AND SURVIVAL RATES AT VIRGINIA COMMONWEALTH UNIVERSITY

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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Introduction: Endodontic microsurgery treatment is an option for teeth with apical periodontitis and may be indicated for teeth with previous endodontic treatment that have not healed, teeth with canal obstructions which would impede a non-surgical approach, and where a biopsy is needed. The purpose of this study is to evaluate healing after endodontic microsurgery in 2-dimensional PA radiographs and 3 dimensional CBCT imaging. **Methods:** Patient records were pooled from graduate resident cases completed at Virginia Commonwealth University in the Graduate Endodontic Clinic between the years 2010 to 2020. Cases were identified using the CDT codes and a key word search within the patient record data base. Eighty-Four teeth were identified and met the criteria with a minimum follow up of 6 months. All patients had a PA radiograph and CBCT imaging before the procedure and PA radiograph immediately after the surgery. Of those

84 teeth, 24 cases had a CBCT imaging with a minimum of 6 month after the procedure. Outcome types were divided into three categories, healed, healing and non-healed, based on radiographic evaluation by the examiners. **Result:** The overall success rate was 90% for both periapical (PA) evaluation and CBCT evaluation. **Conclusion:** Endodontic microsurgery is an effective and a predictable procedure with a successful outcome when used in appropriate cases. Multiple factors improve the success such as using high-power magnification and ultrasonics, a smaller osteotomy, and using biocompatible materials.

Introduction

Endodontic microsurgery is a treatment option for teeth with apical periodontitis and may be indicated for teeth with previous endodontic treatment that have not healed, teeth with canal obstructions which would impede a non-surgical approach, and where a biopsy is needed(1). Apical periodontitis is an inflammatory mediated disease that is associated with the root end of the teeth. Healing of apical periodontitis can be achieved by non-surgical root canal therapy, non-surgical retreatment, apical surgery or extraction. The goal of endodontic therapy is to eliminate or prevent this inflammation. Non-surgical root canal therapy is often the first treatment option for teeth with apical periodontitis. Existing periapical pathosis had the strongest effect on treatment outcomes(2). The success rate of endodontically treated teeth without an apical radiolucency is 92%. However, teeth with an apical radiolucency have a lower success rate at 72%(3). In cases with persistent apical periodontitis, non-surgical retreatment is considered the first option when the root filling is the cause of failure, or the canals are accessible and negotiable. However, endodontic surgery is an option when the lesion did not heal after initial therapy or retreatment. It is also a valid treatment option in situations with persistent intracanal infection after iatrogenic changes occured to the original canal anatomy. Complex canal anatomy might affect the success rate of the non-surgical root canal treatment and in this case the surgical approach might be the treatment of choice(4). The surgical intervention aims to remove the infected root-end and soft tissue pathology and seal any remaining bacteria in the root canal system from the periradicular tissues. Using modern techniques such as high power magnification, ultrasonic root-end cavity preparations, and the use of biocompatible root-end filling materials for the root end surgery have demonstrated favorable outcomes, with a success rate of approximately 90%(5)(6). Traditional surgical endodontic treatment was performed by root-end resections with a 45 degree bevel, retrograde preparation of the canal with burs and placement of root-end fillings(7). Amalgam and IRM were used widely. However, the treatment in the modern technique was performed with the aid of a microscope. It consisted of local anesthesia, flap, osteotomy with a high-speed bur, root-end resection of 2 to 3mm with minimal or no bevel, retrograde cavities prepared using ultrasonics and placement of retrograde fillings with MTA or RRM(4)(8). An updated meta-analysis study showed that the surgical endodontic treatment performed by the modern technique had a success rate close to 90%(6). The advantages of microsurgery over traditional apical surgery included easier identification of root apices, smaller osteotomies and shallower resection angles that conserved cortical bone and root length. In addition, a resected root surface under high magnification and illumination readily reveals anatomical details such as isthmuses, canal fins, microfractures, and lateral canals. Combined with the microscope, the ultrasonic instrument permits conservative, coaxial root-end preparations and precise root-end fillings that satisfy the requirements for mechanical and biological principles of endodontic surgery(4). It has been reported that the success rate of modern endodontic surgery is significantly higher than the traditional root end surgery technique(9). Setzer et al. had a meta-analysis study that compared the outcome of both of these techniques. Twenty-one articles were included in this study. They found that the success rate for traditional root end surgery was 59%. However, the success was higher in the endodontic microsurgery group and it was 94%. They concluded that, with the modern technique, high success rates can be achieved in periapical surgery(9). Mineral trioxide aggregate

(MTA) and Bioceramic Root Repair Material (RRM) are now widely used as a root-end filling material.

