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ENDODONTIC MICROSURGERY-A REVIEW

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ABSTRACT

Endodontic surgery has become endodontic microsurgery in recent years. Microsurgical techniques produce predictable outcomes in the healing of endodontic lesions by using state-of-the-art technology, devices, and materials that harmonize with biological concepts. In this review article, we have elaborated the current concepts, techniques, microscope, flap design, newer materials and prognosis of microsurgery.

Keywords: Microscope, osteotomy, root end resection, prognosis, microsurgery

INTRODUCTION

Endodontic surgery is employed for treating apical periodontitis which is unresponsive to nonsurgical retreatment. Examination of failed clinical cases and extracted teeth by surgical operating microscopes reveal that the surgeon may not always be able to predictably locate, clean, and fill all the complex apical ramifications with traditional surgical techniques. These limitations can be overcome with the use of magnification and illumination of the microscope and the specificity of microsurgical instruments, especially ultrasonic instruments (1). The advantages of microsurgical approach include ability to clearly visualize the root apices, smaller osteotomies and shallower resection angles that conserve cortical bone and root length. A resected root surface under high magnification (4x to25x) and illumination readily reveals anatomical details such as isthmuses, canal fins, microfractures, and lateral canals (2). A recent study on healing, as evidenced by radiographic changes, 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(3). Cross-sectional studies have reported that molars treated by endodontists using a microscope have significantly higher survival rates than molars treated by dentist who did not use a microscope after 10 years (4).

DENTAL OPERATING MICROSCOPE (DOM)

Apothekar introduced the microscope in 1981. Microscopes have a number of advantages compared to loupes. Because loupes can be worn on the head and may be used with or without external light sources (5). This necessitates weight limitations and restricts the oculars to the bare minimum of lenses needed for magnification. By contrast, the microscope is a self-supported unit. Therefore, additional lenses or prisms are not a concern. A microscope allows the clinician to maintain an upright posture. Another advantage of loupe magnification or microscopy is the incorporation of LED illumination. Head-mounted and in-built lights provide excellent visualisation of the operating field (6). For non-surgical and surgical endodontics, different magnification ranges are required.

Binoculars and Microscope body with magnification and fine focus adjustments are the basic components in DOM. The beam splitter is the principal part that makes possible the attachment of other observation and documentation accessories. A beam splitter will divert approximately 20% of the available light intensity to still photography or a video camera. Magnification changers are available in 3-, 5-, or 6- step manual changers, manual zoom, or power zoom changers(7).

ANAESTHESIA AND HEMOSTASIS

Preparing the patient for anesthesia is important and can significantly reduce the patient's anxiety. A topical anesthetic, Lidocaine ointment USP, 5%, is applied for a minimum of 1 to 2 minutes(8). It has been shown that an inadequately anesthetized patient produces considerably more endogenous catecholamine in response to discomfort than is contained in the anesthetic solution, and inadequate hemostasis leads to a prolonged, difficult to control procedure. Adequate hemostasis can be achieved by a vasoconstrictor containing anesthetic (e.g., 2% lidocaine solution with 1:50 000 epinephrine) being injected into the submucosal tissues at the surgical site at least 20–30 minutes before the incision is made. Injecting into soft or osseous tissues after the incision has been made is useless because powerful vasodilating neuropeptides at the incision site override any vasoconstrictor effect(9). Injection has to be slow and controlled. Rapid injection produces localized pooling of solution, resulting in delayed and limited diffusion into adjacent tissues, minimal surface contact with microvascular and neural channels, and less than optimal hemostasis. 5% Lidocaine ointment or EMLA paste (2.5% each of lidocaine and prilocaine) are much more potent. They are applied to the injection site on a cotton swab for 1–2 minutes(10).Topical hemostatic agents used are ephinehrine pellets, ferric sulphate, Thrombin, gelfoam, Absorbable collagen Microfibrillar Collagen Hemostats, and Surgicel TM.

FLAP DESIGN

A proper flap design and soft tissue management are important to perform endodontic microsurgery appropriately. The primary purposes of the flap design and elevation are to provide adequate surgical access to the underlining bone and root structure and to promote a scar-free soft tissue healing (11). Various flap designs have been discussed in the literature. Examples include 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 gingiva and its modifications and semilunar flaps (12).

The most popular submarginal flap is the flap design by Ochsenbein and Luebke (13). Two releasing vertical incisions are connected by a scalloped horizontal incision. The submarginal flap is only to be used, when there is a broad zone of attached gingiva with a minimum of 2 mm. The underlying apical lesion or surgical bony access must not extend to the flap margins. This flap design has the advantage of leaving the marginal gingiva untouched and it does not expose any restoration margins. Possible scar tissue formation is another disadvantage of the submarginal flap. Vreeland and Tidwell modified the submarginal incision by placing a scalloped horizontal incision 1 to 2 mm below the gingival margin(14).

