Review Article

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Endodontic Microsurgery: An era of sophistication

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ABSTRACT

Background: Endodontic surgery has now evolved into endodontic microsurgery. By using state-of-the-art equipment, instruments and materials that match biological concepts with clinical practice, we believe that microsurgical approaches produce more predictable outcome in the healing of the periapical lesions of endodontic origin. In this review article, we aim to provide the most current concepts, techniques, various microsurgical instruments, dental operating microscope and materials required in endodontic microsurgery.

Keywords: Endodontics, microsurgery, dentistry.

INTRODUCTION

Endodontic microsurgery, combines the magnification and illumination provided by the operating microscope complimented with the use of micro-instruments such as micro-mirrors, micro-scalpels, micro-scissors and fine monofilament sutures.[1] The desire to eliminate disease at the root end, the need to obtain a clearer understanding of the complexities of pulpal anatomy and the use of enhanced magnification, illumination have led to contemporary apical surgery, more accurately described as apical microsurgery.[2] With the advancement in instruments and materials endodontic surgery can today be performed with better accuracy and more predictability of results.[3]

Definition and principles of endodontic microsurgery:

Endodontic microsurgery, as it is now called, combines the magnification and illumination provided by the microscope with the proper use of newer micro-instruments.[1] The triad of endodontic microsurgery encompasses magnification, illumination and instruments. Without any of these elements, microsurgery would not be possible. Magnification and illumination are provided by the dental operating microscope and have fundamentally changed the way endodontic surgery is performed. With bright, focused light on a 4X to 31X of magnified surgical site, the clinician can see every detail of the apical structures and can execute surgical treatment more precisely. As an additional benefit, the magnification has also resulted in smaller osteotomies. The third element of the triad is instrumentation. Working in a magnified surgical site, various micro-surgical instruments are used.[4]

Advantages of endodontic microsurgery:

The advantages of microsurgery include easier identification of root apices, smaller osteotomies

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and shallower root resection angles that conserves cortical bone and root length. In addition, a resected root surface under higher magnification and illumination readily reveals anatomical details such as isthmus, apical ramifications and lateral canals. Combined with the microscope, the ultrasonic instruments permits more conservative, coaxial root-end preparations and for accurate root-end filling restorations that satisfy the requirements for mechanical and biological principles of endodontic surgery.[1]

Indications of endodontic microsurgery:

1. When their is inability to access or prepare the canal due to abnormal anatomy or physiological/pathological changes, for example sclerosis and severe root curvature.[5]

2. In cases of instrument separation, where the fragments of tiny instruments are in the apical third of the curved roots which failed to be removed non-surgically, a microsurgical approach is a much safer and predictable means to retrieve the fractured instruments.

3. In cases of overfilling, endodontic microsurgery is an effective and safe means to remove extruded root-filling materials and infected debris that can cause periapical inflammation.

4. Lesions situated very close to vital anatomical structures such as inferior alveolar nerve, lingual nerve, mental foramen, maxillary sinus, nasal cavity have high risk of damage and in these cases, microsurgical approach becomes an absolute indication.[6]

Differences between traditional and endodontic microsurgery[7]:

1. In traditional endodontic surgery:-

a) Osteotomy size: Approx. 8–10 mm.
b) Bevel angle degree: 45–65 degrees.
c) Inspection of resected root surface: cannot be seen
d) Isthmus identification & treatment: impossible.
e) Root-end preparation: seldom inside canal.
f) Root-end preparation instrument: using bur.
g) Root-end filling material: amalgam, GIC
h) Sutures: 4 x 0 silk.
i) Suture removal: 7 days post-op.
j) Healing Success (over 1 year): 40–90%.

2. In endodontic microsurgery:-

a) Osteotomy size: Approx. 3-4 mm.
b) Bevel angle degree: 0-10 degrees.
c) Inspection of resected root surface: always seen clearly.
d) Isthmus identification & treatment: always.
e) Root-end preparation: always within canal.
f) Root-end preparation instrument: Using ultrasonic tips.
g) Root-end filling material: MTA, Biodentine, Bioactive glass.
h) Sutures: 5 x 0, 6 x 0 monofilament.
i) Suture removal: 2-3 days post-op.
j) Healing Success (over 1 year): 85-96.8%.

