RECENT CONCEPTS IN ENDODONTIC MICROSURGERY: A REVIEW

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Abstract

With the evolution of dental operating micrscopes and complementary microsurgical instruments endodontic surgery now has been renamed as endodontic microsurgery. Although the basic principles of endodontic surgery have not been dramatically changed, micro-techniques with micro-instruments, efficient preparation and placement of the root end filling material provides favorable outcome and success to endodontic microsurgery.

Key Words: - Apicoectomy, dental operating microscope, microsurgery.

Introduction

Endodontic microsurgery is performed with precision and predictability in such a way that it eliminates the assumptions inherent in traditional surgical approaches. It refinement in existing basic surgical techniques that are made possible by the use of the surgical microscope and subsequent improved visual acuity.[1] Endodontic microsurgery, combines the magnification and illumination provided by the microscope complimented with micro-instruments such as micro mirrors, micro scalpels, micro scissors, fine monofilament sutures etc. Of prime importance are gentle handling of tissues and passive wound closure aiding in primary uneventful healing, making the procedure more acceptable.[2] Using the ultrasonic tips the retro preparation is more precise, coaxial with the root canal, the entire circumference is cleaner, the retro fill is also more accurate.

With the advancement in instruments and materials endodontic surgery can today be performed with accuracy and more predictability of results that were not possible to reach 10 or 15 years ago. Better visualization with microscopes, along with a more thorough understanding of the biology of wound healing, has contributed to the evolvement of "microsurgical endodontics".[3]

Magnification

In dental practice, the tissues are usually very fine resulting in a situation in which the natural visual capacity reaches its limits. Therefore, the clinical procedure may be performed successfully with the use of magnification improving precision and, hence, the quality of work.

Visualization of finer details is enhanced by increasing the image size of the object. Image size can be increased by getting closer to the objects or by magnification. Magnification increases the focal length in order to see small objects accurately, which in turn increases the working distance between the eye and the object allowing, extra-ocular muscles to remain more relaxed and a dentist to maintain normal posture.[4]

Visualization during surgical and conventional endodontic treatment has historically been limited to two-dimensional dental radiography representative of a three-dimensional biologic system and what could be seen with the naked eye (perhaps enhanced by loupes). Today, endodontic treatment is to a large extent viewed as a microsurgical procedure. The principle upon which all microsurgery is based is the observation that the hand can perform remarkably intricate micromanipulations as long as the eye can see a magnified field and it can be interpreted by the mind. Magnification affects vision by increasing the size of an image on the retina. "Visual image" is the basic parameter used to describe how large something appears, and is expressed in units of degree or cycles/degree.

An optical magnification instrument enables the endodontist to magnify a specified treatment field beyond that perceived by the naked eye. These instruments can be

I. Loupes,
II. Dental operating microscope,
III. Endoscopes, and
IV. Orascopes

Loupes are the most common magnification system used in dentistry. There are fundamentally two monocular microscopes, with side by-side lenses angled to focus an object. The magnified image that is formed has stereoscopic properties that are created by the use of convergent lens systems.[5,1,6]

Dr. Apotheker and Dr. Jako in 1978 brought the concept of magnification, in the form of an operating microscope, into dentistry. They postulated that the tremendous improvements in visual acuity, made possible through the use of the operating microscope, would be beneficial to the discipline of endodontics.[7]

There are five basic advantages in using the DOM and accompanying documentation systems (digital micro photography and videography) for an endodontic specialist include: -

1. Increased visualization
2. Improved quality
3. Precision of treatment
4. Enhanced ergonomics and ease of proper digital documentation
5. Increased communication ability through integrated video[8]

A recent addition to the field of visualization devices in endodontic surgery is the fibre –optic endoscope. Endoscopy has several clinical advantages compared with surgical microscopy during endodontic microsurgery. Owing to its non-fixed field of vision, the endoscope allows the treatment field to be viewed at various angles and

distances without loosing depth of the field and focus. [9]The endoscope is more versatile then the microscope.

Orascopy involves using the Orascope, a modified medical endoscope, for treatment in the oral cavity. It uses fiber optics, making the instrument lightweight and flexible. In the past, fiber-optic imaging provided superior ergonomics but suffered from poor image quality. But the Orascope uses a unique lens design combined with a digital image processing system in the camera, allowing the fiber optics to surpass the image quality of the medical rod lens.[10,11]

Microsurgery done under loupes has made a great difference in all surgical fields due to its desirable qualities of obtaining cleaner incisions, reduced hemorrhage, reduced trauma at the surgical site and closer wound apposition. Since the surgical procedure is less traumatic and less invasive, healing occurs by primary intention which is rapid with minimal granulation tissue or scar tissue. Within 48 hours vascular anastomosis has been observed in the healing tissue with reduced pain and inflammation. Therefore the end point appearance of the tissue is superior, hence, making microsurgery a preferable option.

