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MINIMALLY INVASIVE TECHNIQUES FOR PERIODONTAL REGENERATIVE THERAPY- AN OVERVIEW

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ABSTRACT

Minimally Invasive Periodontal Surgery (MIPS) is a surgical technique using small incisions indicated for performing regenerative therapy in periodontal defects. It can be performed using magnification from surgical microscopes, surgical telescopes, or endoscopic visualization. MIPS seals the healing wound from the contaminated oral environment by ensuring primary closure. Preserving soft tissues and maintaining minimal gingival recession, minimal hypersensitivity claim to be essential requisites to meet the demands of the patient and the clinician in the esthetic zone. Minimally invasive methods for periodontal treatment yield long-term reductions of probing depths and enhanced clinical attachment levels. The exclusive property of MIPS is that it reduces the chair time required to perform the procedure and results in limited morbidity to the patient during the surgical procedure, as well as in the postoperative period. However, it cannot be applied in all cases. A stepwise decisional algorithm should support clinicians in choosing the proper approach.

INTRODUCTION

Periodontitis is inflammation of the periodontium that extends beyond the gingiva and produces destruction of the connective tissue attachment of the teeth. Periodontal therapy should ideally arrest disease progression and regenerate the lost attachment apparatus.

The aims of periodontal regeneration are to achieve:

1. Mitotic activity in the epithelium of gingiva and connective tissue
2. Formation of new bone
3. Continuous deposition of cementum

Regeneration is an advanced healing event that occurs when the systemic and local conditions are favourable and when therapy is properly applied. The systemic conditions include the control of periodontitis, a low total bacterial load in the mouth and cessation of smoking habits (Cortellini P *et al, 1993, 1995;* Mayfield L *et al*, 1998; Silvestri M *et al*, 2003; Tonetti M *et al*, 1993, 1995, 1996). The local conditions include the presence of space for the formation of the blood clot at the interface between the flap and the root surface (Haney JM *et al*, 1993;Sigurdsson TJ *et al*,1994; Cortellini P *et al* 1995; Wikesjo UME *et al*, 2003; Kim CS *et al*, 2004), the stability of the blood clot to maintain continuity with the root surface avoiding formation of a long junctional epithelium (Linghorne WJ *et al*, 1950; Hiatt WH *et al*, 1968;Wikesjo UME *et al*, 1990) and the soft tissue protection to avoid bacterial contamination (Selvig K *et al*, 1993; DeSanctis M *et al*, 1996; Sanz M *et al*, 2004).

The surgical approach to periodontal regenerative therapy has been gradually modified leading to techniques that are more conservative while handling soft tissues. Therefore Minimally Invasive Periodontal Surgery (MIPS) was developed. Minimally invasive surgery has been defined as the ability to perform a procedure through a substantially smaller surgical wound than was previously necessary to accomplish the same surgical goals (Fitzpatrick JM *et al*, 1990;Hunter JG *et al*, 1993). It enables minimization of soft tissue trauma and removal of granulation tissue from periodontal defects using a much smaller surgical incision than that used in standard bone graft techniques. Use of operating microscopes, surgical telescopes or endoscopic visualisation for enhanced magnification and microsurgical instruments are further employed to increase the surgical effectiveness.

Advent of Minimally Invasive Periodontal Surgery

In the recent past, urge for more friendly, patient-oriented surgery have insisted clinicians to emphasise their motive in the development of less invasive approaches. The key to performing minimally invasive procedures is the ability to

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adequately see the small surgical site and successfully complete the indicated surgical manipulations. Following this path, Harrel and Rees proposed minimally invasive surgery (MIS) with the aim to produce minimal wounds, minimal flap reflection, and gentle handling of the soft and hard tissues thereby limiting the embarrassment of blood supply (Harrel SK and Rees TD, 1995). Retention of the preoperative gingival architecture and replacement of the gingival papilla at or coronal to the presurgical position minimizes the occurrence of gingival recession which is one of the hallmarks of this procedure. Cortellini and Tonettiintroduced the minimally invasive surgical technique (MIST), which stressed the aspects of wound and blood clot stability and primary wound closure for blood clot protection (Cortellini P and Tonetti MS, 2007). It also fosters favourable esthetic outcome with reduction in postsurgical contraction and morbidity. Adhesion and maturation of blood clot on the root surface without movement, together with primary intention wound closure are essential in achieving periodontal tissue regeneration as opposed to repair by means of a long junctional epithelium (Polimeni G *et al,* 2006). Further modified minimally invasive surgical technique (M-MIST) additionally, incorporated the concept of space provision for regeneration.

