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Minimally Invasive Surgery: A Paradigm Shift in Surgical Procedures

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Abstract:- Minimally Invasive Surgery (MIS) and microsurgery have significantly transformed periodontal treatment by reducing tissue trauma and improving patient outcomes. MIS focuses on minimizing flap reflection and tissue manipulation, preserving blood supply, and ensuring the stability of blood clots at the wound site, which collectively reduce postoperative complications such as shrinkage and discomfort. Microsurgery, enabled by advancements in surgical microscopes, enhances visual acuity and allows for precise surgical interventions. In periodontology, the integration of MIS and microsurgery has led to refined surgical techniques that prioritize minimal tissue disruption, passive wound closure, and the use of specialized microsurgical instruments. These approaches offer significant advantages over conventional flap surgeries, which were often associated with extensive tissue damage, prolonged healing times, and aesthetic compromises. The evolution of MIS in periodontology represents a shift from resection-based procedures to those focused on regeneration, emphasizing the importance of skill enhancement and the adoption of advanced technologies. As MIS techniques continue to develop, they hold the potential to become the standard of care, providing patients with effective, less invasive treatment options that result in better clinical and aesthetic outcomes. The current article's goal was to gather and record different minimally invasive periodontology techniques. Peer-reviewed materials from journals, Medline/PubMed, Google Scholar, and other reviews served as the foundation for the research.

***Keywords**:- Microsurgery, Flap Surgery, Periodontitis, Tissue Trauma.*

I. INTRODUCTION

Minimally Invasive Surgery (MIS) is a surgical approach that reduces flap reflection and tissue trauma, thereby maintaining the stability of the blood clot at the wound site by preserving the essential blood supply, which in turn minimizes postoperative shrinkage over time. Microsurgery, a refined surgical technique made possible by advancements in visual acuity through the use of surgical microscopes, was broadly defined by Daniel RK in 1979 as a technique performed under magnification provided by an operating microscope. Periodontal microsurgery, defined by Shanelec in 1992, refers to refinements in basic surgical techniques made possible by the use of a surgical microscope and the enhanced visual acuity that it provides.

The philosophy of minimally invasive surgery encompasses three key principles: 1) enhancing surgical precision through improved motor skills, 2) achieving exact primary apposition of the wound edge through passive wound closure, and 3) utilizing microsurgical instruments and sutures to minimize tissue trauma. Periodontitis is a chronic inflammation of the periodontium that extends beyond the gingiva and involves the destruction of the connective tissue attachment of the teeth. Treatment typically involves debridement of the tooth surface and adjacent areas through scaling, root planing, and periodontal flap surgery.

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While scaling and root planing are conservative, non-surgical treatments, periodontal flap surgery provides access to the underlying bone for complete debridement, leading to pocket depth reduction, periodontal regeneration, and the maintenance of a healthy periodontium that can be sustained through routine home care by the patient.

Historically, conventional flap surgeries were employed to treat advanced cases of periodontitis, using extensive flaps to access diseased tissues. These procedures often resulted in the loss of interdental papillary gingiva, gingival height, and contour, as well as root sensitivity and crestal bone resorption. Such changes were considered inevitable consequences of the surgical procedures. Additionally, the extended duration of these surgeries often led to extensive tissue manipulation, resulting in increased postoperative pain, swelling, edema, and delayed healing. There has been a continuous effort to reduce or eliminate these surgical complications.

With technological advancements, there was a shift from resection to regeneration in the early 1980s, as researchers sought less invasive procedures that minimized postoperative mortality and morbidity. Any surgical procedure should be easy to perform, cause minimal trauma to tissues during both the intraoperative and postoperative phases, be time-efficient, not impose an economic burden on the patient, and ultimately benefit the general population. Considering these factors, Wickham and Fitzpatrick introduced Minimally Invasive Surgery (MIS), defining it as "smaller and more precise surgical procedures utilizing small incisions, operating microscopes, and microsurgical instruments and materials to achieve the same surgical endpoints as conventional techniques—such as probing depth reduction and regeneration of bone and supporting tissues—but with minimal negative changes in soft tissue contours and better aesthetic results."

Hunter and Sackier (1993) further refined the concept of MIS, describing it as "the ability to miniaturize our eyes and extend our hands to perform microscopic and macroscopic operations in areas that previously required large incisions." This concept was not new in general surgery, where laparoscopic surgeries, laser eye surgeries, and the use of magnification in neurosurgery were already in practice. In 1995, minimally invasive surgery (MIS) was first introduced into the periodontal literature by Harrel and Rees. This method involves surgical access that minimizes tissue trauma from reflection and manipulation, leading to better stabilization of the blood clot and reduced surgical morbidity. As surgical techniques become more minimally invasive and instruments continue to evolve, it is crucial that operators and surgeons also enhance their operating skills, as these procedures become increasingly technique-sensitive.

