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Endodontic Microsurgery – An Overview

Bushra Almas[1], H. Murali Rao[2], B.S Keshava Prasad[3], Megha Rao[4]
[1]*Post Graduate Student, Department of Conservative Dentistry and Endodontics, D.A. Pandu Memorial RV dental college, Bangalore , India.*
[2]*Professor, Department of Conservative Dentistry and Endodontics, D.A. Pandu Memorial RV dental college, Bangalore, India.*
[3]*Professor and Head of the Department of Conservative Dentistry and Endodontics D.A. Pandu Memorial RV dental college, Bangalore, India.*
[4]*Post Graduate Student, Department of Conservative Dentistry and Endodontics, D.A. Pandu Memorial RV dental college, Bangalore, India.*

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Abstract
Endodontic diseases of pulp and periapical origin are treatable with nonsurgical endodontic treatment. Certain conditions attribute to failure of non surgical root canal treatment. Surgical endodontics is preferred in such cases but due to poor visibility, unsuitable instruments ,post operative complications, surgery was seen as a last resort. With the advancements in technology such as operating microscope, newer instruments and improved materials, endodontic surgery emerged as Endodontic Microsurgery.

Keywords : Endodontic surgery, microsurgery, microsurgical instruments, dental operating microscope

Introduction

The level to which the clinician sees is well established to have an impact on the quality of treatment. As Carr famously said,"You cannot treat what you cannot see" applies perfectly here. As a result, it was apparent that discovering ways to better our vision could only help us achieve our objectives.[1] There has been an outbreak in the development of newer techniques, devices, and materials for nonsurgical and surgical endodontics in the past decade. Endodontic treatment has become more precise as a result of these advancements. These advancements have allowed clinicians to perform surgeries that were previously thought to be impossible. The most important advancement was the introduction and use of the Operating Microscope (OM) which changed both nonsurgical and surgical endodontic therapies.[2] In surgical endodontics, the apical region of the root end can be examined carefully and an apical root resection can be performed without an exaggerated bevel thus ,making it easier to perform class I cavity preparations along the root's longitudinal axis.[1]
Along with increased microscope visualisation, technological advancements such as specifically developed instruments, improved root end filling materials, and a better understanding of the biology of wound healing have all contributed to the modern idea of "Microsurgical Endodontics."[3] These developments marked the beginning of the era of endodontic microsurgery.[4] Studies have proved that there is a substantial difference in the outcome of surgery performed with and without the use of microscope.[5,6]

Endodontic microsurgery was defined as a surgical treatment performed with an operating microscope on extremely small and intricate structures. It now combines the microscope's magnification and illumination with the correct application of novel microinstruments. Endodontic microsurgery eliminates the assumptions inherent in standard surgical procedures and can be conducted with precision and predictability. Microsurgery's importance and relevance in modern endodontic therapy can be summed up in a simple formula.[7]
Magnification + Light = Excellence

History[8]

Surgical management of abscessed teeth has been practiced for hundreds of years, although surgical resection of roots did not become common place until **1880s**

- Hullihen in 1845 - Surgical Trephination
- Smith in 1871- First root end resection
- 1880s - Curettage was performed to remove diseased tissue around the apex

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- Farrar in 1880 - Performed a procedure on abscessed teeth referred to as an "apicotomy."
- Black GV in 1886 - Amputation of the apex of the root in the case of long-neglected abscess with the use of a fissure bur
- Garvin, Luks, Gaerny in 1916 - Use of root end preparations and root end fill with amalgam
- Neumann in 1926 - Split thickness surgical flap now a days known as Oschenbein-LuebkeFlap
- Tangerud BJ- 1939 - Miniature handpiece for root-end preparations

Classification of microsurgical cases

Endodontic microsurgical cases have been classified into classes on the basis of the etiology, presence and size of the periradicular lesion, the degree of tooth mobility, as well as the pocket depth by **Kim and Kratchman**[9] (Figure 1)

Classification of Microsurgical Cases

Class A	Class B	Class C	Class D	Class E	Class F
No periapical lesion, Clinical symptoms not resolved	Small periapcal lesion with clinical symptoms	large periapical lesion progressing coronally	Similar to Cass C	large periapical lesion with an endodontic-periodontal communication to the apex.	apical lesion and complete denudement of the buccal plate
normal pocket depth	No periodontal pocket	No periodontal pocket	Deep periodontal pockets	no obvious fracture	
no mobility,	No mobility	No mobility	No mobility	No mobility	No mobility
NSRCT* not successful	Ideal candidates for endodontic microsurgery				