Clinical Strategies

The main objective in treating a given periodontal defect is to apply the best performing procedure with the minimum load of intra- and post-operative side effects and morbidity. Minimally invasive surgical technique (MIST) was used for treatment of multiple intrabony defects whereas modified MIST (M-MIST) for isolated intrabony defects. The basic ideology behind MIST follows the concepts of MIS and in addition involves the application of papilla preservation techniques with a microsurgical approach. The design of M-MIST allows both access to root surface instrumentation and minimization of flap elevation through the elevation of the buccal flap alone. This further enhances stability of blood clot during wound healing and prevents the collapse of the papilla into the defect thereby preserving more space for the regeneration to occur.

Surgical approaches

Mist

The MIST is based on the elevation of the defect-associated interdental papilla along with minimally extended buccal and lingual flaps (Cortellini P *et al,* 2007). The papilla preservation technique, the modified papilla preservation technique, and the simplified papilla preservation flap are important elements in terms of MIST since they can guarantee minimal access to the periodontal defect.

Papilla preservation technique (PPT)

Takei et al proposed a new surgical approach called the papilla preservation technique (Takei HH *et al,* 1985). The buccal aspect of the flap is elevated with a sulcular incision around each tooth, without involving the interdental papilla. The lingual/palatal flap design involves a sulcular incision along the lingual or palatal aspect of each tooth and a semi-lunar incision across each interdental papilla. This incision dips apically from the line angles of the tooth so that the papillary incision line is approximately 5 mm from the gingival margin. This enables the interdental tissue to be dissected from the lingual/palatal aspect so that it can be elevated intact with the facial flap.

Modified papilla preservation technique (MPPT)

Cortellini et al published this new approach as a modification of Takei's technique for interproximal regenerative procedures (Cortellini P *et al,* 1995). A horizontal incision is performed on the buccal papillary tissue at the base of the papilla. A full-thickness palatal flap, along with the interdental papilla, is elevated. A buccal full-thickness flap is raised with vertical releasing incisions and periosteal incisions, when required.

Simplified papilla preservation flap (SPPF)

Cortellini et al proposed the simplified papilla preservation flap (SPPF) (Cortellini P *et al,* 1999). It is initiated with an oblique incision across the defect-associated papilla, from the gingival margin at the buccal line angle of the involved tooth to the mid interproximal portion of the papilla below the contact point of the adjacent tooth. A full-thickness palatal flap, including the papilla, and a split-thickness buccal flap are then elevated.

Importance of width of interdental space in the selection of flap design

The entry incision in MIST, which is performed on the buccal side of the interdental papilla, is dissected with two different methods depending on the width of the interdental space. The width of the interdental space is measured with a periodontal probe as the distance between the two root surfaces. The periodontal probe is positioned horizontally about 2 mm apical to the tip of papilla. The SPPF is preferred whenever the width of the interdental space is 2mm or less, while the MPPT is used at sites with an interdental width greater than 2mm, and the crestal incision is applied next to an edentulous area.

Modified MIST

The overall idea of the M-MIST is to provide a very small interdental access to the defect through a small buccal window without elevating palatal flap (Cortellini P and Tonetti MS, 2009). The entry incision is performed on the buccal side of the interdental papilla and follows the same principles described for the MIST approach. The interdental incisions involve the buccal aspect of the teeth neighbouring the defect and do not involve the next papillae. A triangular buccal flap is minimally elevated to expose the residual buccal bone crest without detaching interdental papilla from the residual interdental bone crest and supracrestalfibers. The microblade is positioned to dissect the supracrestal interdental tissue from the granulation tissue. Then, the granulation tissue is carved away from under the papilla and the root surface is completely debrided with mini-curettes. At the end of the procedure, the buccal flap is repositioned and sutured to the interdental supracrestal soft tissues which is still anchored with their fibers to the root cementum. On the whole, M-MIST facilitates the preservation of “soft tissue roof” over the defect.