II. PRINCIPLES

The World Congress of Minimally Invasive Dentistry (MID) defines minimally invasive dentistry as a set of techniques that prioritize the health, function, and aesthetics of oral tissues by preventing disease or intercepting its progression with minimal tissue loss. Dr G.V. Black, known as the father of modern dentistry, introduced the concept of "extension for prevention," which contrasts sharply with the principles of MID. MID emphasizes early diagnosis and disease interception with minimal loss of healthy tooth structure, aiming to alter cariogenic flora either chemically or mechanically, to remineralize early lesions, and to focus on repairing rather than replacing defective restorations. Early diagnosis is crucial to prevent the loss of tooth substance, necessitating the use of advanced caries detection methods, such as laser fluorescence and ultraviolet illumination, which can detect caries before they progress to the enamel.

Dentistry is an art grounded in precision. While the human eye can discern fine details, its capabilities are significantly enhanced when images are sharpened and magnified. Microsurgery is a concept that intrigues many dental professionals, yet the inability of many clinicians to perform these procedures highlights a lack of understanding within the dental profession of the true potential of microsurgery. Periodontal microsurgery is a technique that increases visual acuity by using a microscope with magnifications exceeding 10x. The introduction of loupes, surgical operating microscopes, and micro-instruments has elevated periodontal surgery to a new level of sophistication, making the microsurgical approach a remarkable reality.

This review focuses on the application of periodontal microsurgery in managing flap procedures, root coverage, periodontal regeneration, and more recently, implant surgical procedures. Periodontal microsurgery refines basic surgical techniques by enhancing visual acuity through the use of surgical microscopes.

The three essential components of microsurgery, known as the microsurgical triad, are magnification, illumination, and refined surgical skills with specialized instruments. As noted by Belcher et al. in 2001, improving these elements is essential for achieving greater accuracy in surgical interventions. Without any one of these components, microsurgery is not feasible.

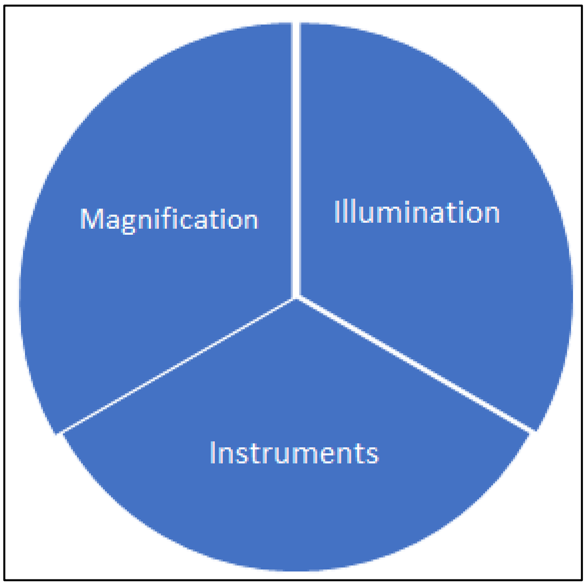

Fig 1 Microsurgical Triad

III. MAGNIFICATION

Dentists use magnification to enhance visualization, either by moving closer to the object or using magnification tools. The two main optical aids are magnification loupes and the surgical operating microscope (SOM).

A. Magnification Loupes

Introduced to medicine in 1876 by Saemisch, magnification loupes are commonly used in dentistry today. They allow for ergonomic benefits, increased working distance, and improved visual acuity. Loupes consist of two monocular microscopes with side-by-side lenses that focus on an object to create a stereoscopic, magnified image. The Keplerian optical system characterizes their convergent lens pattern. In periodontics, three types of loupes are used: simple, compound, and prism loupes.

B. Key Optical Features of Loupes

- Working Distance: The distance from the eye lens to the object, typically ranging from 30 to 45 cm, promoting better ergonomics and reducing eye strain. Short working distances can cause back, neck, shoulder, and eye problems due to increased eye convergence.
- Working Range (Depth of Field): The range where the object stays in focus. Although normal vision's depth of field extends to infinity, loupes limit this range, affecting posture and eye muscle position.
- Convergence Angle: Aligns the two oculars to the same distance and angle, varying with interpupillary distance. Wider-set eyes will have more convergence at shorter distances.

C. Types of loupes

➢ *Simple Loupes*

Simple loupes, which are basic magnifiers, have limited functionality and are composed of a pair of single, side-by-side meniscus lenses. They are prone to spherical and chromatic aberration, causing image distortion of the viewed object. Although they are cost-effective, the restrictions in size and weight render simple loupes unsuitable for magnification beyond 1.5 diameters, as this significantly reduces working distances and depth of field.

➢ *Compound Loupes*

Compound loupes utilize multiple converging lenses separated by air spaces to enhance refracting power, magnification, and working distance. These lenses can be achromatic, reducing chromatic and spherical aberrations by focusing two wavelengths in the same plane—an essential feature for periodontics magnification loupes. Typically, compound loupes are integrated into or attached to eyeglasses and can be adjusted according to clinical requirements without significant size or weight increase. Based on the Galilean optical system, they provide approximately 2.5X magnification. The benefits include superior magnification, broader depth of field, extended working distances, and a larger field of view. However, drawbacks include the lack of variable magnification and the potential need for a separate light source and anti-reflective coating to prevent light loss.

