MODERN AND CLASSICAL APPROACHES IN ENDODONTIC SURGERY

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ABSTRACT

Aim: The variable rate of the success of conventional endodontic surgery has led to the need for development of new techniques and instruments whereby classical endodontic surgery evolves into modern endodontic microsurgery. This article provides a systematic overview of the modern approach to surgical procedures in the domain of endodontic surgery with a critical overview of the basic differences and benefits of modern versus traditional doctrine, highlighting recent technologies and materials that contribute to a greater percentage of successful treatment of pathological lesions.

Materials and methods: Scientific papers, longitudinal studies, case studies, and clinical studies based on the recent dental trends in the world were analyzed and additional data was extracted from the professional literature and web pages.

Conclusion: Using a dental operating microscope, microsurgical instruments and biocompatible materials together with modern microsurgical principles, the rate of success of modern endodontic surgery is significantly higher than the success rate of conventional methods.

Keywords: endodontic microsurgery, dental operating microscope, magnification, root end resection, isthmus, ultrasonic retro-preparation, root-end filling material, prognosis, success rate

Introduction

Endodontic surgery is a dental procedure that treats cases of apical periodontitis that cannot be successfully treated via conservative orthograde endodontic treatment or other non-surgical retreatment [1, 2]. The most common procedure in endodontic surgery is apicoectomy, which implies surgical removal of the apical part of the tooth root along with the pathologically altered tissue, including the accessory root canals and additional apical openings that could be the cause of the failure of endodontic therapy [3]. Statistics reveals that large number of teeth treated by conventional methods have adequate prognosis; however, failure is an inevitable outcome in 5-10% cases, which, as such, require endodontic microsurgery [4].

In accordance with the above, in recent years there have been major changes in the concepts and procedures used in endodontic surgery. The changes relate to the approach and mode of inspection of the operating field, the size of the instruments, the use of ultrasonic tips, suturing materials and reintegration of tissues, and surgical techniques and procedures. The use of micro-instruments in combination with the operating microscope makes the process easier and more precise [1]. The aforementioned technical achievements have significantly increased the percentage of treatment success.

Disadvantages of classical endodontic surgery

Traditional opinion that endodontic surgery should be the latest therapeutic solution is based on insufficient clinical knowledge, previous experiences with inappropriate surgical instruments and inadequate overview of the operating field, frequency of postoperative complications and numerous failures [5]. As a result, a large number of teeth that could have been saved were unjustly extracted and compensated with implants [6].

Using a classical method, the therapist may locate important anatomical structures, such as large blood vessels, mental foramen or maxillary sinus, only approximately. Though the chances of injury to these structures are minimal, traditional endodontic surgery cannot guarantee safe work due to its invasive character [5, 7].

If based on traditional doctrine, it is assumed that the success of endodontic surgery depends only on the complete removal of necrotic tissue and the complete obturation of the entire root canal system, then the reason for the failure of the surgical treatment is quite clear. Examination of failed clinical cases and extracted teeth with an operative microscope confirmed that the therapist, however, could not approximately locate, clean, shape and obturate the ramification of the apical complex using traditional endodontic-surgical techniques [5, 8].

Differences between classic and modern endodontic surgery

The main advantages of modern endodontic surgery, in relation to classic endodontic surgery (**Table 1**), include:

(1) facilitating identification of the apex of the tooth root;

(2) less invasive osteotomy, and a significantly smaller angle of resection, which maximally spares cortical bone and the root of the tooth [7]; and

(3) a detailed examination of the surface of the resected root under high magnification is ensured [4]. Ultrasonic instruments in combination with a microscope allow conservative, coaxial final preparation and precise retrograde cavity obturation according to mechanical and biological principles of endodontic surgery [1, 5, 7, 9].

Visualization of the operating field

Success in endodontic microsurgery is conditioned by localization of the entire root canal system together with its uncompromising cleaning of pathologically changed tissue, as well as shaping and three-dimensional obturation [4]. Using the operating microscope (**Figure 1**), the therapist has easier access to hard-to-reach places affected by pathological processes and much more precise removal of pathological lesions, with minimal damage and invasion of healthy tissue when compared to conventional endodontic surgery.