Regenerative Materials (Cortellini P and Tonetti MS, 2015)

Choice of the regenerative material is based on the defect anatomy and on the flap design chosen to access the defect. Implanting a barrier and/or a filler depends on the need to stabilize the blood clot and the surgical flap. The need for extra stabilization of the treated area increases when a large flap with high degree of mobility is designed for treating one-wall or a wide two-wall defect. The bone anatomy per se provides enough stability without the requirement of barrier and filler especially when a low-mobility, minimally invasive flap is designed for treating narrow two-wall and three-wall defects. Three different regenerative concepts have been explored

1. Barrier membranes
2. Grafts
3. Wound healing modifiers such as amelogenins, growth factors

If a M-MIST approach is applied, amelogenins or no regenerative materials are the elective choices, irrespective of the bone anatomy as there is no great need for a supportive biomaterial. If a MIST approach is applied, amelogenins or growth factors can be used in containing defects (narrow two-wall and three-wall) or in combination with a filler in non-containing defects (one-wall or a wide two-wall). If a large papilla preservation flap is elevated, stability to the area is enhanced by applying barriers or fillers or combination of barriers and fillers or combination of amelogenins/growth factors and fillers. Amelogenins alone are preferred in defects with a prevalent 3-wall morphology or in well-supported 2-wall defects. Cortellini and Tonetti proposed MIST in combination with enamel matrix derivative (EMD) to treat isolated intrabony defects (Cortellini P *et al*, 2007). Cortellini et al proposed the application of a single MIS technique to treat multiple adjacent defects (Cortellini P *et al*, 2008). Furthermore, a consistent decrease of complications was observed when barrier membranes were refrained from use and amelogenins were incorporated in the surgical procedure (Esposito M *et al*, 2009; Trombelli l *et al*, 2010)

Suturing Approach

Monofilament suturing materials are best suited since they are atraumatic. The suturing approach is chosen according to the type of regenerative strategy applied. It will consist of a single internal modified mattress suture when M-MIST or MIST approach is chosen and amelogenins alone are applied. It will consist of a combination of 2 internal mattress sutures applied at the defect associated with the interdental area to reach primary closure of the papilla in the absence of any tension when a large papilla preservation flap with a periosteal incision is used in association with a barrier or a graft or a combination. Vertical matrix suture is recommended in the anterior areas whereas modified matress suture is a better option in the posterior teeth.

Table 1 Differences between conventional periodontal surgery and minimally invasive periodontal surgery

Conventional Periodontal Surgery	Minimally invasive Periodontal Surgery
Involves extensive elevation of soft tissue flaps	Facilitates decreased tissue manipulation that lessens overall trauma to surgical sites and permits faster healing
Flaps are designed as wide and mobile to allow access to defects with extension to the neighbouring teeth	Performed with small incisions and limited only to the facial or lingual aspect without extending to the healthy teeth
Increased patient morbidities such as thermal sensitivity, interproximal food impaction and compromised esthetic outcomes	Reduced patient morbidity and chair time
Excessive apical displacement of the gingival margin in the treatment of periodontal defects	Post-operative gingival recession is minimum
No necessity to use loupes, microscopes and microsurgical instruments	Use of loupes, microscopes and microsurgical instruments

Conventional Periodontal Surgery Vs Minimally Invasive Periodontal Surgery

Radical changes in dental surgical procedures and armamentarium with evolution of novel instruments and materials have drastically reduced the invasiveness of conventional periodontal surgery.

Technical Implications

Application of MIST and M-MIST requires surgical skills and a proper surgical setting. The major disadvantage is lack of visibility and proper manipulation of the surgical field. The minimal flap reflection reduces the angle of vision and light penetration into the surgical field. To overcome these problems, microsurgery came into play.