Operating microscope in endodontic microsurgery:

Apotheker[8] in 1978 brought the concept of magnification, in the form of an operating microscope into the field of dentistry. They postulated that the tremendous improvements in visual acuity with the use of the operating microscope, would be beneficial to the discipline of endodontics. The surgical field can be inspected at high magnification so that small but, important anatomical details, e.g. the extra apex or lateral canals, can be identified and managed well. Furthermore, the integrity of the root can be examined with great precision for fractures, perforations or other signs of damage. Removal of diseased tissues completely with precision and distinction between the bone and root tip can easily be made at higher magnification.[7]

At higher magnification the osteotomy can be made small (3-4 mm) and this results in faster healing and less post-operative discomfort. The number of radiographs can be reduced or may be eliminated because the surgeon can inspect the apex or apices directly and precisely. Video recordings or digital camera recordings of procedures can be used effectively for communicating with patients and communication with the referring clinicians can be improved significantly.[7]

Instruments in endodontic microsurgery:

Instruments used in endodontic microsurgery are basically the same as those used in conventional surgery but they are finer and smaller. Being small in size they must be sturdy enough to handle the oral tissues which can be sometimes tough. Stainless steel is a material of choice for microsurgical instruments because it provides greater degree of hardness and flexibility.[6]

Basic tray setup for initial surgical access consists of surgical instruments such as small round micro mirror, medium oval micro mirror, handle for micro scalpel, scissors, retractor, periosteal elevator, spoon curette, surgical forceps. Instrument tray for root-end filling and suturing consists of Castroviejo needle holders, micro explorer, micro burnisher and plugger. Modifications in the geometry and transmission of forces at the working tips of the instruments have been made to facilitate for the secure and more precise handling of tissues, needles and sutures.[6]

Soft tissue management: Incision and flap designs:

Endodontic surgery first requires exposure of the bone overlaying the tip of the root and then revealing the root end. To access the bone, a full thickness flap must be raised. This comprises a soft tissue flap, which consists of gingival and mucosal tissue as well as periosteum.[6]

The following management procedures have changed from the traditional techniques.

1. The semilunar incision, the most popular flap design technique with anterior teeth, is no longer recommended because of inadequate access and scar formation.[9]

2. The papilla based incision has been developed to prevent loss of interdental papilla height with sulcular incision.[10]

3. Flap retraction during the surgery is facilitated by making a resting groove in the bone, especially during mandibular posterior surgery, to ensure retraction.[11]

In the sulcular full-thickness flap design, the main disadvantage is recession and shrinkage of the papilla. Velvart[12] proposed the papilla based incision for the marginal mucoperiosteal flap to prevent or minimize loss of interdental papillary height.

Suture removal is done within 48 to 72 hours and not after a week, newer suture materials are monofilament and gauge 5 X 0 or 6 X 0 to provide rapid healing.[1] With the current method the base of the flap is as wide as the top and vertical incisions follow the vertical blood vessel alignment. This facilitates nearly scar-free healing while still providing more than adequate access to the surgical site.[7]

Minimal trauma should be inflicted during incision and raising of the flap. The flap design plays an important role as to how much recession will occur postoperatively and allows better healing.[6]

Osteotomy:

The osteotomy should be as small as possible but as large as necessary to accomplish the clinical objectives. There is a tendency during surgery to enlarge the osteotomy towards the coronal margin, away from the apex. This tendency results in excessive removal of healthy bone around the neck of the crown causing a perio-endo communication. When this happens, the long-term prognosis for the tooth becomes poor. With the microsurgical techniques, the size of the osteotomy is significantly smaller, just 3 to 4 mm in diameter.[13]

Rubinstein[14] study on healing, as evidenced by radiographic examination, showed that there is a direct relationship between the size of the osteotomy and the speed of healing: the smaller the osteotomy, the faster the healing. For instance, a lesion smaller than 5mm would take an average six months, a 6 to10 mm size lesion takes about seven months and larger than 10 mm size lesions requires eleven months to completely heal. Thus, the osteotomy should be as small as possible but as large as necessary to accomplish the clinical objectives.

