Utilization of the Surgical Microscope for Advanced Plastic Periodontal Surgery

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The increased demand for mucogingival aesthetics has required the optimization of periodontal procedures. Microsurgery is a minimally invasive technique that is performed with the surgical microscope and adapted instruments and suture materials. While this hardware and knowledge of various operations are necessary to achieve patient aesthetic expectations, clinicians must be willing to undergo an extended period of systematic training to become familiar with novel operating procedures and instruments. This article describes the application of the surgical microscope to provide enhanced perioplastic treatment.

Key Words: microsurgery, mucogingival surgery, magnification, microscope

The term "mucogingival surgery" was introduced in 1957 and applied to surgical procedures that ameliorated the relationship between gingiva and alveolar mucosa.[1] Mucogingival surgery has evolved from traditional pocket therapy into a plastic surgical method that includes periodontal, peri-implant, and mucosal concerns (eg, papilla loss, buccal root recession, volumetric defects, unaesthetic or asymmetric gingiva), whether they are caused by anatomic, developmental, or traumatic deformation.[2] Root coverage,[3-6] increase of keratinized tissue,[7,8] augmentation of the alveolar defect,[9-11] and delocalization of the gingival line[12] are among the surgical methods that have been introduced and modified since the 1980s. Utilizing these procedures, the majority of periodontal concerns (ie, except papilla reconstruction) can be resolved today with success and predictability.[13]

Successful mucogingival invasion depends upon the selection of an atraumatic surgical approach, which is limited by the dexterity of the surgeon and the perception of the human eye. While the use and advantages of the surgical microscope have been extensively discussed in endodontic literature,[14,15] few authors have described the application of magnification in periodontal surgery.[16-19] This article demonstrates the use of the surgical microscope in aesthetic perioplastic surgery. It describes the required optical devices as well as the surgical considerations for the selection of sophisticated

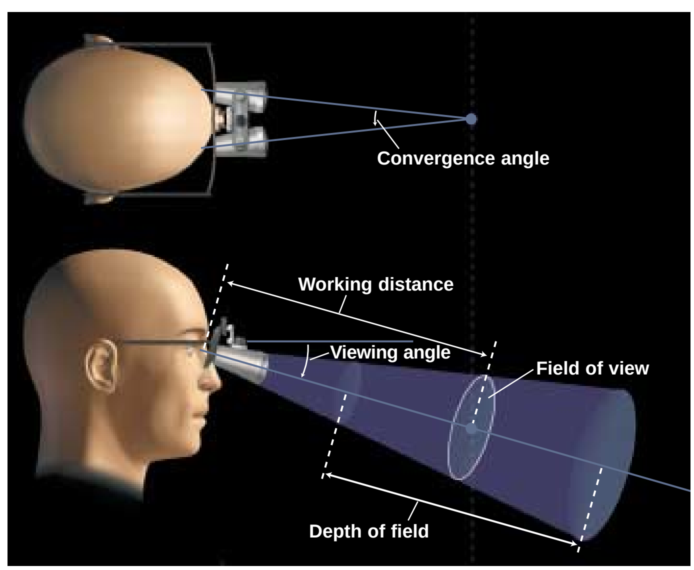

Figure 1. Diagram indicates the principal optical features of loupes.

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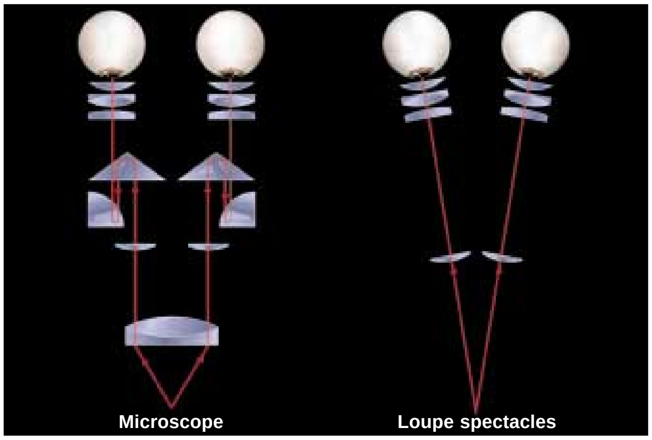

Figure 2. Diagram illustrates the comparison of vision enhancement with loupes and a microscope. The loupes necessitate eye convergence while vision is paralleled through the microscope.