The endodontic surgery protocol involves administration of local anesthesia, flap reflection, removal all granulomatous tissue and bone to reach the root apices, resection of the root apices, retro-preparation of the root canal space, placing the root end filling material and flap closure with sutures(4). Many root end filling materials have been used. Amalgam and IRM were used widely in the traditional technique. However, Bioceramic materials such as MTA and RRM are the materials of choice in the modern endodontic surgeries. Zinc oxide cement reinforced with ethoxy benzoic acid (super-EBA) was used during the early stage of the modern technique before MTA was introduced. An ideal root end filling material should be biocompatible, have high mechanical strength, a short setting time, high radiopacity, be dimensionally stable, be bactericidal, or bacteriostatic; be easy to handle; and provide an excellent seal(10).

Traditionally, amalgam was the material of choice for many years. It was inexpensive, easily available, easy to handle, had a radiopaque appearance on the radiographs, and was previously thought to have a reasonable outcome(10)(11). However, studies have shown that amalgam also had many disadvantages. Corrosion and dimensional changes were two of these disadvantages. It has been reported that electrochemical corrosion is responsible for failure of amalgam in root end fillings. Also, amalgam might cause tissue discoloration (amalgam tattoo). Several studies have reported unfavorable tissue responses to amalgam which were associated with inflammation. Another disadvantage of amalgam was leakage when used as a root end filling material. It did not provide an effective seal. Finally, amalgam had poor outcomes when used in endodontic surgery(10)(11)(12)(13). Due to these disadvantages, IRM and super EBA were introduced to use as root end filling materials. They were biocompatible. Studies demonstrated that both materials allowed significantly less leakage compared to amalgam(10)(11). Although the clinical outcomes of super EBA and IRM were higher than amalgam, they also had some disadvantages such as, moisture sensitivity, irritation of vital tissue, solubility, and difficult handling of the material(10)(12). Today, MTA and Endosequence root repair material (RRM) are the materials of choice for endodontic microsurgery. In the mid-1990s, MTA was introduced as a root end filling material in endodontics(14). It has hydrophilic particles which allow the material to set in a wet environment(10). Several studies demonstrated that MTA leaked less and adapted to the root end cavity wall better than the earlier retrofilling materials(15). Also, the presence of blood had no effect on the sealing ability of MTA(12). It also had antibacterial activity(16). When using MTA as a root end filling material, it helps with inducing a new layer of cementum adjacent to it(17). Because of these characteristics, MTA was not only used as a root end filling material, but also for repairing perforations, vital pulp therapy and cases with open apices. Von Arx et al. did a long-term study of teeth treated with apical surgery and a root end filling with MTA. They found the success rate using MTA to be 81.5% after 10 years. However, MTA does have a few disadvantages. One of them was the discoloration to the surrounding tooth structure. Also it has a granular consistency which makes it hard to handle and it has a long setting time(14). Hachmeister at el. evaluated MTA material in a leakage study. One group had MTA as a root end filling material and the other used MTA as an apical plug. They concluded that the leakage was related to the delivery technique, not the material itself(18). Endosequence root repair material (RRM) has been introduced to the field of endodontics to overcome some of the MTA limitations. It is a Bioceramic and biocompatible material. One difference between MTA and RRM is that the RRM is premixed and ready to use from a syringe. Several studies have shown that RRM and MTA are similar in characteristics(19)(20). Chen et al. evaluated RRM and MTA in a dog model study(21). They examined healing after apical surgery. In periapical radiographs, RRM and MTA showed similar healing. However, on CBCT and micro-computed tomographic images, RRM showed superior healing at the resected root surface. A prospective randomized clinical study evaluating MTA and EndoSequence RRM in endodontic microsurgery showed no significant difference in outcome. The RRM group showed 92% and 84% success rates on PA and CBCT imaging, respectively. The MTA group exhibited 94.7% and 86% success rates on PA and CBCT imaging, respectively(8).