Feature	Loupes	Operating microscopes
Maximum magnification factor	X6(-)	X24(+)
Field of view	Larger(+)	Smaller(-)
Direct view of surgical field	Always possible(+)	Only indirect view possible(-)
Non magnified view	Possible(+)	Not possible(-)
Assistant scope	Not available (-)	Available depending on equipment model (+)
Optical zoom	Not available (-)	X4 to x24(+)
Shadow-free illumination	Possible with some light systems(+/-)	+
Flexibility/mobility of the system	+	–
Ergonomics/working comfort	–	+
Ease of handling	+	–
Protection against eye strain	–	+
Training time for surgeon	Shorter(+)	Longer(-)
Training time for assistant	Shorter(+)	Longer(-)
Camera/video documentation	Not possible(-)	Available depending on equipment model (+)

Table I-Comparison between Loupes & Microscope[12]

Specific indications for microsurgery

1. In cases of iatrogenic canal blockage where instrument separation occurs, endodontic microsurgery additionally provides a non-destructive and successful means to address instrument separation that may occur during the cleaning and shaping phase of nonsurgical endodontics. In cases of instrument separation where the fragments of tiny instruments are in the apical third of curved roots and cannot be removed, a microsurgical approach is a safer and predictable means to manage these cases.
2. Endodontic microsurgery provides a treatment option for canal calcification or severe curvature due to its direct access to the root end.
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. Patients with shallow vestibules with small periapical lesions have limited access, where microscope aids in exploring small bony cavities and locating tips of the roots.
5. Failure of previous traditional surgery associated with constant pain or swelling can be re-treated with less invasive microsurgery.
6. Lesions situated very close to vital anatomical structures such as inferior alveolar nerve, lingual nerve, mental foramen, maxillary sinus, nasal cavity etc. have high risk of damage where microsurgery becomes absolute indication.
7. To explore the apical third anatomy- ramifications, apical deltas, accessory canals etc.
8. Tooth with thin roots requires precise root end resection which is possible only through microscope to preserve maximum tooth structure.

Micro-instruments for microsurgery

Microsurgical techniques and new materials have changed the typical surgical instrument tray dramatically over the past 15 years. Instruments have been designed to take full advantage of the increased visibility obtained with dental operating microscopes, endoscopes, and orascopes. Better visualization of the surgical site would have limited value without microsurgical instruments such as ultrasonic tips for root-end preparation and micro mirrors for inspecting the root end.

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.

Basic tray setup for initial surgical access consist 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 consist 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 the secure and precise handling of tissues, needles and sutures. Various manufactures (Hu-friedy, Salvin dental, Sybron Endo, Dentsply) provide their catalogue of the surgical instruments one can order from that according to their requirement.

Soft Tissue Management: Incision And Flap Designs

Endodontic surgery first requires exposure of the bone overlaying the tip of the root(s) and then revealing the root end(s). 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. To mobilize the flap various modes of incisions can be selected including horizontal incisions, sulcular and submarginal, and vertical releasing incisions.

The wide variety of flap designs reflects the number of variables to be considered before choosing an appropriate flap. As conditions vary with each individual patient and specific situation, their will always be a need to select the best flap design for every single case such as marginal mucoperiosteal flaps with one (triangular flap) or two (trapezoidal or rectangular flap) releasing vertical incisions, submarginal mucoperiosteal flaps with the horizontal incision within the attached gingival and its modification and semi lunar flaps.[13-17]

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.[18]
2. The papilla base incision has been developed to prevent loss of interdental papilla height with sulcular incisions.[19]
3. Flap retraction during the surgery is facilitated by making a resting groove in the bone, especially during mandibular posterior surgery, to ensure retraction.[20]

In the sulcular full-thickness flap design, the main disadvantage is recession and shrinkage of the papilla.[19,14] Velvart[19,21] proposed the Papilla based incision for the marginal mucoperiosteal flap to prevent or minimize loss of interdental papillary height.

The type of incision described bears a high risk of postoperative necrosis, as the only blood supply to the un-reflected marginal tissue is derived from the periodontal ligament.

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.

Osteotomy

The osteotomy[22] should be as small as possible but as large as necessary to accomplish the clinical objective. 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 easily causing a perio-endo communication. When this happens, the long-term prognosis for the tooth is poor. With the microsurgical techniques, the size of the osteotomy is significantly smaller, just 3 to 4 mm in diameter. This is just larger than an ultrasonic tip of 3 mm in length, yet allows the tip to vibrate freely within the bone cavity.

A major purpose of using the microscope during the osteotomy is to clearly distinguish the root tip from the surrounding bone. This differentiation is one of the most important advantages of using the microscope. It would be ideal to locate the root tip precisely all the time. However, if the apical lesion has not fenestrated or if the lesion extends lingually, then locating the apex can be a real challenge, even for the experienced surgeon.