OSTEOTOMY

An osteotomy, which entails the removal of the cortical plate to expose the root end, must be approached deliberately and carefully, so that the osteotomy is made exactly at the apices. Once the surgeon is sure of the exact location of the apex, the cortical bone is removed slowly and carefully with copious water spray under low magnification(15). The Lindemann bone cutter and a 45 degree surgical handpiece are best suited for creating an osteotomy. The advantage of the 45 degree surgical handpiece is that water is directed along the bur shaft, while air is ejected out from the back of the handpiece This creates less splatter than conventional handpieces and decreases the chance of emphysema. The 45 degree angle gives the operator better direct visibility(16). It is very important to differentiate between bone and root tip, the root has a darker, yellowish color, and is hard, whereas the bone is white,soft, and bleeds when scraped with a probe. When the root tip cannot be distinguished from its surroundings, the osteotomy site is stained with methylene blue, which preferentially stains the periodontal ligament. The absence of a distinct PDL stain at medium magnification (×10 to ×12) indicates that the root tip is very small in relation to the osteotomy. The advantage of using the microscope for osteotomy is the minimal removal of healthy bone structure(17). This more conservative osteotomy generally results in faster healing and, as a result, greater patient comfort. The intact cortical plate with a periapical lesion is the most common situation in surgical endodontics. If there is thin cortical bone, probes will penerate through the bone to the lesion. The cortical bone overlying the lesion is thick, puncturing the bone should be done with a Lindemann in a 45 degree surgical handpiece. The size of the lesion is always larger than it appears on the radiograph. This phenomenon is a result of the fact that the lesion begins in the medullary bone and progresses to the cortical bone, where the damage is therefore smaller. Traditional endodontic surgery uses relatively large instruments. Consequently, the size of the osteotomy will be large approximately 10 mm in diameter to allow the surgeon to view and treat the apices with a conventional mirror and a microhandpiece. The microscope has changed the perceptions that even a small osteotomy looks large at higher magnifications (×8 to ×16), there is a tendency to want to make the osteotomy even smaller (18). Since the length of an ultrasonic tip is 3 mm, the ideal diameter of an osteotomy is about 4 mm leaving just enough space to manipulate the ultrasonic tip and microinstruments within its confines. A key hole modification to the osteotomy is used when there a retrograde deeper than 3 mm into the canal is indicated,by creating a narrow vertical extension of the osteotomy in an apical direction will make enough space for the tip to fit in minimum osseous tissue removal(19). Khoury and Hensher reported a “bone window” (lid) approach, which provided better access and intraoperative visibility to the desired lesion location while avoiding extensive removal of alveolar bone. It is indicate where there is no detectable buccal cortical plate fenestration, or where a thick cortical plate is expected eg: mandibular molars. Longer fine-toothed saw tips of 10 mm are used to create a rectangular-shaped bone window to uncover the area of the lesion and the apices of the roots. Two small round holes are created in the plate before removing it. These holes will later help with maintaining good circulation of the surgical site. When the apical procedure is completed, the buccal bone plate is repositioned, stabilized using a membrane, and covered with a resorbable membrane before repositioning the flap(20).

ROOT END RESECTION

Once the granulation tissue is removed to the extent where the root apex is clearly identified, 3 mm of the root tip is resected perpendicular to the long axis of the root. A

Lindemann bur can be used in a 45 degree angled handpiece using copious water spray(21). An anatomical study of the root apex conducted at the University of Pennsylvania revealed 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 (22). The main reason to resect the root end is to remove the pathologic process, anatomic variations like apical deltas, iatrogenic mishaps(ledges, perforations, fractured instruments),and for creation of apical seal.

With a traditional surgical technique, it was recommended that the angle of root end resection should be 45 degrees to 60 degrees (long bevel) from the long axis of the root facing toward the buccal or facial aspect of the root. The purpose of giving the steep bevel was to provide enhanced direct visibility to the cut root surface and allow the surgeon to perform a root end preparation with a bur (23). But the steeper bevel has complications like unnecessary removal of buccal supporting bone, there is chance of missing the lingual canal or accessory canal emerging from the main canals to a lingual direction,more exposed dentinal tubules on the cut root surface can be associated with an increased risk of bacterial microleakage postoperatively, and risk of perforation in lingual dentinal walls. On the contrary, microsurgery suggests a 0◦ bevel (short bevel), perpendicular to the long axis of the tooth which has the advantages preservation of root length, less chance of missing lingual anatomy and less exposed dentinal tubules(24).

INSPECTION OF THE ROOT END

Inspection under high magnification is the key step of microsurgery that is missing from traditional surgical techniques. A careful inspection will identify the possible reason for failure of the non-surgical treatment. In traditional surgical techniques, root resection is performed without magnification. As a result, inspection of all anatomical details of the cut root surface is impossible. In microsurgery, magnification of the microscope should be set at the range of ×16 to ×25 higher than the rest of the surgical steps. During inspection, the resected root end is rinsed and dried with a Stropko irrigator. The dried surface is then stained with methylene blue, which is applied to the root surface with a microapplicator tip (25). The findings and anatomical details that can be identified during inspection were classified into macrofindings and microfindings. Macrofindings included isthmuses and missed canals, while microfindings included craze lines. Identification and management of the isthmus was absent in the traditional old apical surgery. At the 3-mm level from the original apex, an isthmus was found at 90% of the mesiobuccal roots of maxillary first molars, 30% of the maxillary and mandibular premolars, and over 80% of the mesial roots of the mandibular first molars. All this evidence shows that the isthmus is a part of the canal system and not a separate entity. It is essential that the entire canal and isthmus be prepared to a depth of 3 mm(26).