There are many factors that are associated with the outcome of endodontic surgery. The pre-operative size of the periapical lesion is one of these factors. Some studies have shown improved outcomes with surgery with smaller lesions(22)(23). On the other hand, other studies reported no correlation between the outcome of the surgery and the size of the lesion(24). Another factor that might affect surgical outcomes is the root end filling material used(25)(26)(27). Not only the material but also the depth of the root-end filling material might affect the outcome. A minimum depth of 2.5mm is required for both MTA and RRM to provide good apical seal. Teeth with an apical root fracture have a poor prognosis. Another factor that might affect the outcome is the pre-operative symptoms. Patients with existing symptoms before a procedure have a lower healing rate when compared with asymptomatic patients(22). The root canal filling quality is another significant preoperative prognostic factor. Teeth with a poor quality root canal filling have a 9 times greater chance of failure compared to teeth obturated with a good quality filling(8). Antibiotic therapy before a procedure was found to have no influence on the healing rate. Von Arx et al. found that there was no statistically significant difference between patients treated with antibiotics before surgery (80%) and patients treated without it (89%). Also, they found no relation between the gender and age of the patients with outcomes. Moreover, the healing rate was not affected by smoking. Both smoking and non-smoking groups showed similar healing rates. They also found that first time surgical procedures had a higher success rate than re-surgery. They concluded that case selection should be considered in periapical surgery in order to have a successful treatment (22).

Periapical radiography (PA) has been the standard method of imaging for endodontic diagnosis and evaluation and the most commonly used method for evaluation of healing. It is a two-dimensional radiograph that can determine the mesial-distal dimension. This technology has many limitations. The Buccal-Lingual dimension cannot be evaluated. Also, a periapical lesion might not be detectable until 40% of the cortical bone is demineralized or 7.1% of mineral bone loss has occurred(28). Sometimes, lesions within cancellous bone alone can't be detected on the PA radiograph. Moreover, bone destruction might not show when defects are superimposed by roots or any other anatomical structure. With these limitations, making an accurate interpretation of the presence of a lesion or the size of lesion might be challenging. The use of Cone-beam computed tomography (CBCT) provides an accurate 3-dimensional image of the teeth and surrounding tissues. CBCT scans are categorized into large, medium, and limited volume based on the size of the field of the view. In Endodontics, the limited field of view is preferrable since we can capture the area of interest and the surrounding structures and there is less radiation dose(29). Also, the smaller the volume the higher the resolution of the image. CBCT can show anatomical features that PA's, panoramic and cephalometric images cannot. It shows the area of interest in three different planes (sagittal, axial and coronal). This technology helps the dentist to visualize complex anatomy around the teeth such as the maxillary sinus and the mandibular canal. It also helps with identifying all the root canals in the tooth. In endodontic microsurgery, CBCT is used to identify the size of the lesion and evaluate the surrounding anatomy. It helps to evaluate the bone status around the defect to see if there is any perforation through the cortical bone. In the joint position statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology regarding the use of CBCT, they had fourteen recommendations when the PA and/or CBCT should be taken. One of them was to consider taking CBCT before surgery in order to have a better assessment of the area of interest. There are multiple indications for CBCT in endodontics other than pretreatment surgical planning. These include patients with non-specific signs and symptoms, teeth with potential extra canals, intra-appointment use in cases with calcified canals, teeth with suspected vertical root fractures, non-healing of previous endodontic treatment, management of trauma, and to differentiate between external and internal root resorption(21). However, as with any technology, CBCT has some disadvantages and limitations which include higher radiation doses to patients compared with other dental images. Artifacts from existing restorations or metal subjects around the area of interest might affect the quality of the scan(30).