➢ *Prism Lopes*

Schmidt prisms or rooftop prisms are used in these loupes to extend the light path through a series of mirror reflections, enhancing the field of view, depth of field, and working distance. The prisms fold the light path, shortening the loupe's barrel, resulting in superior magnification. The compact design allows these loupes to be conveniently mounted on eyeglass frames or headbands. Additionally, they offer technical benefits such as improved magnification, a larger surgical view, broader depth of field, longer working distances, and the integration of coaxial fibre optic lights, which significantly enhances illumination of the operative area.

➢ *Surgical Operating Microscope*

The surgical operating microscope features a complex lens system providing stereoscopic vision with magnification ranging from approximately 2.5x to 20x, specifically between 10x and 20x for periodontal surgeries. It operates based on Galilean optical principles. The microscope can be mounted on the ceiling, wall, or floor, ensuring clinicians are not burdened by its weight or the need for a stabilized field of vision. According to Burkhardt and Hürzeler (2000), the optical unit of the microscope includes a magnification changer, objective lenses, binocular tubes, eyepieces, a lighting unit, and additional attachments. The magnification changer, or "Galilean" changer, contains one cylinder housing two Galilean telescope systems, each with a convex and concave lens providing different magnification levels.

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➢ *Periodontal Endoscope*

The periodontal endoscope enables subgingival visualization of the root surface at magnifications between 24x and 48x. This is achieved using a 0.99 mm fibre optic bundle, which includes a 10,000-pixel capture bundle surrounded by multiple illumination fibres. This bundle is connected to an instrument called an "explorer" and is delivered to the gingival margin. A single-use sterile sheath isolates the fibre, allowing for repeated use, typically averaging 70 to 80 uses per fibre. The captured image is displayed on a screen, providing the user with real-time video of the magnified environment (about 3 mm of the screen at a time). The fibre optic endoscope can be attached to periodontal probes and ultrasonic instruments designed to accommodate it.

IV. ILLUMINATION

When choosing an accessory light source, it's important to consider its total weight, light quality and brightness, ease of focusing, and transportability between surgeries. In loupes, each lens refraction causes a 4% light transmission loss and a 50% reduction in brightness unless anti-reflective coatings are used. Surgical microscopes, on the other hand, use coaxial fibre-optic illumination, providing an adjustable, bright, evenly lit, shadow-free circular light spot parallel to the viewing axis. Various fibre optic light sources can be attached to handpieces, instruments, or loupes, aiding in deposit removal from moderate to deep periodontal pockets. Recently, halogen lamps have become popular, but xenon lamps, lasting up to ten times longer, offer an alternative. Xenon lights have daylight-like qualities with a whiter colour, producing a brighter, more authentic image with better contrast.

V. MICROSURGICAL INSTRUMENTS

Microsurgical instruments are designed to make precise incisions and closures that facilitate healing by primary intention. These instruments are typically much smaller, often by a factor of ten. They can be made from titanium or surgical stainless steel. Titanium instruments are lighter, resist magnetization, and offer reliable manipulation of needles, sutures, and tissues, but they are more susceptible to deformation and generally more expensive. The Internal Precision Grip, or pen grip, is preferred for microsurgical tools. Instruments are usually about 18 cm long and often have a coloured coating to prevent unwanted metallic glare under the microscope. To minimize hand and arm muscle fatigue, each instrument should weigh no more than 15–20 grams (0.15–0.20 N). Retractors and elevators are also downsized for microsurgery. A basic periodontal microsurgery instrument kit typically includes knives and scalpel blades, micro scissors, anatomic and surgical micro forceps, a micro needle holder, and a micro scalpel holder.

A. Micro Ultrasonic Instruments

Micro ultrasonic instruments refer to advanced powered tools used for supragingival debridement. These instruments are small, roughly the size of a periodontal probe, and can be employed for both supra- and subgingival treatments. They operate at varying power levels with minimal to no water spray and require little or no additional hand instrumentation. Their small size reduces the risk of over-instrumentation of root surfaces as they are generally not sharp or abrasive.

➢ *Microsurgical Knives*

Microsurgical knives are designed to make precise, clean incisions for preparing flap margins for primary intention healing. The Castroviejo microsurgical scalpel, for example, creates incisions at 90-degree angles to the surface. Magnification helps in identifying and trimming ragged wound edges for a cleaner finish. These knives are noted for their extreme sharpness and compact size. The crescent knife is suitable for intrasulcular procedures, while the spoon knife is used to undermine the lateral sulcular area for connective tissue graft placement. Scalpel blades, such as the mini crescent microsurgical blade, come in various types including blade breaker, crescent, mini crescent, spoon knife, lamellar, and sclera knives.

➢ *Microsurgical Scissors*

Microsurgical scissors are used for dissecting tissues, blood vessels, and nerves. They come in various types, including micro scissors, extra fine micro scissors, both straight and curved. The most commonly used microsurgical scissors are 14 cm and 18 cm long.