If the root tip cannot be seen, careful drilling and microscopic examination along with applying methylene blue stain, preferentially staining the periodontal ligament, allows root tip identification as well as a small osteotomy.

Bevel angle

Elimination or minimization of the bevel angle is one of the most important benefits of microsurgery. With the traditional rotary bur, the steep bevel angle of 45 to 60 degrees was recommended.[23-26] The purpose of this steep bevel was simply for access and visibility.[25] In fact, with the traditional techniques bevelling to this degree was inevitable, since the surgical instruments were large.

There is no biological justification for a steep bevel angle. It was strictly for the convenience of the surgeons for apex identification and for the subsequent apical preparation.[27] In fact, bevelling causes significant damage to the vital tissue structures that the surgery is designed to save, i.e. buccal bone and root. By diagonal resection, the result of steep bevelling, the buccal bone is removed along with a large area of the root causing, in effect, a large osteotomy. Furthermore, bevelling frequently misses the lingually positioned apex, causes elongation of the canal and reduction of the root diameter, thereby weakening it.[27]

Microsurgical Technique	**Traditional Technique**
No bevels or less than 10 degree	Acute bevel (45-60 degree)
Expose few dentinal tubules	Exposure many tubules

Small osteotomy	Large osteotomy
Minimal loss of buccal plate	Greater loss of buccal plate
No danger of perio communication	Greater danger of perio communication
Easy identification of apices	Frequent missing of lingual apex
No lingual perforation	Easy lingual perforation

Table II- Comparison between Microsurgical and Traditional technique

Root-End Resection

Root end resection is most pivotal step of the endodontic surgical procedure, as errors here are magnified with respect to the subsequent root end preparation and successful sealing of the apical extent of the root canal system.

The carpenters' axiom of **''measure twice, cut once''** has great significance, as root structure cannot be replaced once it has been removed, so careful consideration must be given to the length and angle of the resection process.[22]

First and foremost are the restorative implications of the resection with regard to crown-root ratio. There are histological guidelines for how much of the root end should be removed but if, in doing so, the integrity and stability of the remaining tooth is compromised, alternative treatment options should be explored. If there is sufficient root length in sound bone, then the amount of root apex that is removed is dictated by the prevalence and distribution of the apical ramifications the surgeon hopes to eliminate. A resection level of 3 mm from the anatomic apex will eliminate 93% of lateral canals and 98% of any other ramifications such as deltas, fins, and so forth [22]. As these percentages are very similar at 4 mm from the apex, root-end amputation of 3 mm is advised since this leaves on average of 7 to 9 mm of the root, providing sufficient strength and stability. A root-end amputation of less than 3mm does, most likely, not remove all of the lateral canals and apical ramifications, therefore, posing a risk of reinfection and eventual failure.

Before the introduction of the microscope, resected root ends were routinely bevelled to enable the surgeon to visualize the resected surface(s). It was not uncommon for bevels of 30-45 degree, or even greater to be placed because of ''convenience.'' This bevelling was most often rendered by with a #4 to #6 round bur attached to a large, straight nose cone hand piece, such as with a fissure burr in a conventional slow-speed hand piece.

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.

The anatomical details of the resected root surface are complex. All types of shape and forms can be found in the canal system that can be round, oval, S-shaped, and isthumses, and so forth can be observed.[25] This important step in microsurgery is not considered at all in the traditional surgical technique.

Root End Preparation

Prognosis of endodontic surgery is highly dependent on good obturation and sealing of the root canal, an optimal cavity preparation is an essential prerequisite for an adequate root-end filling after apicoectomy. Since sonically or ultrasonically driven microsurgical retro tips became commercially available in the early 1990, this new technique of retrograde root canal instrumentation has been established as an essential adjunct in peri radicular surgery.

Ultrasonics (US) and sonic tips has various advantages over bur preparation

- 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.
- Smaller osteotomy for surgical access because of the advantage of using various angulations and the small size of the retro tips.
- Deeper and more conservative cavities that follow the original path of the root canal more closely
- A better-centered root-end preparation also lessens the risk of lateral perforation
- 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.
- They also enable the removal of isthmus tissue present between two canals within the same root.
- It is considered a timesaving technique that seems to have a lower failure rate.
- US produced less smear layer in a retro-end cavity compared to a slow-speed handpiece.

Improved visualization combined with a more conservative approach when selectively removing tooth structure, particularly in difficult situations in which a specific angulation or tip design permits access to restricted work areas, offers opportunities that are not possible with conventional treatment. Integration of new technologies such as ultrasonic tips, leading to improved techniques & use of materials has changed the way endodontics is being practiced today.