There are many studies comparing PA’s and CBCT in detecting periapical radiolucencies and influencing treatment plans. Estrela et al. compared these two techniques in their ability to detect lesions. They had one thousand fourteen images that were evaluated by three observers. Apical radiolucencies were seen in 40% of cases with PA’s. However, CBCT was more accurate in detecting apical radiolucencies in 60% of the cases having such findings(31). CBCT is more sensitive in detecting apical lesions than PA’s. Patel et al. had a 2-part study. In part 1, they compared the prevalence of periapical lesions with PA and CBCT while in part 2, they looked at the radiographic outcome after 1 year. They had 151 teeth that were diagnosed with endodontic diseases. Periapical lesions were detected in 20% of the teeth with PA’s. However, CBCT detected lesion in 48% of the cases(32). After one year of completing the root canal treatment, they evaluated the teeth again. In PA’s, the healed rate was 92% and it was 73% for CBCT. The healing rate was 97% and 89% for PA’s and CBCT respectively. They concluded that a lower healing rate was seen with CBCT compared to PA’s(33). In another study by Ee et al., they looked at the treatment planning decisions made using CBCT versus PA. They had thirty endodontically treated teeth with three endodontists that reviewed the PA first and then CBCT two weeks later. They found that the treatment plan was modified in approximately 62% of the cases after getting more information from the CBCT(34).

The purpose of this retrospective chart review study was to evaluate success and survival rates of EMS at Virginia Commonwealth University by evaluating the radiographic outcomes from an endodontist and an oral radiologist point of view. Previous studies have shown that patient and tooth related factors might affect the outcome of the surgery. We also analyzed the relationship between some of these potential prognostic factors and the outcome of EMS.

Methods

Patient records for this study were pooled from resident cases completed at Virginia Commonwealth University (VCU) in the Graduate Endodontic clinic after approval from the Institutional Review Board at the university (HM20018897). Cases were selected from January 1, 2010 through December 31, 2020. In order to identify cases, a search of the VCU School of Dentistry's patient charting software, AxiUm CE (LEADTOOLS Technologies, ©2017) was performed using the CDT codes established by the American Dental Association (ADA) and the American Association of Endodontists (AAE) for apical surgery procedures – D3400, D3410, D3421, and D3425. Additionally, a key word search was performed for the following terms within chart notes of the prescribed time period: apical surgery, microsurgery, apicoectomy, and root end surgery.

The inclusion criteria were as follows:

- Age 18 years and older consenting to the surgical procedure.
- Noncontributory medical history (American Society of Anesthesiologists class I and II)
- A true endodontic lesion.
- Radiographs documenting pretreatment and follow-up of acceptable diagnostic quality.
- A recall radiograph of at least 6 months after the procedure.

The exclusion criteria were defined as follows:

- Nonconsenting patients and patients younger than 18 years of age
- Medical history with American Society of Anesthesiologists class III to V
- Insufficient coronal restoration
- Non-restorable or traumatized teeth
- Radiographic presence of nonapical root resorption
- Resurgery
- Vertical root fracture

After selecting the cases that met the inclusion criteria, the corresponding PA's and CBCT images were de-identified prior to evaluations. Data on tooth type, retro-fill material, prior surgical treatment were collected. All EMS procedures were performed by postgraduate residents under the supervision of endodontic faculty. For the purpose of the study, outcome types were divided into three categories based on radiographic data on follow-up visits. Each case was assigned to one of the following groups:

1. Healed: Normal periodontal ligament space. The absence of periapical radiolucency.
2. Healing: reduction in size of pre-operative periapical radiolucency.
3. Non-healed: a periapical radiolucency that has remained the same or has increased in size; or development of a radiolucency in cases for which no radiolucency was present in the immediate pre-treatment radiograph.

Three board certified specialists (two Endodontists and one Oral and Maxillofacial Radiologist) were calibrated to understand radiographic outcome determinants and asked to place each case into one of the three categories using a PowerPoint. Evaluators graded radiographic healing only, without knowledge of patient symptoms or the recall period. Once these evaluations were completed, the results were analyzed by a statistician.

Statistical Methods

All data was gathered via chart review from the axiUm CE (LEADTOOLS Technologies, ©2017) program, with all data placed into an Excel spreadsheet. Data was described using counts and percentages. Association between success rate and patient characteristics (tooth type, patient sex, filling material) were assessed using chi-squared tests.

Results

A total of 84 PA radiographs were assessed by 3 independent raters. From the total number, 24 cases had pre- and post-op CBCT images available in addition to the PA's which were also scored by the same 3 raters and classified as healed, healing, or failed cases. Figure 1 shows examples of healed, healing, and non-healed cases. There were 42 anterior teeth, 21 premolar teeth and 21 molar teeth. The follow-up period for the cases evaluated ranged from 6 months to 9 years. Sixty-two teeth were treated with BC-RRM as a root end filling material and 21 teeth were treated with MTA. In one of the teeth, the root was resected but wasn't retro-prepared nor filled with any material. The overall success rate of endodontic microsurgery based on the PA's was 90% (ranged between 84% and 96% among the raters) (Table 1). The survival rate in this study was 97.6%.