- ***NSRCT** = Non surgical root canal treatment

Inference :

- Periapical lesions categorized into classes A–F
- Lesion types A, B, and C represent lesions of endodontic origin are ranked according to increasing size of periradicular radiolucency.
- Lesion types D, E, and F represent lesions of combined endodontic- periodontal origin and are ranked according to the magnitude of periradicular breakdown.

No mobility in any of the classes

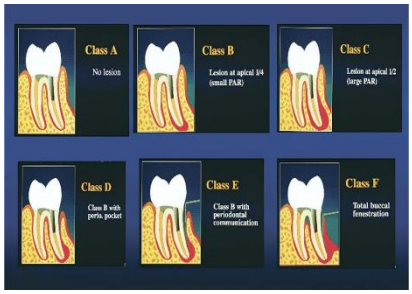

Figure 1- Classification of microsurgical cases

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Comparison of traditional and microsurgical endodontics

Endodontic surgery is usually perceived as difficult as it requires the surgeon to approximate the location of anatomical structures such as large blood vessels, the mental foramen, and the maxillary sinus. Although the chances of damaging these structures are minimal, yet there seems to have traditional endodontic surgery does not have a positive image in the dental profession because of its invasive nature and questionable prognosis.[7]

While on the other hand , the advantages of microsurgery include easier identification of root apices, smaller osteotomies and shallow resection angles that conserve cortical bone and root length. In addition, a resected root surface viewed under high magnification and illumination will reveal anatomical details such as isthmuses, canal fins, microfractures, and lateral canals. Along with the microscope, use of ultrasonic instruments permits a conservative, coaxial root-end preparations and root-end fillings which are precise, thus, satisfying the requirements for mechanical and biological principles of endodontic surgery.[9,10]

Differences between traditional and microsurgical approaches[4,9]

	Traditional	**Microsurgery**
Magnification	loupes	Dental operating microscope
Flap design	Semilunar flap	Papilla preservation
Identification of the apex	Difficult	Precise
Osteotomy size	Approx. 8–10 mm	3–4 mm
Inspection of resected root surface	None	always
Bevel angle	Large (45degree)	Small(<10 degree)
Isthmus identification & treatment	Impossible	always
Root-end preparation	Approximate (seldom insideCanal)	Precise (always withinCanal)
Root-end preparation Instrument	Bur	ultrasonic tips
Root-end filling material	Imprecise	precise
Sutures	4 X 0 Silk	5 X 0, 6 X 0 monofilament
Suture removal	7 days post-op	2–3 days post-op
Healing Success (over 1 year)	40-90%	85-96.8%

Endodontic Microsurgery's triad:

Magnification, illumination and instruments make up the TRIAD of endodontic microsurgery. Microsurgery would not be possible without any of these components.

Magnification – Dental operating microscope[2,11]

One of the most significant developments in surgical endodontics has been the adoption of the surgical microscope.

Benefits of using surgical microscope in clinical practice:

- Inspection of surgical field at high magnification to observe minute and fine details
- Evaluation of surgical techniques in a better way

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- Fewer or no radiographs needed during the surgery
- Video recording of the procedure for patient teaching
- Communication with referring dentists and insurance companies
- Reduction of occupational stress
- Documentation of cases

Use of magnification in stages of Endodontic Microsurgery[9] :

Magnification	**Stage of surgery**
Low (x3 to x8)	Orientation , alignment of surgical tips
Midrange (x10 to x16)	Surgical procedures, retropreparations
High (x16 to x30)	Inspection and observation of fine details

Illumination[2]

Light sources attached to DOM allows the clinician to see depth of field.
As the magnification is increased, the effective aperture of the microscope is decreased, and therefore more light is needed
Two light sources systems are commonly available:
1.The xenon halogen bulb used in a fan-cooled system and
2. The quartz halogen bulb

Microsurgical instruments[12]

Microsurgical instruments are miniature versions of regular surgical instruments that are specifically designed for the precision needs of endodontic microsurgery to work under the microscope. The design and manufacturer of the first generation of microinstruments is *Dr.Garry Carr*[10]
Microsurgical instruments are described under following categories

1. Examination Instruments(Figure 2)
The examination instruments include the mirror, periodontal probe, explorer, and microexplorer. The dental mirror, periodontal probe, and endodontic explorer are standard instruments in endodontic practice. The micro explorer is the only tool built exclusively for microsurgery. On one end, the 2-mm tip is bent 90 degrees, while on the other, it is bent 130 degrees. This instrument is especially effective for locating the exact location of a leak on the resected surface as well as differentiating a fracture line or a crack from an insignificant craze line.