Modern concepts and operative approach to soft tissues

Modern operative procedure of soft tissues differs significantly from the traditional one. The most

COMPARISON OF CLASSIC AND MODERN ENDODONTIC SURGERY		
	Classic	**Modern**
Magnification	The eye or loupe (1-4x)	Microscope (4-24x)
Lighting	Dental light	Focused light
Instrumentation	Macro instruments	Micro instruments
Size of osteotomy	Large diameter (8-10 mm)	Small diameter (3-4 mm)
Angle of resection	Acute (45-60 °)	Shallow (0-10 °)
Final preparation	It is not perpendicular to the axial tooth axis	Perpendicular to axial tooth axis
Depth of final preparation	1 mm	3 mm
Overview of the resected area	Not	Always
Material for obturation	Amalgam	MTA
Success rate	Below 50%	Above 90%

Table 1. Overview of basic differences between classic and modern endodontic surgery. Adapted [reprinted] from "Contemporary Endodontic Microsurgery: Procedural Advancements and Treatment Planning Considerations" [10]

commonly used semilunar incision is no longer recommended because of inadequate access to surgical site and difficult postoperative healing [9]. Removal of sutures is completed two to three days after surgery, but not one to two weeks. The main reason for this is in the fact that after 72 hours, the tissue tends to heal through the sutures, which can be very painful and uncomfortable for the patient during its removal [7]. New materials for suturing wounds, monofilamentous thread 5-0 and 6-0, allows faster healing and are presented today (**Figure 2**) [5, 7, 12]. Papilla base incision (PBI) is designed to maintain the height and integrity of interdental papillae, which are usually impaired by the use of

Figure 1. Modern clinical practice in which a dental operating microscope, besides clinical benefits, provides an ergonomic advantage to the therapist. Reprinted from "Surgery Concepts and Practice: A Review" [11].

Figure 2. (A) Microscopic stitching using monofilamentous string 5-0 and 6-0 (B) Removing seams after 48 hours (C) Wound healing, one week postoperatively. Adapted [reprinted] from " Modern Endodontic Surgery Concepts and Practice: A Review " [11].

sulcus incisions [13]. Finally, the retraction of the flap is facilitated by forming a relaxation groove inside the bone (**Figure 3**).

Optimal osteotomy

Thanks to the advantages of the operating microscope, osteotomy within the microsurgical procedure becomes further precise and less invasive, with a diameter of 3 to 4 mm in comparison to the traditional protocol where such diamond reaches a size up to 10 mm (**Figure 4**) [12, 14]. Smaller diameter of osteotomy is crucial for faster healing [15, 16]. The greatest advantage of using an operating microscope in osteotomy is the ability of clear distinguishing the tooth root from the surrounding bone. The root is dark yellow in color and more solid if compared to the softer, less solid bone that bleeds during probe scraping [5, 7]. Differentiation of the root from the surrounding bone under magnification is a crucial moment for maintaining less invasive osteotomy, and one of the greatest advantages of endodontic microsurgery.

Microsurgical concepts of the resection of the root apex

Reduction or complete elimination of the bevel angle is one of the greatest advantages of modern endodontic surgery (**Figure 5**) [5, 7]. According to the traditional procedure, root resection was performed at an angle of 45 ° to 60 ° [5, 7]. The only purpose of making this angle is easier access and visibility to the resected surface [18]. In essence, this angle was inevitable in classical endodontic surgery as the surgical instruments used were very large

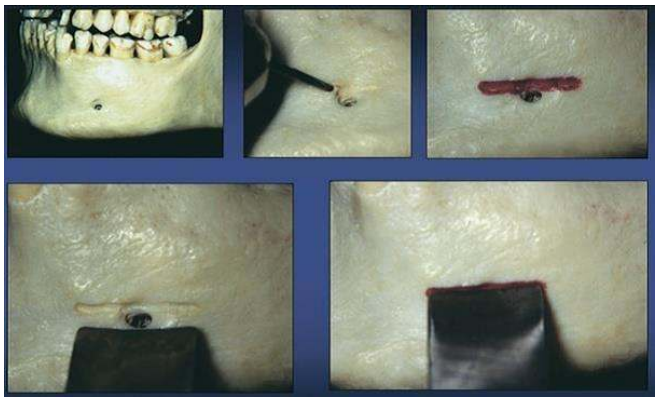

Figure 3. Overview of Groove tehnique. A small, narrow bony groove was formed just above the mental foramen. KP # 1 retractor remains in the groove enabling nerve protection during osteotomy. This technique prevents frequent retractor decompression during surgery and consequently reduces postoperative discomfort. Adapted [reprinted] from "Modern Endodontic Surgery Concepts and Practice: A Review" [11].