Figure 3. Illustration demonstrates proper hand position for utilization of microsurgical instruments.

instruments and suture materials. With clinical examples, the advantages of the microsurgical technique are documented, and the results of traditional and innovative approaches are compared and critically judged.

Materials and Methods

Using magnification, existing surgical methods can be refined and the potential for clinical success can be visibly improved. Nevertheless, the apparent increase in structure size alters the operator's perception of the surgery. While the visual aspect gains importance, the influence of tactile sensitivity diminishes. Although hand movements are difficult to control due to the new perspective, microsurgical techniques can be learned by any clinician. Significant time and continuous training must be invested until the movement sequences can be executed in an efficient and controlled manner.

Magnification Loupes

Loupe spectacles are optical aids for magnified projection of an object on the retina. For dental use, these multiple-lens systems must provide proper working distance, depth of field, and convergence angle. The loupes should also ensure correct field of view and viewing angle (Figure 1). These optical aids are classified as Galilean or prism loupes depending on their construction. Galilean loupes consist of convex and concave lenses. The projection comparison meter as a function of the front lens is restricted to a field of ×2 by ×3.5. In contrast to prism loupes, Galilean loupes allow a larger field to be viewed at any magnification.

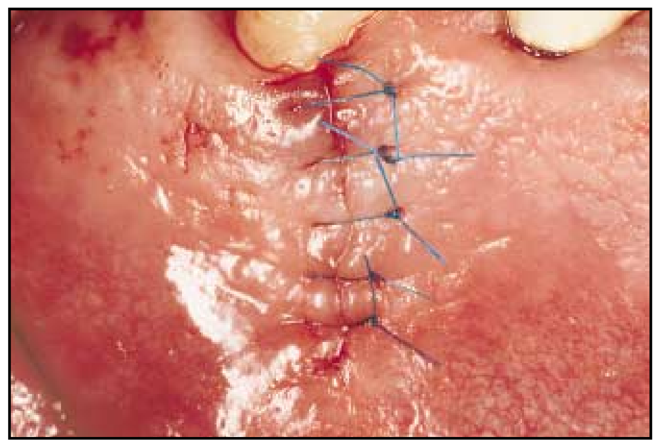

Figure 4. Primary wound closure is achieved with 7-0 isotactile polypropylene sutures.

Prism loupes consist of several convex lenses. By diverting the light beam with prisms, their optical length is longer than their actual length. Thus, magnifications of ×3 to ×5 are possible. For intraoral regions that are difficult to view (eg, lingual or palatal aspects), prism loupes with magnifications of ×4.5 to ×5 have become traditional in periodontal surgery. These aids offer a compromise between magnification, depth of field, and size of the field of view.

In addition to working distance and viewing angle, the convergence of loupe spectacles is paramount for a relaxed stereoscopic view (Figure 2). Since the potential for adaptation and calibration are as important as the optical characteristics, all these factors must be considered prior to the purchase of loupes. Calibration faults allow the eye muscles to tire before pain symptoms can be transferred to the neck and shoulder muscles.

Figure 5. Preoperative buccal view of root recession of the maxillary left canine.

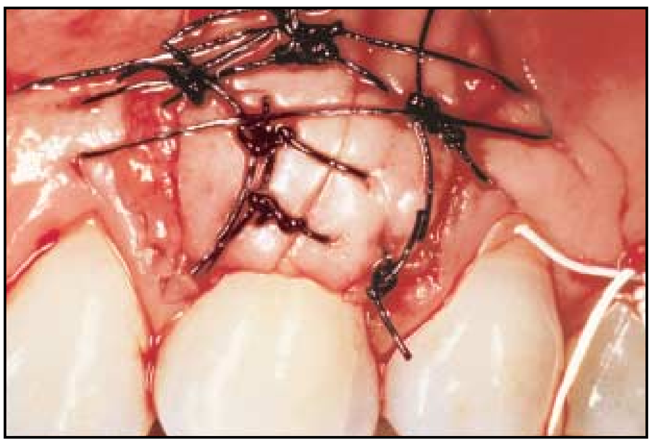

Figure 6. Macrosurgical coverage of the root recession is achieved with a connective tissue graft.