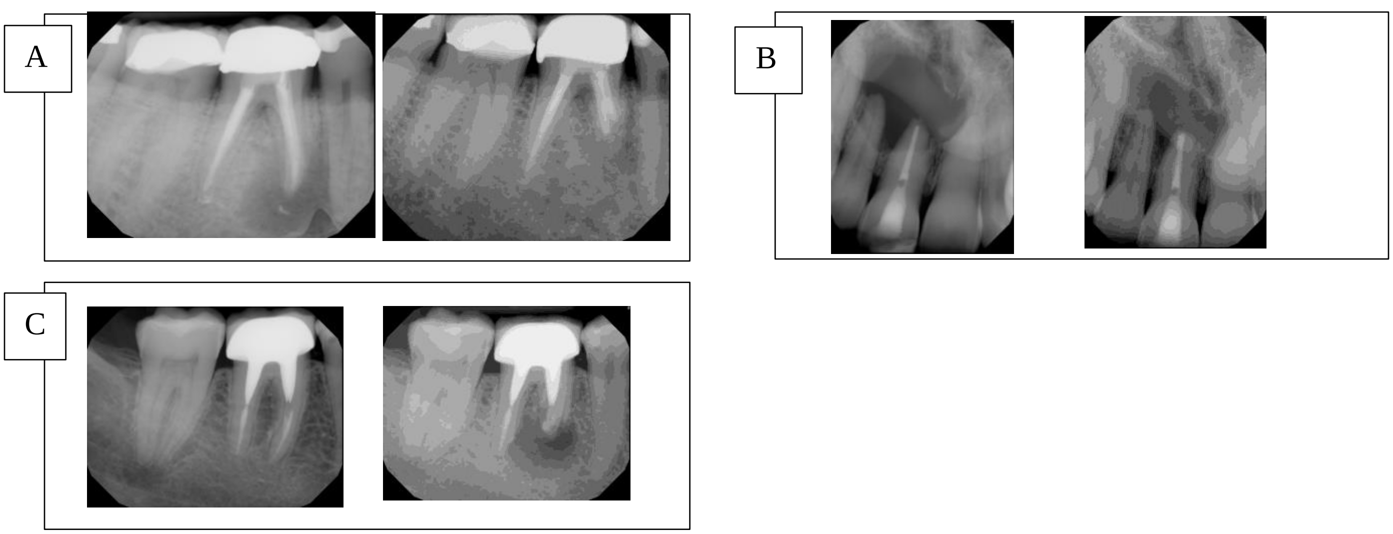

Figure 1:Representative periapical radiographs of cases in each outcome. (A) example showing healed. (B) example showing healing. (C) example showing non-healed

Table 1: Treatment outcome

	Endodontist 1 (GM)		**Radiologist (AJ)**		**Endodontist 2 (SA)**		**Overall**	
	PA	**CBCT**	**PA**	**CBCT**	**PA**	**CBCT**	**PA**	**CBCT**
Healed	53, 63%	14, 58%	63, 75%	16, 67%	54, 64%	16, 67%	67%	64%
Healing	18, 21%	6, 25%	18, 21%	7, 29%	22, 26%	6, 25%	23%	26%
Failed	13, 15%	4, 17%	3, 4%	1, 4%	8, 10%	2, 8%	10%	10%

The 24 cases that had a pre and follow-up CBCT were assessed to be successful in 90% of the time when averaged between the 3 raters (Table 2). Based on the material used, the success rate of EMS using pro-root MTA or BC-RRM was similar and equal to 90% (75/84 teeth). Based on the type of the tooth that underwent EMS, the success varied. Anterior and premolar teeth were successful 89% of the time, whereas molars were successful 93% of the time. With regards to patient's sex, males (32 teeth) had a success rate of 88.6% and females (52 teeth) had a slightly higher success rate, which was 91% (table 3). PA success rate was not statistically significantly associated with tooth type (anterior, premolar, molar), patient's sex, or the retro-fil material (pro-root MTA or BC-RRM). For one rater (Endodontist), there was a marginal association between patient's gender and success rate with a 75% success rate for males and 90% for females. Ratings from the other two raters did not demonstrate this trend (100% vs 94% and 91% vs 90%).