Periodontal Microsurgery

Periodontal microsurgery is the refinement of conventional surgical procedures made possible by the improved visual acuity gained with the use of surgical microscope (Tibbetts LS and Shanelec D, 1998). Surgical microscopes use coaxial fiber-optic illumination and produce an adjustable, bright, uniformly illuminated, shadow-free, circular spot of light that is parallel to the optical viewing axis. Microsurgery incorporates three different principles (Acland R, 1989).

1. Improvement of motor skills, thereby enhancing surgical ability.
2. An emphasis on passive wound closure with exact primary apposition of wound edge.
3. The application of microsurgical instrumentation and suturing to reduce tissue trauma.

Microsurgical instruments

Microsurgical instruments must be approximately 15 cm in length and circular in cross section to enable high precision movement (Tibbetts LS and Shanelec D, 2009). The working tips of microsurgical instruments are sharper and smaller than those of regular instruments. However, shorter instruments with rectangular cross-section are not recommended.

Microsurgical Knives

These knives have the characteristic ability to create clean incisions to prepare the sharp flap margins for healing by primary intention. Incisions are made at right angles to the surface using Castroviejo microsurgical scalpel. Magnification permits easy identification of ragged wound edges for trimming and freshening. Various types of knives such as cresent, lamellar, blade breaker, sclera and spoon knife can be used. They offer the dual advantage of extreme sharpness and minimal size.

Microsurgical Scissors

There are various types of scissors such as micro scissors, extra fine micro scissors (straight), extra fine micro scissors (curved).

Microsurgical needle holders

They are made of titanium and designed to hold the fine needles. They differ in the way they grasp the needle e.g. a grasp with flat surface if a flat needle is used.

Microsurgical needles

Microsurgical needles are made of stainless steel directly swaged onto the suture ends. Reverse cutting needle of size 16 to 19mm is preferred. Techniques of microsurgery include accurate needle placement, optimal tissue union, and tying of square and slip knots.

Microsurgial sutures

Periodontal microsurgery facilitates the use of 6-0 to 9-0 sutures. Microsurgical wound apposition reduces gaps or voids at the wound edges, thereby aiding in rapid healing with less post-operative inflammation and pain. The geometry of microsurgical suturing consists of the following points:

1. Needle angle of entry and exit of slightly less than 90 degrees
2. Suture bite size of approximately 1.5 times the tissue thickness
3. Equal bite sizes (symmetry) on both sides of the wound
4. Needle passages perpendicular to the wound

Microraspatorium, bone scraper, papilla elevatorium, microscalpel holder and a dental microforceps are also routinely used in microsurgery

Applications of Periodontal Microsurgery

Perioesthetics

Periodontal microsurgery has wide implications in root coverage procedures such as rotational, free gingival, double papilla, and the sub-epithelial connective tissue grafts since it causes minimal trauma and enhances the wound healing process (Deepa D *et al*, 2014). The combination of small microsurgical instruments and delicate surgical techniques result in fine, crisp, narrow and accurate incisions, gentle tissue handling and precise repositioning of the wound margins with smaller needles and sutures. The main advantages of microsurgery are rapid wound healing, low morbidity and less discomfort. In addition, narrow incisions and small surgical wounds further add on to the better esthetic results. The high survival rate of the vascularized graft is due to the retained blood supply from the base of the pedicle, which can be enhanced through microsurgery.

Periodontal flap Surgery

Periodontal flap margins can be elevated with uniform thickness and scalloped butt-joint by using microsurgical techniques. This aids in precise adaptation of the tissue to the teeth or the opposing flap in an edentulous area, thus eradicating the gaps and dead spaces avoiding the need for new tissue formation and enhancing periodontal regeneration. Further, the coronal displacement of the flaps over the defects was at ease and experienced less tension with the microsurgical techniques, thereby facilitating rapid healing and return of the mucogingival line to its original position (Andrade PF *et al*, 2010; Belcher JM, 2001).

Root visualization and preparation

Success of periodontal therapy depends on visual access to the root surface for removing the residual calculus, treating the pathologically altered root surface, and achieving a clean and smooth root surface. Root planing is more effective when done under greater magnification and enhances periodontal regeneration.