Surgical Microscope

The surgical microscope (OPM) is a complicated system of lenses that allow binocular viewing at a magnification of approximately ×4 to ×40. In contrast to loupes, both light beams fall parallel onto the retinas of the observer so that no eye convergence is necessary and the demand on the eye muscles is minimal (Figure 2). The OPM consists of the magnification changer, objective lenses, lighting unit, binocular tubes, and eyepieces. It can be fixed to the floor or mounted on the wall or ceiling.

Magnification Changer

The magnification changer or "Galilean" changer consists of one cylinder, into which two Galilean telescope systems (consisting of convex and concave lenses) with various magnification factors are built. These systems can be used in either direction depending on the position of the magnification changer; a total of four different magnification levels are available. Straight transfer without any optics yields magnification factor 1. The combination of the magnification changer with varying objective lenses and eyepieces yields an increasing magnification line when the control is adjusted.

The stepless motor-driven magnification changer must achieve a magnification of ×0.5 to ×2.5 with one optical system, which is operated by either a foot pedal or an electric rotating control mounted on the microscope body. The operator should decide whether to use the manual or motorized magnification changer. If the magnification must be changed frequently, it can be accomplished more quickly with the manual changer than the motorized one, which has no in-between levels. While the motorized system improves the focus and comfort over the manual system, the former is more expensive.

Objective Lenses

As processed by the magnification changer, the image is only projected by one single objective. This simultaneously projects light from its source twice for deflection by the prisms into the operation area (ie, coaxial lighting). The most frequently used objective is 200 mm (f = 200 mm). The focal length of the objective generally corresponds to the working distance of the object.

Lighting Unit

The lighting unit is necessary with high magnifications and is a significant advantage of the OPM. In recent

Figure 7. Buccal view of the root recession site 3 days following the completion of the surgical procedure.

years, the use of halogen lamps has been increased. These lamps provide a whiter light than do lamps using conventional bulbs due to their higher color temperature. As halogen lamps emit a considerable portion of their radiation within the infrared spectrum, OPMs are equipped with cold-light mirrors to keep this radiation from the operation area.

Binocular Tubes

Depending on the area of use of the OPM, two different binocular tubes are attached (ie, straight and inclined tubes). With straight tubes, the view direction is parallel to the microscope axis. Using inclined tubes, it is inclined by 45° to the microscope axis. In dentistry, only "inclinable" tubes — which permit continuously adjustable viewing — are feasible due to ergonomic reasons. The precise adjustment of the pupil distance (distance between the user's pupils) is the basic precondition for the stereoscopic view of the operation area.

Eyepieces

The eyepieces magnify the interim image generated in the binocular tube. Varying magnifications can be viewed (×10, ×12.5, ×16, and ×20) using different eyepieces. Eyepiece selection not only determines the magnification but also the size of the field of view. An indirect relationship exists between the magnification and the field of view. The ×10 eyepiece generally provides a sufficient compromise between magnification and field of view. Modern eyepieces allow a correction facility within −8 to +8 diopteries, which is a purely spherical correction.

The majority of OPMs consist of modules and can be equipped with attachments that include integrated video systems, photographic adapters for cameras, color printers, and powerful lighting sources. Prior to purchasing accessories and instruments, inexperienced clinicians should gather information on eyepieces. The purchase of magnifying loupes is recommended to accustom oneself to working under magnification.

Figure 8. Buccal view of the surgical site 4 weeks postoperatively. Note slight inflammation and small portions of uncovered root surface.

Figure 9. Postoperative view of the macrosurgical site approximately 1 year following treatment. Note the visible root surface and scars.

Microsurgical Instruments

Proper instrumentation is fundamental for a microsurgical invasion. While various manufacturers have complete sets of microsurgical instruments, they are generally conceived for vascular and nerve surgery and therefore inappropriate for use in plastic periodontal surgery. As the instruments are primarily manipulated by the tips of the thumb, index, and middle finger, their handles should be round yet provide traction so that finely controlled rotating movements can be executed. They should be approximately 18 cm long and lie on the saddle between the operator's thumb and the index finger and simultaneously be slightly top heavy to facilitate exact handling (Figure 3). In order to avoid an unfavorable metallic glare under the OPM, the instrument should have a colored coating surface. The weight of each instrument should be a maximum of 15 g to 20 g to avoid hand and arm muscle fatigue. The needle-holder should be equipped with a precise working lock that should not exceed a locking force of 50 g. High locking forces generate tremor, and low locking forces reduce the feeling for the movement. A set of titanium microinstruments (Periodontal Microsurgical Kit, Hu-Friedy, Chicago, IL) has recently been developed for periodontal use. It comprises a needle-holder, microscissors, microscalpel holder, and surgical and anatomical forceps. As

Figure 10. Preoperative view of root recession present on same patient at the site of tooth #6(13).