The root has a darker, yellowish color and is hard, whereas the bone is white soft and bleeds when scrapped with a probe. This step is essential for keeping the size of the osteotomy small. If the initial osteotomy is prepared without magnified

examination, the chances are that the osteotomy will be too large and thus violating one of the main advantages of microsurgery. If the root tip is not seen, careful drilling and microscopic examination along with applying methylene blue stain, preferentially allows for better root tip identification as well as smaller osteotomy.[7]

Bevel angle:

1. **In Microsurgical Technique[7]:-**

- No bevel or less than 10 degree bevel.
- Exposes fewer dentinal tubules.
- Smaller osteotomy.
- Minimal loss of buccal plate.
- No danger of periodontal communication.
- Easy identification of root apices.
- No lingual perforation.

2. **In Traditional Technique[7]:-**

- Acute Bevel (45–60 degrees).
- Exposure of many dentinal tubules.
- Larger osteotomy.
- Greater loss of buccal plate.
- Greater danger of periodontal communication.
- Frequent missing of lingual apex.
- Easy lingual perforation.

An approximate 60% success rate has been reported by Friedman[15] in 1998, when root-end resection was traditionally performed with a bevel of 45° to allow visualization of the main canal, followed by a root-end cavity preparation with a round bur. With the introduction of the intraoral microscope, root-end resection at 90° and apical preparation using an ultrasonic retro tip to the depth of 3-4 mm, this allowed a success rate of over 90% as demonstrated by Tsesis in 2006.[16]

Root end resection:

Root end resection is most pivotal step of the endodontic surgical procedure. The carpenter's axiom of 'measure twice, cut once' has great significance in root end resection, as root structure cannot be replaced once it is resected, so careful consideration must be given to the length and angle of the root end resection.[13]

Anatomical study of the root apex shows that at least 3 mm of the root-end must be removed to reduce 98% of the apical ramifications and 93% of the lateral canals.[1] As these percentages are very similar at 4mm from the apex, we recommend root-end amputation of 3 mm, since this leaves on average of 7 to 9 mm of the root length, providing sufficient strength and stability to the tooth. A root-end amputation of less than 3mm does not remove all of the lateral canals and apical ramifications, therefore, posing a risk of re-infection and eventual failure.[7]

Once a root tip is resected perpendicular to the long axis of the root, proper identification of anatomical details and their management are some of the most important and unique steps in microsurgery and are critical for the success of the treatment.[1]

With the aid of micro-mirrors placed at 45 degrees to the root surface, the reflected view of the root shows every anatomical details of the canal system, which is critical for a successful surgery. The anatomical details of the resected root surface are complex. When cutting the root perpendicular to its long axis, round, oval, horse-shoe shaped, S-shaped, two to five small round and oval shaped canals and isthmus can be observed and this important step in the microsurgical technique is not considered at all in the traditional surgical technique.[7]

Root end preparation:

The conventional root-end cavity preparation technique using rotary burs in a micro-hand piece shows several problems for the clinician.[14, 17, 18]

1. Access to the root-end is difficult, especially with limited working space.
2. There is a high risk of a perforation of the lingual root-end or cavity preparation, when it does not follow the original canal path.
3. There is insufficient depth and retention of the root-end filling materials.
4. Necrotic tissue in the isthmus cannot be totally removed.

The aim of the root-end preparation is to remove the intracanal filling material and irritants and to create a cavity that can be properly restored.

The ideal root-end preparation can be defined as a Class 1 cavity with atleast 3mm in depth, with walls parallel and coincident with the anatomic outline of the root canal space.[19] Richman[20] first introduced the use of ultrasonics in endodontics in 1957, using a modified ultrasonic periodontal chisel scaler for root canal debridement and apicoectomy.

Ultrasonic and Sonic tips has various advantagesover Bur preparation[6]:

1. Enhanced access to root ends in a limited working space. This leads to a smaller osteotomy for surgical access because of the advantage of using various angulations and the small size of the retro tips.
2. Smaller osteotomy for surgical access because of the advantage of using various angulations and the small size of the retro tips.
3. Deeper and more conservative cavities that follow the original path of the root canal more precisely.
4. A better-centered root-end preparation also lessens the risk of lateral perforation.
5. Geometry of the retro-tip design does not require a beveled root-end resection for surgical access, thus decreasing the number of exposed dentinal tubules and minimizing apical leakage.
6. They also enable the removal of isthmus tissue present between two canals within the same root.
7. Considered as a time-saving technique.