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. Moreover, the suture materials should have a surface that facilitates a traumatic passage through the tissues without causing capillarity in order to minimize immune response in the affected tissues.

Capillarity is the process by which the suture materials, particularly those with multifilament fibers, draw fluids and microorganism into the wound like the wick of the candle. Consequently, it is also referred to as the wick effect. Last but not least, absorbable suture materials must have a defined absorption time.

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.

Wound healing during microsurgery

The healing process requires closure of the hiatus between the reflected and the un-reflected tissue with connective tissue and epithelium. Wound closure seems to be quite critical in terms of healing outcome. When adaptation of the tissue edges is ideal and the tissues are positioned in very close proximity in the vertical and horizontal dimension to each other, only few cells need to be generated to bridge the gap. Close adaptation of margins is possible when surgery is performed under microscope.

In microsurgery flap closure is per-formed with polyamide 6-0 sutures and suture is removed after 4 days and areas with better healing are visible and the incision is barely recognizable.

Tension free approximation of the wound margins is crucial to the success of endodontic surgery. Tension can be reduced by using a greater number of sutures and by choosing fine microsurgical materials. Adequate flap mobility can be ensured through the use of an appropriate flap design and releasing incisions. Microsurgical approach prevents the surgeon from exerting excessive tension on the edges of the flap during suture closure. Size 6-0 and 7-0 microsurgical suture materials will tear if too much force is used when the sutures are tied.

Rapid soft tissue healing is a result of reduced tissue trauma & enhanced wound closure during microsurgical procedure.

Microsurgical training

Training in more advanced techniques can also be acquired in periapical surgery and endodontics in general, avoiding the use of live subjects and in particular, preventing practice on human patients.

In 1999—The American Association of Endodontics required all endodontic graduate students to be microscope proficient. In 2005, several dental schools integrate microscopes into undergraduate programs.

The most important skills to practice are the handling of suture materials and the tying of knots under optical magnification. Microsurgical suture skills can be practiced by stretching a piece of rubber dam over a wooden board that has a hole cut out in the middle. Instruments are held in a pen grip while the little finger and ring finger rest against a stable surface for support. The support prevents premature fatigue and minimizes physiologic tremor.

The clinician should first practice these techniques on an appropriate model before performing them on patient. Pig jaws are very well suited for hands-on training in microsurgical procedures.[12]

Discussion

Surgical endodontic treatment is performed on very small anatomic structures usually with limited access. Microsurgical principles, which include the use of a dental operating microscope, micro-instruments, ultrasonic tips, and more biologically acceptable root-end filling materials, have been introduced. The success rate of micro-endodontic surgery is reported to be approximately 90%. The relative risk ratio showed that the probability of success for endodontic microsurgery was 1.58 times that of traditional root-end surgery, which means that endodontic microsurgery has a considerably higher and predictable clinical outcome. Because the surgical technique has become more precise and predictable than traditional endodontic surgery, the predictors affecting the clinical outcome of endodontic microsurgery might have changed.

The use of the specifically designed retro tips allows the operator to clean the root canal from an apical approach, leaving clean dentinal walls not only on the lingual or palatal side, but also on the buccal aspect, which was impossible to clean with the previous techniques The cavity now can be made 3 mm deep, without the necessity of making undercuts, since there is no need of further retention.

The effect of a root-end filling material is the most commonly studied factor among the intra operative factors. Recently, biocompatible materials, such as IRM, Super EBA, and MTA, have been used with the microsurgical technique.

Advanced techniques and newer materials along with sophisticated equipments are available which help in better diagnosis, patient friendly treatment procedures and predictable prognosis, but operator's skills, experience plays an important role in the probable outcome of the treatment. Also it is important for the existing practitioner to continuously educate themselves of the latest technology and techniques for betterment of their patients.

Conclusion

Exact therapy requires exact vision. High-quality endodontic therapy is the basis for long-term function and biologic success, ensuring that patients remain free of pain. State-of-the-art equipment and thorough clinical know-how are vitally important to reach this goal. Today, a small but growing number of clinicians are providing endodontic and endo-restorative treatments based on direct microscopic visualization of the pulp chamber and coronal portions of canal systems. This huge shift in clinical accuracy from low magnification ―tactile-driven endodontics to ―vision-

based endodontics is bringing a revolution to the field of endodontics with greater success rate.

Use of magnification tools such as surgical operating microscope and magnifying loupe in dentistry not only improves the quality of care provided to patients, but also expands the range of treatments that can be offered. In combination with magnification and illumination, resected roots reveal intricate anatomical details. In conjunction with ultrasonic root-end preparation and tight sealing of the root end cavity, the requirements for mechanical and biological success are more adequately fulfilled. New era of micro dentistry, micro endodontics and micro suturing for various microsurgical procedures in dentistry is gaining popularity with magnification tools.

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