➢ *Microsurgical Needle Holders*

These tools are designed to securely hold fine needles. Their design varies depending on how they grasp the needle, such as using a flat surface for flat needles.

➢ *Micro Forceps*

Micro forceps are utilized to handle delicate tissues without causing damage and to hold fine sutures while tying knots. Jeweller forceps are particularly strong and can be used to separate small vessels and nerves.

➢ *Microsurgical Needles*

Microsurgical needles are crafted from stainless steel and are directly attached to the suture ends. They come in various tip styles, including taper point, conventional cutting, reverse cutting, and spatula or side cutting. Effective microsurgery techniques involve precise needle placement, optimal tissue alignment, and the tying of square and slip knots. To minimize tissue trauma, it is preferable to use the sharpest needles, such as reverse cutting needles with precision tips or spatula needles with micro tips. For periodontal microsurgery, a 3/8" circular needle is typically used for optimal results.

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➤ *Microsurgical Sutures*

While 4-0 or 5-0 sutures are commonly used in periodontics, 6-0 and 7-0 sutures are more suitable for periodontal microsurgery. Proper microsurgical wound apposition helps reduce gaps or voids at the wound edges, facilitating quicker healing with less post-operative inflammation and pain. Knots tied under magnification are more secure and less likely to loosen under functional stress. Key aspects of microsurgical suturing include: an entry and exit needle angle of slightly less than 90 degrees, suture bite size about 1.5 times the tissue thickness, symmetrical bite sizes on both sides of the wound, and needle passage perpendicular to the wound.

VI. MICROSCOPE-GUIDED TECHNIQUES IN PERIODONTAL AND PERI-IMPLANT PLASTIC SURGERY

Recessions can generally be treated using a variety of methods and strategies, such as isolation or numerous root coverings. These methods can be categorised according to where the donor tissue for the root coating comes from. Pedunculated soft tissue grafting, free soft tissue grafting, and additive treatment—which replaces connective tissue with biomaterials—are the categories under which these procedures fall. The two most popular methods for treating recessions will be covered in this section: envelope and tunnelling assisted by microscopy techniques and coronal advanced flaps (CAF). We are able to carry out accurate and least intrusive interventions with the use of a microscope.

According to Shannelec, plastic periodontal microsurgery has the following advantages: 1. Improved motor skills, which enable surgical proficiency 2. Principal closure of wounds with a focus on passive flaps 3. Using tiny instruments and sutures to lessen tissue damage Both the incision and the microsuturing process result in less tissue stress when using the microsurgical approach. Furthermore, compared to those following macrosurgery, the healing time, inflammatory time, and necrosis risk are decreased if the first intention closure is carried out. Postoperative patient happiness and patients' long-term cosmetic satisfaction are two further characteristics that favour the microsurgery procedure. There has been evidence of a relationship between postoperative pain and problems and the invasiveness and duration of the surgical method.

When several criteria are met, an ideal cosmetic result in mucogingival surgery can be obtained. These include the suture technique—which is the most crucial parameter—many hours of practice to ensure the microsurgeon's training and mastery of the microsurgical technique, as well as the required instruments, materials, and visual aids.[36]

A. Incisions

Shanelec coined the phrase "periodontal microsurgery," which describes a technique with benefits for periodontal surgery. By combining enhanced visual precision with specially made microsurgical instruments for this process, it is possible to manipulate soft and hard tissues more precisely and with less damage, and to properly debride the defect and the root surface, increasing the likelihood of primary intention healing. Magnifications between 8 to 20 are excellent for periodontal microsurgery, depending on the type of intervention. The depth of field and field of view decreases with an increase in magnification, and therefore, the maximum magnification for a surgical intervention is limited to approximately 12× to 20× for localized problems such as the coverage of a single soft tissue recession.

Regardless of any potential anatomical restrictions, the scalpel blade should be perpendicular to the tissue's surface during the incision. The flap margins can only be achieved at 90° angles or with sufficient thickness on both sides of the incision line in this manner. Avoiding bevels is advised, particularly in thin forms. Furthermore, to obtain uniformly thick corners and well-defined edges, the first incisions that cross one another should be somewhat overextended.38 Utilising a microscope during these treatments is highly advantageous as it provides an up-close view of the flap thickness and boundaries of the incision, particularly when working with delicate tissues like the interdental mucosa that have a restricted vascular network.

There are two types of incisions depending on the direction: Vertical and Horizontal

➤ *Horizontal Sulcular Incision:*

This kind of incision leaves the margins entirely unharmed. With the blade of the scalpel in contact with the tooth and root surface, it is introduced through the gingival sulcus and directed apically towards the osseous tissue. The entire gingival edge is retained and integrated into the flap. Using a microblade in place of a scalpel and a microscope for magnification makes the operation more simpler while yet allowing for complete control and precision.Para marginal incision: This type of incision is located parallel or slightly apical to the gingival margin. The coronal tissue in the line of the Para marginal incision can be removed or de-epithelized depending on the procedure being performed.