Table 2: Outcome for cases with postoperative PA and CBCT

	Endodontist 1 (GM)		Radiologist (AJ)		Endodontist 2 (SA)	
	PA	**CBCT**	**PA**	**CBCT**	**PA**	**CBCT**
Healed	18, 75%	14, 58%	22, 92%	16, 67%	18, 75%	16, 67%
Healing	5, 21%	6, 25%	2, 8%	7, 29%	4, 17%	6, 25%
Failed	1, 4%	4, 17%	0, 0%	1, 4%	2, 8%	2, 8%

Table 3: Treatment outcome by patients and predictive factors

	Endodontist 1 (GM)		Radiologist (AJ)		Endodontist 2 (SA)	
	Success (n, %)	**P-value**	**Success (n, %)**	**P-value**	**Success (n, %)**	**P-value**
Tooth Type		0.7903		0.8056		0.5676
Anterior	35, 83%		40, 95%		38, 90%	
Premolar	17, 81%		21, 100%		18, 86%	
Molar	19, 90%		20, 95%		20, 95%	
Patient Sex		0.0700		0.2840		0.5775
Male	24, 75%		32, 100%		29, 91%	
Female	47, 90%		49, 94%		47, 90%	
Filling Material		0.5775		>0.999		0.4467
BC Putty	51, 82%		60, 97%		57, 92%	
MTA	19, 90%		20, 95%		18, 86%	
No	1, 100%		1, 100%		1, 100%	

Inter-rater reliability was assessed for the 3 pairs of raters for both the radiographs and CBCTs (Table 4). For the PA, the agreement ranged from 0.37 to 0.66. For the CBCT, the agreement ranged from 0.22 to 0.57. For the cases with both PA and CBCT, the agreement was compared for each rater (Table 5). The agreement in the scores were low and ranged from 0.20 to 0.59.

Table 4: Interrater Reliability for Pairs of Raters

Raters	PA (n=84)	CBCT (n=24)
Endodontist 1: Radiologist 1 (GM:AJ)	0.37 (0.08)	0.22 (0.17)
Endodontist 1: Endodontist 2 (GM:SA)	0.66 (0.07)	0.45 (0.17)
Radiologist 1: Endodontist 2 (AJ:SA)	0.48 (0.09)	0.57 (0.17)

Table 5: Agreement between PA and CBCT Rating by Evaluator

	Kappa (PA vs CBCT)	**95% CI**	**Interpretation**
Endodontist 1 (GM)	0.586	0.30-0.87	Weak
Radiologist 1 (AJ)	0.200	-0.08-0.48	None
Endodontist 2 (SA)	0.354	0.00-0.71	Minimal

Discussion

In endodontics, EMS is considered to be a predictable procedure with a high success rate. The purpose of this retrospective study was to evaluate radiographic healing after EMS. Setzer et al, on his meta-analysis study show that EMS had a success rate above 90%(9). Different factors might have an effect on the success rate; in this study, we compared the root end filling material, patient gender and the location of the tooth. The teeth that were included in this study had a follow-up period of at least 6 months and extended up to 7 years. The overall success rate was 90% for PA and CBCT groups. When healing was evaluated with PA radiograph or CBCT, the outcome was not significantly different between the two root-end filling materials (MTA and RRM). The overall success rates for the MTA and RRM on PA's and CBCT was similar and equal to 90%. This finding was similar to other previous studies (8). In contrast to Chen et al, who actually reported a higher healing rate with RRM compared with MTA when CBCT and micro-computed tomography were evaluated in animals (21). The survival rate in our study was 97.6%. Only two teeth out of the 84 teeth included in the study were extracted.

From the total of 84 cases, the overall success rate for EMS based on the PA evaluation was 90% regardless of the type of material used (RRM or MTA). When classified into (healed, healing, non-healed) the percentages were (67%, 23%, 10%) respectively. When looking at the PA's, the OMF radiologist scored the highest success rate which was 96% (75% healed, 21% healing, 4% non-healed). The healed, healing and non-healed rate for Endodontist 1 were (63%, 21%, 15%). The healed, healing and non-healed rate for Endodontist 2 were (64%, 26%, 10%)

respectively. The results suggest that based on 2-D imaging, the OMS radiologist was more likely to classify the cases as completely healed than the endodontists (table 1).