Other applications

Periodontal microsurgery can also be effectively used in interdental papilla reconstruction, alveolar ridge deficiencies, aesthetic implant reconstruction and sinus lift procedures.

Advances in Minimally Invasive Periodontal Surgery

Videoscope assisted Minimally Invasive Surgery (VMIS)

This technique is indicated only for isolated defects (Harrel SK, 2015). Single palatal or lingual flap is preferred since reflecting a buccal flap has a greater potential for visible gingival recession with possible negative esthetic consequences. Lingual access and visualization is much easier when a videoscope is available. The videoscope gives a improved method for direct visualization in surgical procedures that use very small incisions and a greater magnification than telescopes and surgical microscopes. It provides magnification up to 60X (Harrel SK, 2013). Videoscope chiefly comprises of a very small digital camera that can be placed in the surgical site. It has a camera and light source that is a total of 2.7 mm in diameter with a 640 mm flexible insertion tube that makes it ideal for visualization in all parts of the oral cavity. Adaptation of the camera end of the insertion tube of the videoscope to a handle allows the surgeon to place the camera into the minimally invasive periodontal surgical access opening. Incorporated into the handle is a small carbon fiber retractor that can be rotated to retract the very small flaps associated with V-MIS. Since the videoscope camera can be placed directly into the periodontal defect, the root surface is visualised directly at a near 90-degree angle to the tooth.

The modified videoscope with gas shielding technology that uses a constant flow of surgical gases or air over the lens has been developed to avoid blood and surgical debris from obscuring the optics of the instrument. Improved results reported with V-MIS may be attributable to the ability to use smaller access incisions that result in less tissue trauma and post-surgical soft tissue recession, the ability to see and remove small islands of calculus and root abnormalities such as microgrooves. Hence, use of the videoscope adds a new dimension to periodontal regenerative surgery. In the future, a detection device that can differentiate between dentine, cementum and calculus shall be developed in combination with the videoscope to add on to the advantages.

Minimally Invasive Technique In Guided Bone Regeneration

This technique is indicated for partially or completely edentulous healthy adults, with insufficient localized jaw bone volume to receive dental implants (Kfir E *et al*, 2007).

Tunnelling approach

A vertical full-thickness incision is done in the mesial aspect of the edentulous ridge from the free gingiva to beyond the mucogingival junction (MGJ). A dedicated mini-chisel is inserted through the incision between the bone and the periosteum and advanced to gently release the periosteum from the bone. Using this technique, the chisel was advanced from the alveolar crest to beyond the MGJ, until the distal border of the desired GBR segment is reached. Once an initial tunnel has been created, the Foley catheter is placed into the desired GBR zone. Dedicated inflator is used to inflate the balloon to a pressure of 2 atmospheres. Sequential inflations are executed from distal to proximal.

After successive balloon dilatations, an adequately sized barrier membrane can be placed with autologous fibrin and bone graft substitute through this small incision. The incision was closed with 2 to 3 simple sutures and the membrane is secured by a suture to the tissue to prevent any mobility. Primary closure without tension on the suture line is easily accomplished with this small vertical incision. No adverse events involving membrane exposure, tissue dehiscence, infection, or implant failure were evident in this technique.

Periodontal Endoscope with Micro Ultrasonic Instruments

Endoscopic periodontal debridement is the only nonsurgical minimally invasive, real-time video technology available for the subgingival treatment of periodontal disease disclosing minute details such as caries, root fractures, perforations, resorption, biofilm, and calculus that previously may have been undetectable. Prior to periodontal endoscopy, visualization and complete debridement of the subgingival environment were only attained through surgical intervention via open-flap debridement. Even after traditional surgery, deposits of subgingival calculus have been shown to remain (Caffesse RG *et al*, 1986). After the advent of periodontal endoscopy, the ability to clearly visualize and remove calculus with nonsurgical therapy has improved since calculus found on the dental root structure commonly shows up as gold, yellow or white due to the bright fiber-optic illumination (Wilson TG Jr *et al*, 2008). The periodontal endoscope allows for visual access to root surfaces with great magnification of 24 x to 40x, lessening the need for surgical intervention (Kwan JY, 2005). Combined with a simple array of micro ultrasonic instruments, endoscopic debridement can be accomplished in a conservative, minimally invasive way.