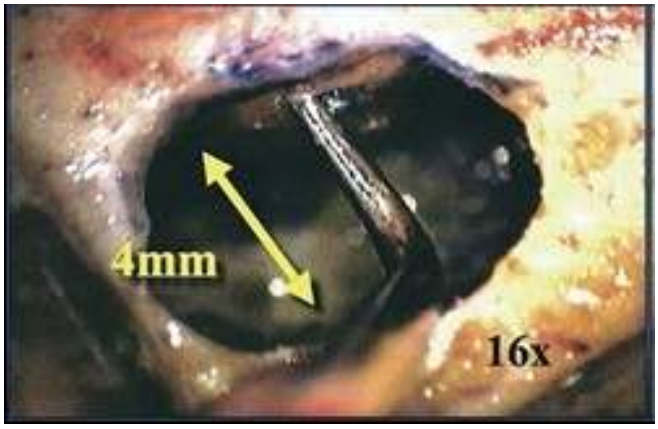

Figure 4. Ideal osteotomy is 4 mm in diameter, and as such within the bones allows unobstructed access with 3 mm ultrasonic tips (magnification x16). Adapted [reprinted] from "Color Atlas of Microsurgery in Endodontics" [17].

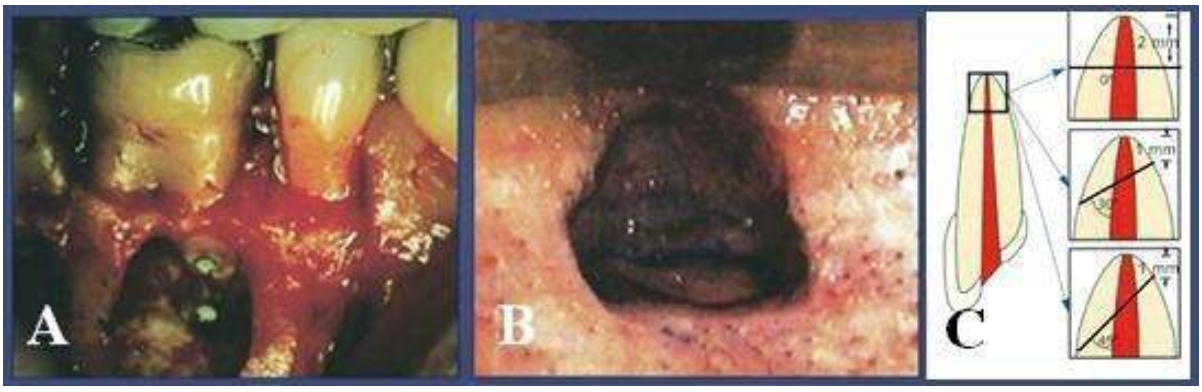

Figure 5. Comparison of (A) extensive osteotomy and acute bevel angle of resection made by the traditional method with (B) a smaller osteotomy without bevel angle of resection completed by modern microsurgical methods. The picture (B) is ten times larger in magnification than presented in the image (A). Adapted [reprinted] from "Modern Endodontic Surgery Concepts and Practice: A Review" [11] (C) Schematic representation of apical resection at angles of 0 °, 30 ° and 45 °. Adapted [reprinted] from "Endodontic microsurgery" [20].

when compared to today's micro-instruments (**Figure 6**). Root resection at such large angles often resulted in significant damage to the supporting tissue [19], which originally should be protected by this treatment. Root end cut at an angle of 0 ° to 10 ° relative to the axial root axis was introduced to minimize the potential risk of disrupting the static ratio of the crown length and root of the tooth, and also the supporting tissue (**Figure 5**) [5, 7, 18].

Root end removal, according to modern concepts, within the amount of 3 to 4 mm, is considered enough sufficient to remove anatomically irregular and contaminated radicular structures [21], as 3 mm of the root tip must be removed at least to neutralize 98% of apical ramifications and 93% of the lateral canals (**Table 2**) [1, 7, 9].

After making the root end resection, one of the most important moment in endodontic microsurgery is localization the micro-anatomic structures of the root, which is at the same time the primary reason for the failure of classical endodontic surgical treatment [1]. This surgical step cannot be adequately performed solely under eye control or using loupes, but exclusively by surgical operating microscopes under large magnification up to 24 times [1, 5, 7, 9, 15, 22]. Identification of the intracanal system and potential defects of the root dentin at the resection surface, with the exception of the operative microscope, is performed with the help of 1% methylene blue solution [9, 23, 24].