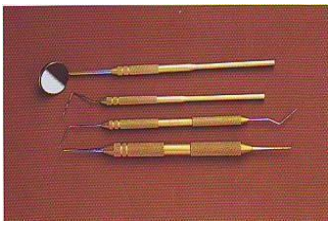

Figure 2 : Examination Instruments

2. Incision and elevation instruments include: 15 and 15 C blades, mini scalpels and blades, Periosteals Molt 9, Prichard PPR3 , PPBuser, P145S, P9HM, P4 elevators. A 15 C blade is ideal for microsurgery to make a

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vertical releasing incision in one stroke. When the interproximal spaces are exceedingly small, microblades are indicated.Periosteals Molt 9, Prichard PPR3(Figure 4), PPBuser, P145S, P9HM, and P4 elevators(Figure 5) are soft tissue elevators.They have thin, sharp edges and points that allow the soft tissues to be lifted off the bone clearly and completely with minimal tissue damage.The Rubinstein Mini-Molts are now available in two different sizes configurations with 2 and 3.5mm working ends and 2 and 7 mm working ends The tiny ends of these devices allow for atraumatic interdental papilla elevation.

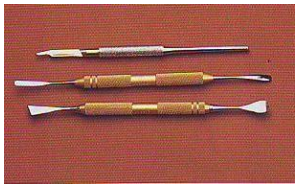

Figure 3 : Incision and Elevation instruments

Figure 4: Pichard elevator

Figure 5 : P4 elevator

3. Retraction instruments : KimTrac P1 and P2 retraction tools separate the raised soft tissues from the surgical region. The Kim/Pecora (KP) 1, 2, and 3 retractors (Figure 6) are 0.5mm thinner and have serrated tips that attach the retractors to the bone. The KP4 retractor is a small, all-purpose retractor with the same features as the others, but with the addition of 10 mm width.

Figure 6: Kim Pecora tissue retractors. (KP1, KP2, KP3 and KP4).

4.Osteotomy instruments.

The Impact Air 45 hand piece (Figure 7) features a 45-degree angled head that makes working in difficult areas easier and is designed to distribute water onto the cutting surface. This decreases the risk of emphysema and pyemia while also producing less spatter than a standard hand piece.

The H 161 Lindemann bone cutting bur features fewer flutes than standard burs, resulting in less clogging and frictional heat, as well as increased cutting efficiency.

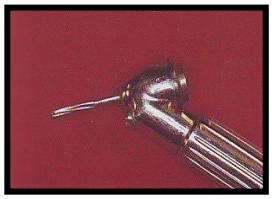

Figure 7: Impact 45 hand piece with Lindemann

5. Curettage Instruments : A periodontal curette, a minijacquette 34/35 scaler, a Columbia 13-14, and minimolten and miniendodontic curettes are employed . Miniendodontic curettes and minijacquettes were designed specifically for this purpose.

6. Instruments for root end preparation

A noteworthy innovation in endo microsurgery is the use of a piezoelectric ultrasonic tips for root end preparation. Carr tips or CTs are ultrasonic tips first invented by Dr.Garry Carr and are available as CT 15. (Kim

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Surgical) Area-specific ultrasonic tips (KiS tips 1-6) (Figure 8) are coated with zirconium nitrite and contain an irrigation port near the tip for efficient irrigation.(Figure 9)