The optic fiber present in endoscope is delivered to the gingival margin coupled with an instrument called an “explorer” for viewing subgingivally. The captured image is relayed to a screen so that the user can see “real time” video of the highly magnified environment. Micro ultrasonic instruments are probe-like (measuring 0.2 mm to 0.6 mm in diameter), driven at ultrasonic speeds (25,000 to more than 40,000 cycles per second), with active working sides on all surfaces of the vibrating instrument essential for supra and subgingival debridement, and provide ultrasonically activated lavage in the working field. A third generation of the glass fiber endoscope is scheduled for the introduction in the near future.

DISCUSSION

Cortellini et al preliminarily evaluated the outcomes of a microsurgical approach in the regenerative therapy of deep intrabony defects in a case cohort study of 26 patients by means of guided tissue regeneration membranes (Cortellini P and Tonetti MS, 2001). Closure was achieved in all treated sites and was maintained in 92.3% of cases for the entire healing period with a CAL gain of 82.8% of the initial intrabony component of the defect. The procedure resulted in significant gain in CAL and minimal gingival recession. Wachtel et al conducted a study on 11 patients to assess the clinical effect of EMD treatment as an adjunct to the microsurgical access flap (Wachtel H *et al*, 2003). Both test and control treatment resulted in a statistically significant mean CAL gain of 2.8 and 2mm at 6 months, and 3.6 and 1.7mm at 12 months, respectively. Combination with EMD application proved to be superior to the microsurgical access flap alone, in terms of probing pocket depth reduction and CAL gain.

Stephen K Harrel *et al* performed prospective assessment of the use of enamel matrix derivative with minimally invasive surgery over a 6 year period (Harrel SK *et al*, 2010). 11-month subject-level data were compared with the 6-year subject-level data for probing depth, clinical attachment and recession. There was no return of probing depth, loss of attachment, gingival recession or reoccurrence of periodontal disease. These data clearly demonstrated that the favourable results originally reported at 11 months were stable over the 6-year study period. Cortellini P et al evaluated the applicability and clinical performances of M-MIST in the treatment of 20 patients with isolated deep intrabony defects in combination with amelogenins (Cortellini P and Tonetti MS, 2009). The percent fill of the baseline intrabony component of the defects in terms of CAL gain was 75.5±10% on an average. The remarkable percent defect resolution and minimal interdental soft tissue recession support the hypothesis of a positive influence of the surgical design of M-MIST on the clinical outcomes. Patients reported a very well tolerated and relatively short procedure of 56.5±8.6 min on an average with an uneventful postoperative period and limited pain or discomfort.

Ribeiro *et al* reported a drastic decline in the extent of root hypersensitivity, post surgical haematoma, edema, suppuration, flap dehiscence, presence of granulation tissue and other complications in sites treated with MIST (Ribeiro FV*et al*, 2011).

Cortellini *et al* designed a randomized controlled clinical trial to compare the clinical efficacy of the M-MIST alone versus M-MIST combined with amelogenins (EMD) and amelogenins added to bone mineral-derived xenograph (BMDX) in the management of isolated, interdental intrabony defects (Cortellini P and Tonetti MS, 2011). Comparisons among the 3 groups revealed no statistical difference in terms of probing pocket depth, clinical attachment level and percent radiographic bone fill of intrabony component of the defect. It was concluded that M-MIST is efficacious in the treatment of intrabony defect with or without the additional use of regenerative materials.

CONCLUSION

Minimally invasive periodontal surgery plays an important role in the field of periodontal regeneration. The ultimate goals of MIPS are increased wound stability, primary closure, and reduced surgical trauma, chair time and patient discomfort. Though many studies prove the efficiency of MIPS by the improvement in clinical parameters and reduction in patient morbidity, there is still an increasing demand to evaluate the success rate of such techniques in periodontal surgery when compared with other traditional ones.

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