The frequent cause of failure in traditional endodontic surgical procedures is the absence of identification of the isthmus, and this is supported by the fact that in 80-90% cases, the isthmus is present already at 3 mm from the tip of the root apex [8]. The isthmus is a narrow ribbon-shaped communication between two adjacent root canals, and contains pulp or pulpal tissue derivatives (**Figure 7**) [1, 25]. As such, it is a part of the canal system, and therefore has to be thoroughly cleaned, shaped and filled with appropriate materials.

Ultrasonic preparation of a retrograde cavity

Contrary to classical endodontic surgery, where the conventional surgical hand-piece is used to produce a retrograde cavity, in modern endodontic surgery ultrasonic instruments are used for the same purpose, especially in terms of molars where numerous intracanal anastomoses and isthmus are present [22, 26]. The quality and depth of preparation

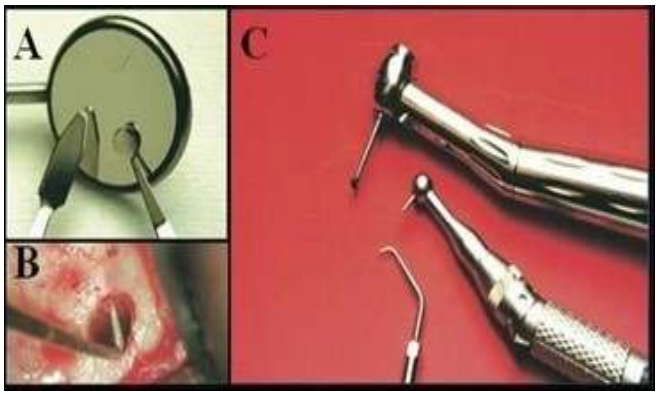

Figure 6. Comparison of traditional root end instruments with microsurgical instrument- ultrasonic instrument. (A) Surgical micro-mirror is much smaller than conventional dental mirror (B) Ultrasound KiS tip positioned for ultrasound preparation of retrograde cavity (C) Conventional hand-piece used for retrograde preparation (up), micro-head hand-piece (middle), modern ultrasonic microtips (bottom). Adapted [reprinted] from "Surgery Concepts and Practice: A Review" [11].

	1 mm	2 mm	3 mm
Apical Ramifications	52%	78%	98%
Lateral Channels	40%	86%	93%

Table 2. Incidence of apical ramifications and lateral canals at the levels of one, two and three millimeters from the top of the apex of the root. Apex resection at the level of three millimeters eliminates a large percentage of ramifications and lateral canals. Adapted [reprinted] from "Endodontic microsurgery" [20].

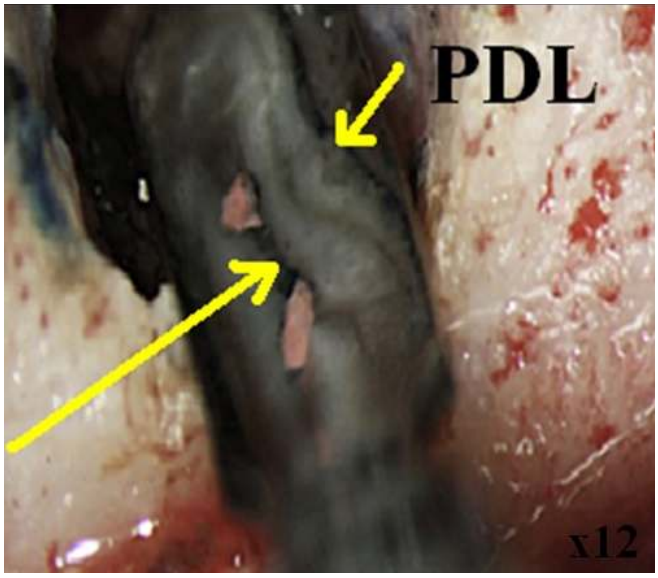

Figure 7. Microsurgical intervention on tooth 36. The resorbed surface on the mesial root is stained with methylene blue and is inspected under a medium magnification (x12). The inspection identifies the relationship that connects the messiobuccal and mesiolingual canal. Adapted [reprinted] from "Modern Endodontic Microsurgery Concepts: A Clinical Update" [9].

were improved using ultrasonic tips of various shapes (**Figure 8**) [27], which significantly reduced errors and complications, such as root wall perforation (**Figure 9**) [5, 28].