➤ *Vertical Incision*

A vertical incision can either be integral to the flap design or serve as a releasing incision. It enhances accessibility or alters the flap’s position. The incision is typically made in the inter-root concavities with a slight divergence. The specific location of this incision depends on the procedure, whether it involves coronal or apical access or displacement of the margin. The goal is to avoid flawed scarring at the interdental papilla level. Therefore, the incision should be placed where the base of the papilla meets the gingival margin, rather than splitting the papilla in the middle. Maximizing the preservation of the papilla volume is crucial. Hence, the incision should not be at the gingival zenith, as this increases the risk of future gingival recession. When relocating the gingival margin, various flap designs, such as trapezoidal or triangular, are used (see treatment of gingival recession).

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B. Flap Designs

Depending on whether the periosteum is included, flaps are categorized as follows:

➢ *Mucoperiosteal Flap (Total Thickness)*

This design includes the epithelium, connective tissue, and periosteum, with the incision reaching the osseous tissue. It has characteristics such as:

- First intention healing
- Relative ease in design and execution
- Adequate blood supply due to the presence of the entire periosteum plexus
- Limited mobility
- Minimal bleeding

➢ *Mucosal Flap (Partial Thickness)*

This flap includes the epithelium, subepithelial connective tissue, and periosteum layer over the osseous tissue. Precision is critical when performing this incision, as the scalpel blade runs parallel to the mucosal tissue, presenting a high risk of perforation. The main advantage of this flap is its mobility, allowing for tension-free relocation in any direction. It has the following characteristics:

- Challenging design and execution
- Reduced blood supply due to maximized design or extension
- Increased bleeding
- Moderate postoperative complications, including slightly more edema

➢ *Combined Flap (Partial/Total/Partial Thickness)*

Introduced by Zucchelli and De Sanctis in 2000, this design moderates flap thickness (partial/total/partial). At the coronal part, a partial incision is made, involving only the epithelium and connective tissue, to improve flap adaptation and healing. In the middle part, a full-thickness lift is performed, including the periosteum, to enhance flap thickness and vascularization. At the apical part, two incisions are made—one deep and parallel to the osseous tissue to release the mucosa from the periosteum and another superficial and parallel to the alveolar mucosa to free the flap from muscular insertions and submucosal tissue. This design has shown superior long-term stability in root coverage for isolated maxillary recessions compared to mucosal or partial-thickness flaps. The design is easy to perform following the proposed protocol, offers good blood flow support, and results in moderate postoperative inflammation.

C. Suture Techniques

Suture techniques should focus on the surgical borders, especially for a flap that has been correctly and passively executed, to avoid tension. The choice of suture material, technique, and knotting method plays a crucial role in the early stages of healing and in resisting mechanical stress during inflammation. Generally, mobile tissue should be sutured to immobile tissue, and it is recommended to slightly lift the immobile border with a micro-elevator while continuously irrigating the tissue to facilitate manipulation and stitching. In microsutures, the biomechanics of knotting, material choice, and suture strength are vital. The use of bimanual techniques with 18 cm instruments is recommended for suturing, allowing comfortable work outside the mouth in small areas and preventing sharp injuries. Very small needles should be inserted in the gingiva near the knotting area. Sutures are generally classified by function as follows:

- Closing sutures
- Tension-relieving sutures
- Combined sutures (closing and tension-relieving)
- Suspension sutures
- Fixation sutures
- Insertion and position sutures

D. Microscope-Assisted Autograft Harvesting

Autologous connective tissue is ideal for reconstructing soft tissue defects, such as root and peri-implant coverage, thickening edentulous ridges, and prosthetic gingival augmentation. Using a surgical microscope for magnification and illumination enhances precision in identifying and harvesting graft tissue, ensuring uniform thickness and size for better survival. While working in the palatal area under a microscope can be challenging, using pivotal objectives and angled optics helps maintain an ergonomic position and simplifies access.

E. Techniques for Graft Harvesting:

➢ *Trapdoor Technique*

Introduced by Edel in 1974, this method involves creating a partial-thickness flap with a horizontal incision and two vertical incisions around the graft area. After determining the graft thickness, the scalpel is angled to ensure uniformity. The flap is then sutured with simple interrupted 7/0 polypropylene sutures.

➢ *Envelope Technique*

Described by Hurzeler and modified by Lorenzana, this technique uses a single horizontal incision to create a flap and access the subepithelial connective tissue. The flap thickness should be at least 3 mm. The horizontal incision is slightly larger than the graft width, and an envelope is created to access and harvest the connective tissue graft. The donor site is sutured with suspension or horizontal mattress sutures.

➢ *Connective Tissue Graft (De-epithelialized Epithelium)*

When the palatal tissue thickness is less than 3 mm, this technique involves a free epithelial graft with a horizontal incision 2 mm from the gingival margin. The scalpel blade should be perpendicular to the osseous tissue. The graft is excised from the horizontal and vertical incisions, ensuring consistent thickness and size. The epithelial layer is removed under high magnification, distinguishing it from the connective tissue. The donor area is sutured, and the exposed palate is protected with a resorbable collagen membrane and acrylic stent for post-operative comfort.