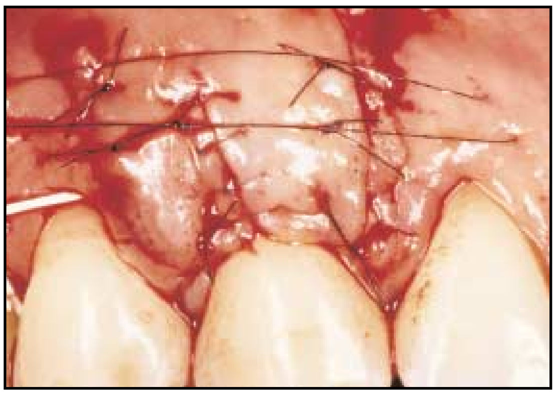

Figure 11. Buccal view of the surgical site following microsurgical coverage with a connective tissue graft.

an innovation, the surgical forceps is designed as a combination instrument. It is an anatomical forceps that converts into a surgical forceps at its end. This combination enables mucosal flaps to be seized and the ensuing thread to be knotted without a change of instruments. In order to avoid sliding of the thread when knotting, the tips of the forceps have flat surfaces or can be finely crosshatched. The latter should be designed to grip fine and rough needles. When closed, no light must pass through the tips. Locks aid in the execution of controlled rotation movements on the instrument handles without pressure. The tips of the forceps should be approximately 1 mm to 2 mm apart when the instrument lies in the hand without any pressure. Diverse shapes and sizes of microscalpels can be acquired from ophthalmology and plastic surgery instrument sets and supplemented with fine instruments (fine chisels, raspatories, hooks, and draining canules) from conventional surgery.

In order to prevent damage, microinstruments are stored in a sterile container or tray. The tips of the instruments must not touch each other during sterilization procedures or transportation. The practice staff should be thoroughly informed about the cleaning and maintenance of such instruments, as cleansing in a thermodisinfector without instrument fixation can irreparably damage the tip of microforceps.

Suture Material Requisites

Suture material and technique are essential considerations in microsurgery.[20] Tight wound closure promotes healing "per primam intentionem" and reduces the potential of postoperative infection. A suture is composed of a needle and a suture strand. Atraumatic sutures consist of a strand that is firmly connected to the needle through a press-fit swage. The needle consists of a swage, body, and tip. The needle tips differ widely depending on the specialty in which they are used. Tips of cutting needles are appropriate for coarse tissues or atraumatic penetrations. In order to minimize tissue trauma in periodontal microsurgery, reverse cutting needles with precision tips or spatula needles with microtips are preferred.[21] Reverse cutting needles have a greater degree of firmness than do round-body needles, which is advantageous for the penetration of coarse gingiva. The shape of the needle can be straight, bent to various degrees, or asymptotically bent. The diameter of the needle body should be flattened in order to stabilize the needle in its holder. For periodontal microsurgery, the 3/8" circular needle generally ensures optimum results. The lengths, as measured along the needle curvature from the tip to the proximal end of the needle lock, extend from 5 mm to 13 mm depending on their area of application. The suture also depends on the thread material, which is classified as either resorbable or nonresorbable. Within these two categories, these materials can be further divided into monofilament and polyfilament threads.