The depth of the average preparation is 3-4 mm [5, 30], but there are additional modern designed instruments that can penetrate up to 9 mm [31]. The ultrasonic preparation is performed according to the first-class cavity principle, in which the walls are parallel to each other and follow the course of the root canal.

Contemporary root end filling materials

The traditional technique of root end preparation with amalgam obturation has been suppressed with development of modern endodontic microsurgery and biocompatible root end filling materials [32, 33, 34]. 3 mm deep ultrasonically prepared cavities must be obturated with material that provides perfect hermetic seal [5]. According to the above, IRM and SuperEBA [15, 35] are often used, although the mineral trioxide aggregate (MTA) is a material of first choice for retrograde filling (**Figure 10**) [36, 37, 38]. However, there are even more modern bioceramic materials, Bioaggregate [39] and EndoSequence (RRM, RRP), which distinctively reveal optimal results with respect to MTA [40].

Clinical prognosis

Clinical success of traditional endodontic surgical treatment is very sporadic [5, 41, 42], and when compared with the results of modern approaches, acceptable results are very low [5]. A classical study by Frank and associates [43] showed that 42.3% of cases treated with a traditional method, which were recorded as successful, were in fact unsuccessful after 11 to 15 years. Based on the studies, it was revealed that the success of the microsurgical procedure was 96.8% after one-year, and 91.5% after 5 to 7 years of the follow-up [6, 15]. Recent studies have shown similar results after one-year and many years following up [44].

Endodontic microsurgery as an integral part of the treatment

According to the above, endodontic microsurgery should not be considered as the last therapeutic measure, but as an integral part of endodontic treatment [5]. As such, endodontic microsurgery should be used in many situations indicated for the rescue of morphological and functional integrity of a natural tooth. This is a predictable method, with minimal postoperative symptoms, which effectively neutralizes and eradicates causes of persistent apical pathology [45, 46].

Figure 8. Display of a set of ultrasonic attachments for retrograde cavity preparation. Adapted [reprinted] from "www.Jmoritausa.com" [29].

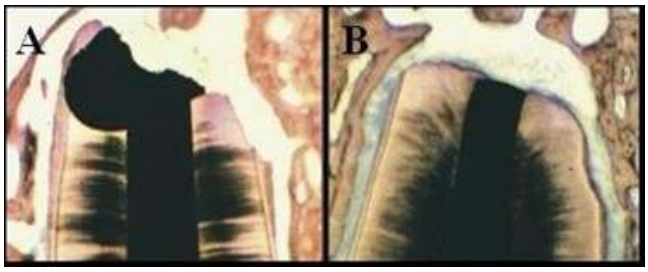

Figure 9. Histological representation of final preparation of retrograde cavity. (A) Conventional retro-cavity preparation by a bur. (B) Contemporary retro-cavity preparation with ultrasonic tip. The attached concludes that the conventional preparation by the bur could result in lingual perforation, while the ultrasound preparation preserves the integrity of the root apex. Adapted from "Modern Endodontic Surgery Concepts and Practice" [11].

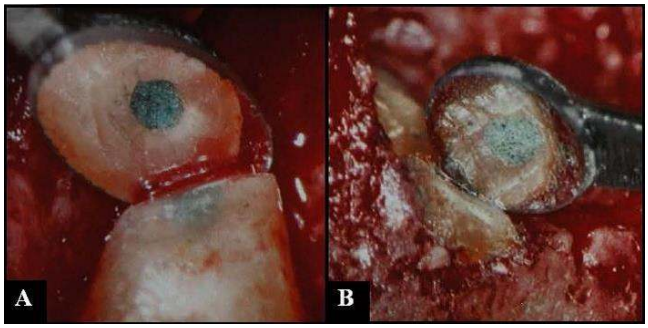

Figure 10. A, B) Display of root end cavity filled with mineral trioxide aggregate (MTA). Adapted [reprinted] from "Endodontic microsurgery" [20].

Conclusion

Endodontic surgery has evolved into endodontic microsurgery, which is considered as predictable

treatment option that can preserve morphological and functional stability of the natural tooth with periapical pathology, which has not been previously achieved by conventional endodontic surgical treatment. By using an operative microscope, allowing optimal visualization and illumination of the operating field, microsurgical instruments and biocompatible materials, together with modern microsurgical principles, the rate of success of modern endodontic surgical treatment is significantly higher compared to conventional methods. Through continuous education of professional staff and patients and consistent dedication to development and emphasizing the importance of non-conventional approach, endodontic microsurgery could become an integral therapeutic procedure in endodontics.

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