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VII. PRECISION LASER ABLATION OF GINGIVAL PIGMENTATION WITH MICROSCOPE ASSISTANCE

Oral pigmentation has both physiological and pathological causes. Physiologically, oral melanin pigmentation is often visible in the gingival tissue, where melanocytes, located in the epithelial basal cell layer, synthesize and store melanin in melanosomes. This can lead to dark-coloured changes in the gingiva, known as melanin hyperpigmentation (MH), which can be seen across all human races. On the other hand, pathological oral pigmentations can result from factors like medications, smoking, genetics, inflammation, UV exposure, hormonal issues (such as Addison's disease, Albright and Nelson's syndrome, and acromegaly), malignant melanoma, and other systemic conditions. To differentiate between physiological and pathological pigmentation, it is essential to take a thorough medical history and conduct a histopathological examination.

- *Uses of Lasers in Gingival Depigmentation*

Gingival depigmentation involves physically removing the gingival tissue around discoloured areas. This requires accurately identifying and targeting the layers where melanin or metal-associated pigments are present, ensuring no residue or pigmentation recurrence. There are several methods for removing melanin hyperpigmentation (MH), including bur abrasion, electrosurgery, chemical surgery, cryosurgery, laser surgery, gingivectomy, flap surgery, gingival grafting, and their combinations. Laser surgery, in particular, is recognized for reducing treatment invasiveness and is widely accepted. Various lasers, such as CO2, diode, Nd, and Er, are used for MH removal.

Laser ablation is considered a highly effective, safe, comfortable, and reliable method for gingival depigmentation, avoiding the need for incisions and suturing typical of traditional methods. However, when used on thin and delicate gingival tissue, CO2, diode, and Nd lasers may cause gingival ulceration and recession due to their intense thermal and deeply penetrating effects. Recently, the use of Er lasers has become more popular for gingival depigmentation because of their capability to efficiently ablate soft tissue with minimal thermal damage to the treated areas.

- *Gingival Depigmentation by Er:Yag Laser*

Melanin depigmentation with an Er laser can be performed using local or topical anesthesia, or in some cases, without anesthesia at all, depending on the severity and extent of pigmentation and the patient's preference. Minor and localized pigmentation often requires only topical anesthesia or none at all. The laser operates at a panel setting of 50 to 80 mJ per pulse, with an actual energy output of 25–40 mJ per pulse and an energy density of 8.8–14.2 J/cm² per pulse using a 600 µm diameter contact tip. The repetition rate ranges from 10 to 30 Hz, and the procedure is carried out under water spray in an oblique contact mode, maintaining a 20–30° angle to the tissue surface.

During the initial phase of ablation, the laser is used to treat a broad area of pigmented tissue at 10–20 times magnification under microscopic guidance, leaving the papillary edges and free gingival margins untreated at first. For right-handed practitioners, the procedure typically moves from right to left, gently removing the pigmented epithelial tissue. The laser beam is applied using a "brush technique" or "sweeping motion technique," which involves a continuous, slow movement with overlapping laser spots. Since the darker brownish epithelial tissue is softer than the underlying white connective tissue, excessive ablation of the connective tissue is generally avoided by using oblique contact irradiation and maintaining a clear surgical field with the water spray**.**

VIII. MICROSCOPICALLY ENHANCED PERIODONTAL REGENERATION

The gold standard for minimally invasive therapy is microscope-assisted periodontal regeneration therapy, which is carried out with the aid of surgical instruments that permit both manual and visual access into confined areas. Coaxial lighting and magnification are essential components that enables provision of regenerative therapy-related care.

Strong coaxial illumination sources and increased magnification give the operator both touch and visual access to the surgical field. This enables the study of root surfaces, the identification of etiologic variables, and the creation of flaps depending on the topographic arrangement of the osseous diseases being treated. It also makes it easier to identify the extent of intraosseous abnormalities, treat root surfaces using mechanical and manual instruments, and distribute regeneration materials—either singly or in combination—like membranes, bone grafts, and biologic modifiers. With the use of these skills, wound stability can be maximised by approximating the wound margins to accomplish primary closure under passive suture-guided tissue approximation.

A. Flap Design

For multirooted teeth with furcation involvement, two scenarios are typically considered: the "keyhole" presentation, marked by horizontal bone loss at the buccal and/or lingual furcation of lower molars and buccal furcation of upper molars, and a combination of furcation involvement with vertical bone loss at any furcation entrance. Surgical access to intrabony and furcation defects, as well as the choice of regenerative biomaterials, should be carefully adapted to the morphology of both soft and hard tissues. In general, the flap design should adhere to the following principles:

- Preservation of Soft Tissues: The interdental papilla and marginal soft tissues should be completely preserved to maintain aesthetics and support tissue regeneration.
- Full-Thickness Flap Elevation: Elevate full-thickness, envelope-like flaps with adequate mesio-distal extension to allow proper access to the defect. This ensures thorough debridement and optimal placement of regenerative materials.