Resorbable Threads

Resorbable threads can be categorized as natural or synthetic (Table 1). Natural thread (ie, surgical gut) has no constant mechanical properties, initiates inflammatory reactions, expands in aqueous surroundings, and is therefore inappropriate in a microsurgical environment.[22] Polyglecaprone (Monocryl, Ethicon Inc., Somerville, NJ) is a hydrolytically absorbable monofilament suture material

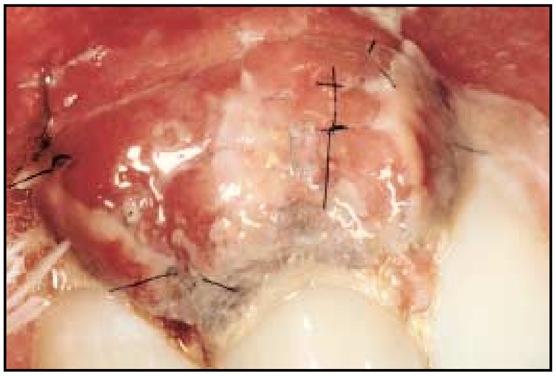

Figure 12. Three-day postoperative view of the root recession site.

Figure 13. Buccal view of the site of root recession 4 weeks postoperatively. Compare with results achieved with the macrosurgical technique (figure 8).

Figure 14. Postoperative view of the microsurgical site approximately 1 year following treatment. Total coverage is observed with few visible scar formations.

and is similar to polyfilament in its handling properties (ie, smoothness, knot security, and tissue penetration). While the strength of the thread is only rated 6-0, its resorption time is 90 to 120 days. When it is desirable to use a resorbable suture with less strength than polyglecaprone, alternative materials (eg, Vicryl, Ethicon Inc., Somerville, NJ) can be selected. Polyfilament threads that range to strength 8-0 are coated to slide smoothly in the tissue. Monofilament materials are also appropriate for microsurgery in strengths 9-0 and 10-0. The period of resorption for these materials depends significantly on the selected thread strength.

Nonresorbable Threads

Polypropylene (eg, Prolene, Ethicon, Inc., Somerville, NJ), a waterproof isotactile thread that is hydrolytically unchanged in the tissues of the body, is the optimum suture material for microsurgery (Table 2).[22] Needle length should range from 11 mm to 13 mm for a papilla suture. At present, no polypropylene suture material of strength 7-0 with a cutting 3/8″ circular needle is available for

Table 1

Recommendations for Resorbable Suture Material

Material	Suture Strength (μm)	Suture Construction	Needle
Vicryl Polyglactine 910	7-0 (50 to 59)	Polyfilament braided	GS-9 6.6 mm Spatula needle, microtip
	8-0 (40 to 49)	Polyfilament braided	GS-9 6.6 mm Spatula needle, microtip
	9-0 (30 to 39)	Monofilament	GS-9 6.6 mm Spatula needle, microtip
	10-0 (20 to 29)	Monofilament	UCS-35 6.2 mm Spatula needle, microtip

Figure 15. Postoperative view of root coverage performed for the maxillary left lateral incisor using the Raetzke technique and 10-0 isotactile polypropylene sutures.

Figure 16. Postoperative situation of the Raetzke graft following 1.5 years. Total coverage is observed over the crown margin, and few scars are visible.

the interdental suture. A synthetic, nonresorbable suture material (Ethilon, Ethicon Inc., Somerville, NJ) that consists of polyamide 6 may be a suitable alternative, but it can initiate a slight inflammatory tissue reaction by

Figure 17. Preoperative occlusal view of a maxillary ridge defect (Seibert Class II) in the left central incisor region.

increasing hydrolytic change. Along with material properties, color is of importance in microsurgery since noncolored material is invisible even under magnification. Intensely dark-tinted threads have proven to be the best.

Requirements of the Surgeon

The restriction of the field of view and the multiple magnification of the object increase the demands on the surgeon. In macrosurgery, movements are controlled by the proprioceptive tactility of the fingers and the palm. Since the adductor and abductor finger muscles are relatively coarse, microsurgical training attempts to improve the fine-tuning of the motor muscles of the hand and arm and the training of the clinician's cognitive abilities. Since a strength 10-0 thread has a diameter of only 20 μm to 29 μm, the knot of the thread can only be controlled visually. When working under the OPM with ×10