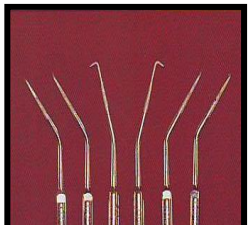

Figure 8 : KiS tips in the order of KiS 3, KiS4, KiS1, KiS 2, KiS5, KiS6

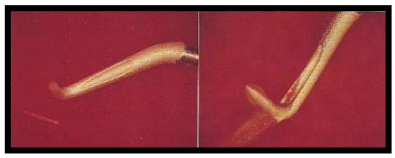

Figure 9: KiS tip with irrigation port near tip

KiS 1 tip: has an 80 degree angled tip and is of 0.24 mm in diameter, is designed for the mandibularanterior teeth and premolars.
KiS 2 tip: has a wider diameter tip and is designed for wider apex teeth (eg: maxillary anteriors)
KiS 3 tip: designed for posterior teeth which are hard to reach. It has a double end and a 75 degreeangled tip for use in the maxillary left side or the mandibular right side.
KiS 4 tip: similar to the KiS 3 except that the tip is angulated at 110 degree, to reach the lingualapex of molar roots.
KiS 5 tip: is the counterpart of the KiS 3 for the maxillary right side and the mandibular left side.
KiS 6 tip: counterpart of the KiS 4 tip

7. Instruments of inspection
Micromirrors(Figure 10): The mirrors are highly polished double-sided instruments available in a variety of sizes and forms, including round and rectangular shapes, that allow for optimal access and vision in all clinical scenarios and are tiny enough for convenient use into an osteotomy size having with a diameter of 4 to 5mm.The flexibility of the rectangular micromirror's neck allows it to be positioned at a 45-degree angle to the resected root, reflecting the entire root surface.

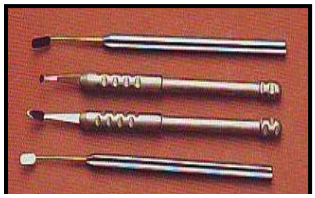

Figure 10 : Micromirror

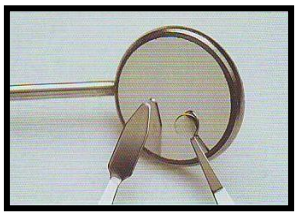

Figure 11 : Micromirror in comparison with regular dental

8.Retrofilling carrier and plugging instruments
On one end of each Retrofilling carrier is a 0.5-mm diameter ball, while on the other is a 1-mm wide blade. The flat surface is used to transport retrofilling material to the retropreparation, while the ball end is used to pack it in. Micropluggers with 3mm long ball ends that are 0.2 or 0.5mm in diameter.
Micropluggers(Figure 12) with different bends and angles and Comparison between microand macro pluggers

Figure 10 : comparison of micro and macropluggers

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9. Instruments for suturing(Figure 11)
Laschal microscissors, or other small-beaked scissors, and the Castroviejo needle holder are utilized to manage 5-0 or 6-0 synthetic sutures used for microsurgical cases

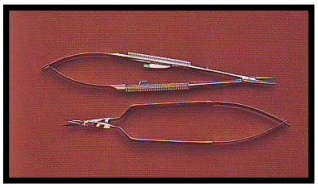

Figure11: suturing instruments (Top- Castroviejo needle holder, bottom- laschalmicroscissors)

10.Miscellaneous instruments
To smooth the bone and root surface, a large ball burnisher and a bone file are used, as well as a micro ronguer to remove granulation tissue from a lesion.

Case selection

Indications : patient presenting with persistent pain after previous endodontic therapy, anatomic variations and procedural errors that prevent complete debridement and obturation of root canals, exploratory surgery

Contraindications :Proximity to anatomic structures , periodontal defects which prevent successful endodontic outcome, very old and ill patients who cannot withstand stress and long surgical procedure , When clinicians encounter situations beyond their ability
Relative contraindication In most cases, the patient's medical condition does not preclude endodontic microsurgery. Patients with such diseases as leukemia or neutropenia in the active state; severely diabetic patients; patients who have recently had heart surgery or cancer surgery; and older, ill patients are the rare exceptions. [13,14]
Pre-assessment: Medical status of the patient, antibiotic prophylaxis, and radiographic evaluation of the tooth for vital information such as length, number of roots, and degree of curvature, among other things.[9]

Procedure for microsurgery
Anaesthesia and Hemostasis are linked because it not only influences the comfort of the patient during the procedure but also improves the convenience of the operator by the virtue of the control of hemorrhage at the surgical site.[4]