ULTRASONIC ROOT END PREPARATION

The clinical demand can no longer be satisfied by use of rotary burs in a micro handpiece, which was the common practice in traditional surgical techniques. Drawbacks of using rotary burs are limited access to the root end, high risk of perforation of the lingual or palatal wall, dome shaped preparation which makes root end filling compromised and insufficient depth of preparation(27).In microsurgery, ultrasonic tips are used. Clinically, more important for an efficient ultrasonic preparation is an extremely light touch in a repeated fashion which increases the cutting efficiency, whereas a continuous pressure, similar to the way a handpiece is used, decreases the cutting efficiency. That is because ultrasonics work through vibration, not through pressure(28).Once the apical preparation has been completed, gutta percha should be compacted with a microcondenser and the preparation should be dried and inspected with a micromirror. Traditionally, root end cavities were dried with paper points before root end filling. This technique, however, is incorrect as particles of paper may be left in the preparation, remaining debris will be compacted in the preparation, and a thorough drying of the cavity may not be obtained. A controlled blast of air in the cavity is now accomplished by use of a Stropko Irrigator. The irrigator allows for the directional administration of air and water (29).

ROOT END FILLING MATERIALS

The main purpose of placement of a root end filling material is to provide an adequate apical seal that inhibits the leakage of irritants that might remain in the root canal after root resection and root end preparation, which may cause surgical failure (30). Several materials have been used for root end filling-Amalgam, gold foil, zinc oxide eugenol cements, Diaket (ESPE GmbH, Seefeld, Germany), glass ionomer cements (GICs), composite resins, intermediate restorative material (IRM, Caulk/ Dentsply, Milford, DE, USA) and SuperEBA (Keystone Industries, Gibbstown, NJ),Mineral trioxide aggregate (ProRoot MTA, Dentsply Interantional, Dentsply-Tulsa Dental, Tulsa, OK, USA), and EndoSequence Root Repair Material (EndoSequence root repair material (RRM) Brasseler, USA.MTA is used commonly because of its advantages excellent sealing ability, and biocompatibility (31).

FLAP REPOSITIONING AND SUTURING

The ultimate esthetic result of the soft tissue manipulation depends on several factors such as the type of tissue, the type of incision, the choice of instruments used to incise, elevate, and retract the flap as well as careful reapproximation and a proper suture technique (32). The soft tissue can become dehydrated during the procedure and rehydrating it will return its natural elasticity and allows for easier reapproximation. The continuous sling suture and the single knot (interrupted) suture commonly used suturing techniques in microsurgery. The single knot suture has the advantage of being a stable, precise suture and allows for primary closure but it requires time and meticulous application, especially while suturing a submarginal flap in the anterior region (33).

PROGNOSIS OF ENDODONTIC MICROSURGERY

The main objective of outcome assessment after endodontic treatment is to observe healing or improvement in apical periodontitis. Modern microsurgical periradicular surgery uses technical advances, mainly the dental operating microscope, ultrasonics, modern microsurgical instruments, and biocompatible root-end filling materials and has obtained highly successful treatment outcomes. The European Society of Endodontology (ESE) defines that regular clinical and radiographic follow-ups for a minimum observation period of 1-year are appropriate. The clinical success of microsurgically approached cases is reported to be as high as 96.8% and 91.5% at the short-term follow-up after 1 year and the long-term follow-up after 5 to 7 years, respectively (34). To obtain a successful outcome in terms of healing of the existing periapical pathology, along with a good long-term prognosis in microsurgery, the strict case selection is of paramount importance. Kim and Kratchman suggested a surgical classification A to F for proper case selection. In order to evaluate the outcome of the surgery, Molven created a diagrammatic representation of the follow-up radiograph to help the observer evaluate an X-ray with a well-defined visual aid in order to reduce bias and observer variability (35) . The radiographic classification consists of four groups. Success was defined as either group 1-complete healing or group 2-incomplete healing (scar tissue formation) and clinically by the absence of pain, swelling, percussion sensitivity, or sinus tract. Failure included group 3 - uncertain healing (reduced lesion size) or group 4; and unsatisfactory healing (same or increase in lesion size)(36)

CONCLUSION

With a high percentage of successful treatment outcomes of conventional endodontics together with high success of surgical endodontics, almost all teeth with endodontic lesions can be successfully treated. The challenge for the future will be the successful and predictable management of perio-endo lesions. Further well-controlled experiments, clinical as well as biological, need to be con- ducted on many new techniques and materials to meet the present and future challenges. On the basis of published research, MTA is the material of choice for use in microsurgery, but new bioactive materials, such as bioceramic, seem to be equally reliable and probably more user friendly in clinical practice.

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