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- Flap Mobility: When significant coronal advancement is required, periosteal incisions and vertical releasing incisions should be used to enhance flap mobility.
- Suture Techniques: Utilize internal mattress or sling sutures to secure passive primary closure of the flap over the regenerative biomaterials during the initial healing phase.

B. Intrabony Defects

The following step-by-step decision-making process can guide clinicians in selecting the appropriate regenerative approach for intrabony defects:

➢ *Surgical Access:*

- Access to intrabony defects can be achieved using one of three incision methods.
- A horizontal incision, as recommended in the MPPT, is suitable when the interdental space is 2mm or wider.
- For interdental spaces narrower than 2mm, a diagonal incision, as described in the SPPF, is preferred.
- A crestal incision is employed when the defect is adjacent to an edentulous area.

➢ *Flap Design:*

- The design and extent of the flap should be tailored to the defect's morphology with two primary goals: enabling effective defect debridement and placement of regenerative materials, while minimizing invasiveness to promote wound stability and enhance the healing process.
- Clinicians must carefully balance these objectives to achieve optimal outcomes.

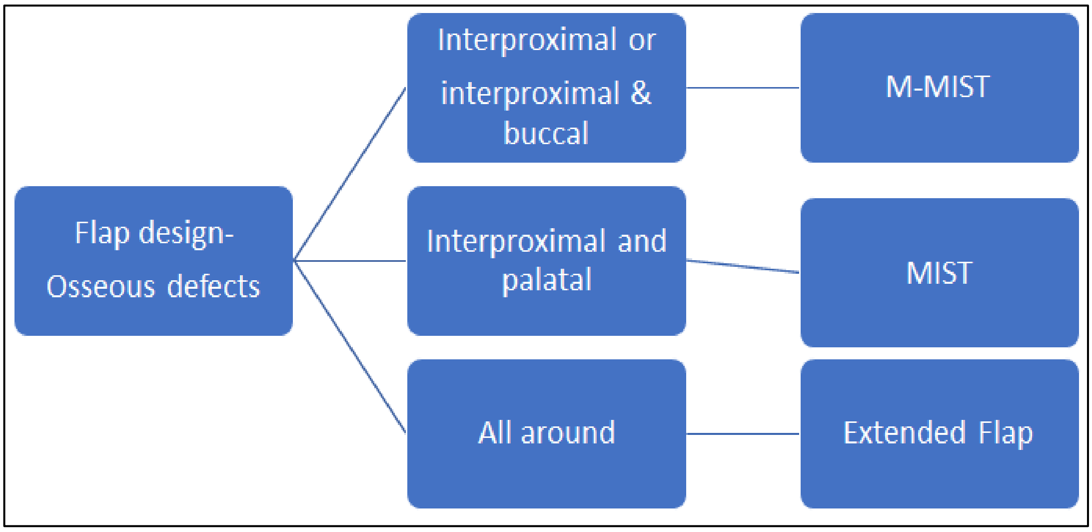

Fig 1 Flap Design

➢ *Step 3: Selection of Regenerative Material*

The choice of regenerative material is influenced by the defect's morphology and the flap design. Amelogenins are generally preferred for contained defects with a primarily three-wall structure or narrow two-wall defects. For non-contained defects, such as one-wall defects, large two-wall defects, or when there is associated buccal and/or palatal/lingual dehiscence, membranes and/or fillers are recommended.

- M-MIST Approach: Amelogenins or no regenerative materials are preferred. However, if there is buccal dehiscence or loss of the interproximal bony wall, especially in wide defects, using a filler might be necessary.
- MIST Approach: Amelogenins are suitable for narrow, contained defects or can be combined with a filler for larger, non-contained defects. In cases where a large flap is elevated, ensuring soft tissue support and blood clot stability is critical. This can be achieved using barriers, fillers, or a combination of barriers and fillers, or amelogenins/growth factors with fillers.

It's important to avoid overfilling the defect with biomaterials, as this can hinder the passive primary closure of the flap. In such cases, a periosteal fenestration may be required to allow for coronal advancement of the buccal flap.

➢ *Step 4: Suturing Strategy*

The suturing technique should be compatible with the chosen regenerative strategy.

- Full-Thickness Buccal Flap without Periosteal Fenestration: A single internal modified mattress suture is recommended.
- Large Buccal Flap with Periosteal Incision: Use a multiple-layer suturing method, as described in the MPPT, to cover a barrier, graft, or combination thereof. Additional single interproximal interrupted sutures can be employed to enhance papilla primary closure and seal vertical releasing incisions.

When performing surgery under a microscope, it's crucial to maintain a stable position that allows for a clear view of the buccal aspect, adhering to ergonomic guidelines. The optimal viewing angle for beginning the surgery and making the buccal incision of the papilla is approximately 50–60° relative to the buccal gingival surface.