Twenty-four cases had pre and post-op CBCT scans in addition to the PA radiographs, the overall success of these cases was 96% for PA's and 90% for CBCT. It is expected to have a higher success rate when looking at PA's, since 3-dimensional imaging are more sensitive in detecting apical periodontitis and small changes in the periodontal ligament (33). Eighty percent of the cases were classified as healed based on the PA's and 15% were classified as healing on the same imaging modality. On the other hand, 64% of the teeth underwent EMS were classified as completely healed based on the CBCT imaging and 80% were considered completely healed on the PA's. The results showed a 16% decrease in healed rate when CBCT imaging were evaluated in comparison to PA's. In a previous study done by Safi et al, they found a somewhat higher discrepancy in the range of 25%. Completely healed teeth on CBCT imaging was 50% compared with 74% on PA radiography(8). The OMF radiologist and one of the endodontists had the same healed rate when looking at CBCT images (67%), the other endodontist had a healed rate of 58% looking at CBCTs. However, the healing rate when looking at CBCTs of the teeth that underwent EMS was 29% for the OMF radiologist compared to 25% for both endodontists. This result suggests a higher healing rate on CBCT images when the radiologist was the one to evaluate (Table 2).

Regarding healing rates, it was evaluated to be 26% based on the CBCT and 15% based on PA's, which was the opposite to what was found on previous studies. Only a few studies have compared healing after EMS on PA's versus CBCT, the results of these studies suggest lower healing for CBCT imaging than 2D imaging(35). Von Arx et al found almost one third of the cases had less healing on CBCT imaging than PA's at the 1 year follow-up.

Based on the type of the tooth that underwent EMS, the success rate varied. In our study, anterior and premolar teeth were successful in 89% of the time, whereas molars were successful in 93% of the time, so molar surgery had a slightly higher success rate (Table 3). Different studies have shown different results regarding the association between the tooth type and success rate. In the 10-year follow-up study of 119 teeth treated with apical surgery and root-end filling with MTA done by von Arx et al, the overall success was 91.6% after 1 and 5 years. In that study, maxillary molars had a significantly higher success rate of healed cases compared with maxillary premolars (95.2% and 66.7% respectively) (36).

With regards to patient's sex, males had an overall success rate of 88.6% and females had a slightly higher success rate, which was 91%. Success rate was not statistically different when associated with tooth type (anterior, premolar, molar), patient's sex, or the retro-fil material (pro-root MTA or BC-RRM). For one rater (Endodontist), there was a marginal association between patient's gender and success rate with a 75% success rate for males and 90% for females. Ratings from the other two raters did not demonstrate this trend (100% vs 94% and 91% vs 90%). Table 2 shows the outcome with regards to the predictive factors. Previous studies done on the same topic did not find any association between patient gender and EMS success rate (37).

In one of the anterior teeth cases where a scar tissue appeared to be evident around the root apex in the 6-year follow-up PA radiograph, both endodontists considered it healed, whereas the OMF radiologist classified it as Healing. Figure 2 shows the tooth with the scar tissue after healing. In the classic study done by Molven et al on the incomplete healing (scar tissue) after periapical surgery- Radiographic findings 8 to 12 years after treatment, they concluded that surgical cases showing features of scar tissue at the follow-up can be regarded as success; they will either heal completely or remain in the scar tissue group (38).

Figure 2: scar tissue after EMS

Limitations of the present study include sample size especially for the teeth with CBCT. Although CBCT was taken pre-operatively for all cases to help with surgical treatment plan, it was not taken routinely for evaluation of healing. Another limitation of this study was the format of the radiographs. All images were in a digital formal (Jpeg). An accurate way will be using a digital image software with enhancing tools.

Conclusion

Endodontic microsurgery is an effective and a predictable procedure with a successful outcome when used in appropriate cases. Multiple factors improve the success such as using high-power magnification and ultrasonics, a smaller osteotomy, and using biocompatible materials. In this retrospective study, the success rate was 90% for both PA and CBCT groups. 97.6% were asymptomatic and considered functional. Both MTA and BC RRM were equally effective when using as a root end filling material.

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