Administration of local anesthetic:
Standard protocol is divided intoregional and local injections and are as follows:
The administration of a long-acting anesthetic agent such as bupivacaine as a block technique to obtain a sustained level of anesthesia beyond the duration of the surgery ,Once regional anesthesia has been achieved, then a local infiltration of lidocaine 1:50,000 epinephrine is injected over the intended flap extent, concentrating the bulk of the infiltration overthe surgical site.4 prolonging anaesthesia not only relieves acute post-operative pain, but it also lessens long-term pain by diminishing central sensitization. Before making the initial incision, wait at least 15 to 20 minutes for the anesthetic's vasoactive agent to constrict the blood vessels in the soft and hard tissues.
Once an incision has been made and the flap is reflected, topical hemostats, play an important role in achieving hemostasis. Hemostasis of surgical area : epinephrine pellets, cotton pellets soaked in ferric sulphate solution , resorbable calcium sulphate paste [4,9,11]

Soft tissue management :
New concepts and practice in soft tissue management

The following management procedures have changed from the traditional techniques.

1. The semilunar incision, the most popular flap design technique with anterior teeth, is nolonger recommended because of inadequate access and scar formation.[4]
2. The removal of sutures is done within 48 to 72 hrs

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3. New suture materials are monofilament, gauge 5-0 or 6-0 to provide rapid healing.[9,10]
4. The papilla base incision (PBI) has been developed to prevent loss of interdental papillaheight with sulcular incisions.[15,16]
5. Flap retraction during the surgery is facilitated by making a resting groove in the bone, especially during mandibular posterior surgery to ensure retraction.[9]

Flap designs :

1. Full mucoperiosteal which can be of triangular, rectangular, trapezoidal and horizontal (envelope) design.
2. Limited flap design which includes submarginal curved (semilunar) and submarginal rectangular (Ochsenbein Luebke).

In almost all cases, the full flap design should be considered before anything else[15]
The Ochsenbein-Luebke flap was the design of choice in the maxillary anterior when there wereconcerns about exposure of crown margins or gingival recession following apical surgery
Velvart proposed the papilla-base flap , which is a hybrid of a full sulcular and split-thickness incision.[15,16]

Flap elevation :The periosteum and overlying gingiva are lifted and reflected with a sharp elevator once the incisions have been formed. In fact, complete periosteum removal allows for a blood-free surgical area, which is crucial in microsurgery[9]

Atraumatic Tissue Retraction and the Groove Technique

When operating in the molar/premolar region near the mental foramen, a new approach to protect the mandibular nerve and prevent nerve parasthesia has been developed. A Lindemann bur or a #4 round bur is used to cut a 15-mm long horizontal groove into the water-cooled bone. To allow space for the osteotomy and subsequent apicoectomy, this groove must be constructed beyond the apex. The groove allows the serrated retractor tip to be securely anchored and the flap to be retracted securely and steadily.[7,15]

Osteotomy : smaller is better

The H 161 Lindemann bone cutter and the Impact Air 45 hand piece are best suited for creating an Osteotomy. Smaller osteotomies, usually 4–5 mm, are recommended for microsurgical procedures because they recover faster. This new size criteria for an osteotomy is "just large enough to manipulate ultrasonic tips(3mmin length) freely within the bony crypt. Water or saline coolant applied immediately to the cutting surface reduces temperature rise and limits or prevents damage.[9]

Distinction between bone and root tip[4:] A major purpose of using the microscope for making the Osteotomy is to clearly distinguish the root tip from the surrounding bone. The root has a darker, yellowish color and is hard, whereas the bone is white, soft, and bleeds when scraped with a probe. The Osteotomy site is stained with methylene blue when the root tip cannot be differentiated from its surroundings. The root tip and the bone can be distinguished from each other at X16

Curettage

periradicular curettage is an important part of the procedure Columbia # 13 and #14 curettes and Molten or Jacquette 34/35 curettes are used to completely remove the granulation tissue under medium magnification (X10 to X16). Large curettes, such as a 33L spoon excavator or a #86 Lucas bone curette are suitable for the enucleation of large lesions.The Jacquette 34/35 scaler allows efficient removal of tissue from the junction of the bone crypt and the
root.7,9,15

Apical root resection

This phase is perhaps the most pivotal of the surgical procedure. Length of resection is dependent on the restorative implications of the resection with regard to crown-root ratio.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.[17]
If there are no obvious microscopic or radiographic issues, apicectomy can be performed by removing 3 mm of the root.[2,11] If there are anatomical variances, separated instruments, or perforations, more than 3 mm of the root

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can be removed, as long as the tooth has enough root length to be stable.[11] A zero-degree bevel should be achieved by resizing the root tip perpendicular to the tooth's long axis. This gives the root-end flling a 90-degree cavo-surface margin.