C. Key-Hole Furcation Defects

Key-hole class II furcation in the lower molars and at the buccal aspect of the upper molar can be predictably regenerated, provided certain morphological conditions are met. These include the absence of gingival recession, a thick gingival phenotype, preservation of interproximal bone peaks coronal to the furcation roof, minimal vertical bone loss around each root, and a root divergence angle that allows effective debridement of the furcation area.

When gingival recession partially or completely exposes the furcation entrance, a periosteal fenestration is planned to allow coronal advancement of the flap. An envelope-like flap design is preferred, with a vertical releasing incision added only if necessary to enhance flap mobility. Following intrasulcular incisions, the flap is extended mesio-distally to involve the two adjacent interproximal spaces. A full-thickness flap is then raised to expose the remaining bone crest and provide access to the furcation area for debridement. Granulation tissue is meticulously removed to reveal the root surfaces and alveolar bone. The root surfaces are carefully scaled and planed using a combination of hand instruments, power-driven tools, and rotating flame-shaped diamond burs. The use of diamond-coated tips on air-driven instruments is also recommended.

IX. MINIMAL INVASIVE SURGERY IN GUIDED BONE REGENERATION

The primary wound closure, sufficient blood supply, clot stability, and space maintenance are the four key biologic criteria that determine the predictable success of guided bone regeneration (GBR).

Compared to traditional bone regeneration surgery, microsurgery allows for more predictable results and enhances the execution of every surgical step in GBR. These advancements stem from enhanced methods for autogenous tissue collection, membrane fixation, and wound closure, as well as the precision, accuracy, and gentle handling of tissues made possible by magnification**.**

The operator's efficiency is increased using the microsurgical method, and treatment results are consistent. The initial step in applying microsurgical principles is to assess the surgical site that has been recommended for augmentation. Furthermore, treatment without magnification may not have the same effects as tissue preparation with nonsurgical therapy under magnification. By permitting accurate placement of surgical incisions and elevation of the flap using microsurgical instruments intended to cause little tissue trauma, microscope-assisted GBR can improve the performance of the surgeon. Magnification and lighting facilitate appropriate material handling, and microsurgical suturing methods minimise tissue injury and encourage primary wound closure.

Angiogenesis, the process of creating new blood vessels, and the development of new bone are closely related. Bone regeneration is heavily reliant on these processes. Angiogenesis, the physiological process by which new blood arteries are formed from preexisting ones, means that during surgery, extra attention must be paid to the remnant bone and periosteum. This is made feasible by the operating microscope's heightened magnification.

X. FUTURE PERSPECTIVES

Robotic microsurgery is increasingly superseding traditional minimally invasive surgical techniques. This advanced method allows delicate surgical procedures to be performed with a system that controls instruments inserted through small incisions from up to 20 feet away. Surgeons manipulate the telerobot while observing the operation through a three-dimensional video, allowing them to witness the remarkable precision it provides. The system can execute each step of a complex operation, including tasks that were previously deemed impossible.

One notable innovation in this field is the Yomi Robot, the first and only FDA-cleared robot-assisted dental surgery system. The Yomi Robot is an assistive surgical technology that utilizes haptic robotic technology to provide physical guidance, enabling the precise and accurate placement of dental implants. Yomi offers computerized navigation that aids in both the planning (pre-operative) and surgical (intra-operative) phases of dental implant surgery. It also facilitates a minimally invasive, flapless approach, which has been shown to result in faster recovery times and less pain for patients. Further research is needed to fully integrate this technique into dental practice.

XI. CONCLUSION

The long-term goals of minimally invasive periodontal therapy are likely to involve a blend of nonsurgical and surgical techniques that minimize invasiveness. As technology advances, it is conceivable that future periodontal disease treatments could involve methods even less invasive than the current approach of inserting a traditional curette into an intact periodontal pocket or sulcus. A potential future technique might involve inserting two medium-sized needles into the gingival tissue, possibly one on the buccal surface and the other on the lingual surface, with all procedures performed through these needles. One needle could be used for visualization, while the other would be utilized for removing calculus, smoothing the root, and placing regenerative materials.

Aesthetic preservation and enhancement have become vital components of modern periodontal treatment, driven by patients' increasing awareness and desire for aesthetically pleasing smiles. Patients are increasingly seeking a youthful, attractive smile featuring healthy gingiva with ideal contours and texture. In this context, periodontal microsurgery plays a

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crucial role in achieving these aesthetic goals. The enhanced visual precision provided by magnification opens up new opportunities for those dedicated to mastering microsurgical techniques. The fundamental principles of gentle tissue handling, precise wound closure, meticulous haemostasis, and minimal tissue damage are central to the microsurgical approach. Periodontal microsurgery shows significant potential for enhancing therapeutic outcomes across a range of periodontal procedures. However, the technology that is considered cutting-edge in minimally invasive periodontal surgery today may seem rudimentary in the future. The potential for advancements in periodontal therapy is virtually limitless, with the promise of increasingly effective and less invasive treatments in the years to come.

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