Ultrasonic tips also make cleaner and deeper root-end cavity preparations, aiding for the better retention of the root-end filling materials.The most recent developments are the zirconium coated and diamond coated ultrasonic tips eg: KiS tips. In regard to diamond coated tips, diamonds adhere to the surface of the tips resulting in a slightly larger diameter, whereas zirconium nitride is processed into the metal making the tip narrower.[1] KiS tips remove gutta-percha from axial walls and prepare ideal root-end preparations faster than the stainless CT-5 tips. Ultrasonic instruments are still being improved upon, and newer types of coating would make a difference in cutting efficiency while minimizing micro fractures.[7]

Root end filling materials:

The objective is to select a biocompatible material capable of producing a hermetic seal that prevents residual irritants and oral contaminants from exiting the root canal system and entering into the periradicular tissues.[21] Numerous root end filling materials have been suggested; however, the use of gutta-percha or amalgam should be totally discouraged due to their poor sealing ability. MTA [Mineral Trioxide Aggregate], its main ingredients are tricalcium silicate (Ca3Si), tricalcium aluminate (Ca3Al) and tricalcium oxide (Ca3O2). Because of its superior sealing ability and biocompatibility over conventional root end filling materials, MTA is more commonly used.[22]

MTA has the capacity to induce bone, dentin and cementum formation in-vivo. In comparison to amalgam and Super EBA as root-end filling materials, MTA consistently resulted in regeneration of periapical tissues including periodontal ligament and cementum.[23] MTA stimulates osteogenic and odontogenic cell proliferation via intra and extracellular Ca^{2+} and Erk dependent pathways and that MTA promotes cell survival via the PI3K/Akt signaling pathway.[7] Another promising biocompatible root end filling material is Biodentine(Septodont), with tricalcium silicate as its main ingredient which has superior handling properties with that of MTA and exhibits similar biocompatibility.[23]

Newer root end filling materials are:

Neo-MTA, Retro-MTA, Ortho-MTA, Endosequence, Bioceramic, Bioactive glass.

Suturing:

Suture materials used in endodontic microsurgery must meet a number of physical requirements including high tensile strength, high tearing strength, good knotting characteristics and high knot security.[6] Suture materials which are often used now are the thinner monofilament polyamide with smaller needles. The 5x0 and 6x0 sutures are ideal for microsurgery and polypropylene sutures (6/0 or 7/0) are also popular.[7,24] The use of 4x0 silk sutures is no longer acceptable because the silk is braided and causes accumulation of plaque causing delayed healing or

secondary inflammation. The thinner and smaller monofilament sutures promote a cleaner surgical site and also helps in rapid healing. With the incorporation of newer materials, concepts and technical modifications, healing after surgery leaves almost no scars. In this age, when esthetics in dentistry is important, microsurgery also contributes to the highest esthetic standards in this field.

Microsurgical needles must have high flexural strength to ensure that they do not bend when passed through tough tissues. Furthermore, they must be ductile enough to prevent breakage when overloaded. The material that best meets these requirements is high-quality stainless steel, which is usually plated with nickel or chrome to facilitate polishing.[6]

Follow-up protocol:

Regular review appointments should be made to asses healing, using criteria based upon clinical and radiological examinations. In order to avoid the limitations of conventional radiographs (anatomical noise, geometrical distortion) periapical radiographs should be taken using beam aiming devices and maintaining the same angulation.[5]

Bone healing of the site of surgery may take several months to even years. In practical terms it is illogical to repeatedly review patients following endodontic surgery. A sensible rationale is to review patients both clinically and radiographically at six months and at one year following surgery.[5]

According to Patel[25] the success of apical surgery should be based on patient's clinical features and not solely upon radiological findings. Therefore the lesions following apical surgery can be classified as:

1. Healed – no clinical signs and symptoms and no residual radiographic radiolucency. Also in this category the typical appearance of the scar is included.
2. Healing – no clinical symptoms and reduced radiographic appearance for a period shorter than four years.
3. Persistent disease – presence of clinical signs, symptoms or persistence of periapical radiolucency.