Root end preparation

In order to maximize the seal provided by the root-end flling, the root-end preparation should be at least 3 mm deep.[18] Ultrasonic tips have a better success rate when utilised to prepare the root-end.[13,19] Root end resection of 3mm coupled with a root end preparation depth of 3 mm, 6mm of infectious etiology in the canal spacewill have been effectively treated[19,20]

Inspection of resected root surface

After the retropreparation is completed, the prepared cavity is inspected with a micromirror at a high magnification (X 16 to X 25). Isthmuses and fins linking the canals must be identified and debrided with the piezo tips if they are present. Gutta-percha thermoplasticized as the ultrasonic unit is triggered is recondensed with a small, 12 mm microplugger, resulting in a smooth, flat base against which the retrofilling material can be placed.[9,19]

Retrofilling materials :

Long term biocompatibility, bacteriocidal or at least bacteriostatic property; excellent sealing ability and promotion of regeneration of the original tissues are all important factors to consider when choosing a retrograde filling material. Bioactive and bioceramic materials are preferred materials. Among various materials used for retrofilling , MTA was shown to have excellent sealing ability, promoted osteoblast activity and had an antimicrobial effect. It was less cytotoxic than amalgam, IRM or SuperEBA.[4,21] Chong et al[22] compared MTA and IRM when used as root-end filling materials in endodontic surgery in which MTA resulted in high success rate than that obtained using IRM. Nevertheless , MTA possess certain disadvantages of poor handling and longer setting time which can be overcome by using Biodentine.[23]

Repositioning the flaps

After the mucogingival tissues have been reflected, a retractor must be secured on sound bone to prevent crushing of the soft tissue, which can result in increased post-operative swelling and bruising. A small round bur can be used to make a fine groove in which the retractor can be positioned to prevent tissue from slipping under it. Excessive retraction trauma can result in increased swelling and delayed healing, thus the length of the crevicular or relieving incisions can be lengthened if necessary to relieve fap tension and avoid straining and tearing. To prevent fap shrinkage, the reflected fap should be rehydrated with sterile saline on a regular basis. Extended intervals of fap must also be considered when calculating surgical duration.[9,15]

Suturing

Monofilament non absorbable sutures are a material of choice for suturing in microsurgery. These synthetic sutures seem to be the least traumatic and cause less inflammatory reaction. A small diameter reverse cutting needle with 5/0 is used commonly. The sutures should be removed 7 days after surgery. [17,24]

Soft tissue healing

Reduced tissue trauma and enhanced wound approximation without tension during microsurgical treatment result in faster soft tissue healing.The flap design has a significant impact on the amount of postoperative recession. After endodontic surgery, papilla base flaps have enabled for nearly recession-free recovery. 29With the incorporation of newer techniques and materials, modifications, healing after surgery leaves almost no scars thus contributing to optimum esthetic recovery.[4,15]

Pain and swelling, ecchymosis, hemorrhage, parasthesia, serious infection are some of the potential post operative complications

Success of endodontic microsurgery

Does the microsurgical approach provide better treatment results than the traditional techniques?According to the data published in Journal of Endodontics in January 1999, the important findings of the clinical study were :

*Most healing takes place by 7.1 months indicating that the usual 6months recall is too short

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*The larger the lesion, the slower the healing indicating a direct relation between the size oflesion and the time required for healing
*Of the endodontic cases that did not involve a periodontal pathology , 96.8% of the cases healed completely within 1 year
*Microsurgical techniques showed greater clinical success at the 1 year recall visit

*The postoperative sequelae are significantly reduced with microsurgery.[9]

Conclusion : Endodontic surgery has now evolved into endodontic microsurgery. With the improvements in equipments, instruments, and materials endodontic microsurgery can be performed with predictable outcomes.

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