CONCLUSION

Clinicians should possess current knowledge about the modern techniques, prognosis and expected outcome of the apical surgery. Shift in clinical accuracy from low magnification to the use of dental operating microscope with higher magnification brought a revolution in the field of endodontics with greater success rate. Microsurgical approach should become part of the treatment plan in treating periapical lesions, before considering the tooth for extraction.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Kim S, Pecora G, Rubinstein R.A. Comparison of traditional and microsurgery in endodontics. Color Atlas of Microsurgery in Endodontics. Philadelphia: W.B. Saunders Company, 2001; 1–12.
2. Richard Rubinstein. Magnification and illumination in apical surgery. Endodontic topics 2005; 11:56-77.
3. Ingle's 6th edition, Endodontic surgery, Chapter 33, Page no: 1233.
4. Sumangali Ananad, E. Soujanya, Ananda Raju, Aravelli Swathi. Endodontic microsurgery: An overview. Dental and medical research, July-Dec 2015; 3:2:31-37.
5. Pop. Oral surgery: Part 2. Endodontic surgery. BDJ Sept 28, 2013; 215:6:279-286.
6. Sahil Dhingra, Mohan Gundappa, Rashmi Bansal. Recent concepts in endodontic microsurgery: A Review. TMJ J Dent. July-Sept 2015; 1:3:86-91.
7. Syngcuk Kim, Samuel Kratchman. Modern endodontic surgery concepts and practice: A Review. J Endod. July 2016; 32: 7: 601-623.

8. Apotheker H. A Microscope for Use in Dentistry. J Microsurg. 1981; 3:772-78.

9. Penarrocha M, Garcia B, Marti E, Balaguer J. Pain and inflammation after periapical surgery in 60 patients. J Oral Maxillo fac Surg 2006; 64:3:429-33.

10. Kramper BJ, Kaminski EJ, Osetek EM, Heuer MA. A comparative study of the wound healing of three types of flap design used in periapical surgery. J Endod 1984; 10:1:17–25.

11. Kim S, Pecora G, Rubinstein R. Comparison of traditional and microsurgery in endodontics. Color atlas of microsurgery in endodontics. Philadelphia: W.B. Saunders, 2001:5–11.

12. Velvart P, Ebner-Zimmermann U, Pierre Ebner J. Papilla healing following sulcular full thickness flap in endodontic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;983 :365-9

13. Kim S, Kratchman S. Modern endodontic surgery Concepts and Practice: A Review. J Endod 2006; 32: 7:601-23.

14. Rubinstein RA, Kim S. Short-term observation of the results of endodontic surgery with the use of a surgical operation microscope and Super-EBA as root-end filling material. J Endod 1999;25:43-8.

15. Friedman DS. Treatment outcome and prognosis of endodontic therapy. Essential endodontology. Oxford: Blackwell Science 1998:367-401.

16. Tsesis I, Rosen E, Schwartz-Arad D, Fuss Z. Retrospective evaluation of surgical endodontic treatment: Traditional versus modern technique. J Endod 2006; 32:412–416.

17. Kim S. Principles of endodontic microsurgery. Dent Clin North Am 1997;41:481–97.

18. Carr GB. Microscope in endodontics. J Calif Dent Assoc 1992;20:55– 61.

19. Carr GB. Ultrasonic root end preparation. Dent Clin North Am 1997;41:541– 4.

20. Richman MJ. The use of ultrasonics in root canal therapy and resection. J Dent Med 1957;12:12–8.

21. Donald E. Practical lessons in endodontic surgery. Illinois: Quintessence Publishing Co., 1998.52-75

22. Torabinejad M, Hong CU, Pitt Ford TR, Kettering JD. Cytotoxicity of four root end filling materials. J Endod 1995; 21:489 –92.

23. Torabinejad M, Pitt Ford TR, McKendry DJ, Abedi HR, Miller DA, Kariyawasam SP. Histologic assessment of mineral trioxide aggregate as a root-end filling in monkeys. J Endod 1997; 23: 225– 8.

24. Velvart P, Ebner-Zimmermann U, Ebner JP. Comparision of long-term papilla healing following sulcular full thickness flap and papilla based flap in endodontic surgery. Int Endod J 2004;37:687-693.

25. Patel S. The use of cone beam computed tomography in the conservative management of dens invaginatus: a case report. Int Endod J 2010; 43: 707–713.