Table 2

Recommendations for Nonresorbable Suture Material

Material	Suture Strength (μm)	Suture Construction	Needle
Ethilon Polyamide	7-0 (50 to 59)	Monofilament	P-1 11.2 mm Reverse cutting with precision tip
Prolene Polypropylene	7-0 (50 to 59)	Monofilament	P-6 7.6 mm Reverse cutting with precision tip
Ethilon Polyamide	9-0 (30 to 39)	Monofilament	CS-35-C 6.2 mm Spatula needle, microtip
Prolene Polypropylene	10-0 (20 to 29)	Monofilament	GS-12 5.4 mm Spatula needle, microtip

through ×20 magnification, only the instrument tips are visible, and the appropriate suture material has a diameter five times smaller. General factors (eg, stress, lack of sleep, caffeine intake, smoking, and alcohol) can unfavorably influence hand and finger tremor and have a negative effect in the learning phase. By carefully oriented exercise on operation models and utilization of magnification, the precision of the clinician's motor skills can be increased from 1 mm to 10 μm. One to 2 hours of training per week for approximately 3 months are recommended for the beginner. Using the time knotting technique, instrument handling and dexterity can be standardized so that the surgeon can totally concentrate on the surgical procedure.

Technical faults should also be eliminated in the initial learning period. The clinician's seated position should be adjusted so that the upper part of the body balances symmetrically and the lower arms and hands are well supported. Treatment chairs designed specifically for microsurgeons are useful as they allow fine tuning of the arm supports. In the learning phase, folded cloth rolls may be placed on the patient's shoulders to enable sufficient hand support.

Clinical Results

Minimal tissue trauma caused by microsurgical incision and suture technique with primary wound closure results in reduced cell necroses and therefore heals faster than with a macrosurgical approach.[23] Wound healing studies of extraoral operation sites have demonstrated the completed epithelization of a wound microsurgically closed within 48 hours.[23] This indicates that the initial incisions facilitate tension-free placement of the mucosal or mucoperiosteal flap, which ensures that primary wound closure can be achieved (Figure 4).

As they are relatively frequent therapies, root coverage and soft tissue augmentation are fundamental to daily practice. Root coverage with free connective tissue grafts[3,4,24] has a higher rate of clinical success compared to pedicle[25] or avascular free grafts[8] by ensuring proper nutrition in connective tissue pockets or coverage with a pedicle mucosal flap. While root recessions can be treated with free connective tissue grafts (Figures 5 through 9),[4] microsurgical techniques heal more rapidly with minimal scarring (Figures 10 through 14).

With connective tissue graft techniques that are microsurgically modified, type I and II recessions (as classified

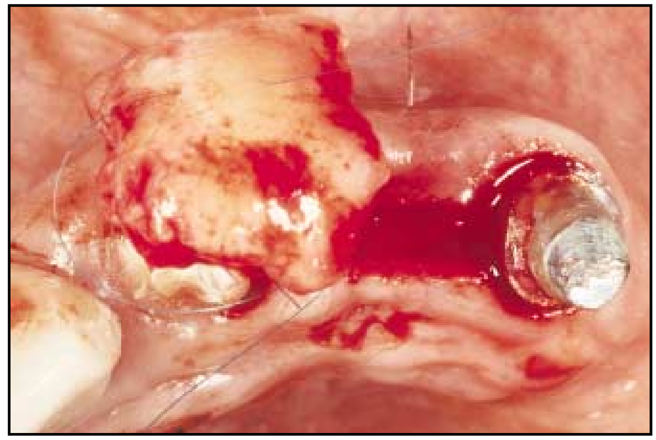

Figure 18. Occlusal view of the surgical site demonstrates the use of 8-0 and 10-0 suture materials to secure the graft in place.

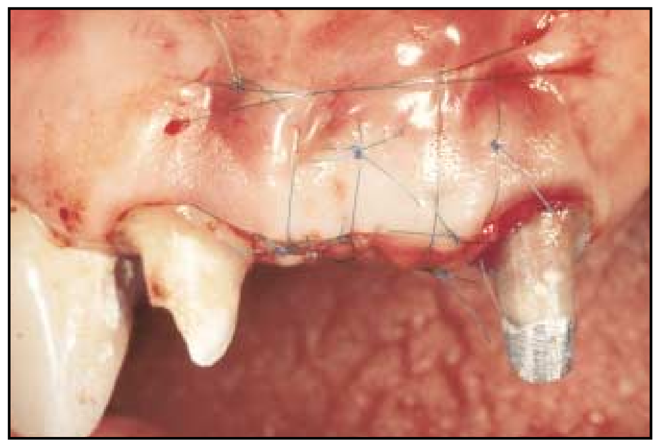

Figure 19. Buccal view of the wound closure following microsurgical soft tissue augmentation.

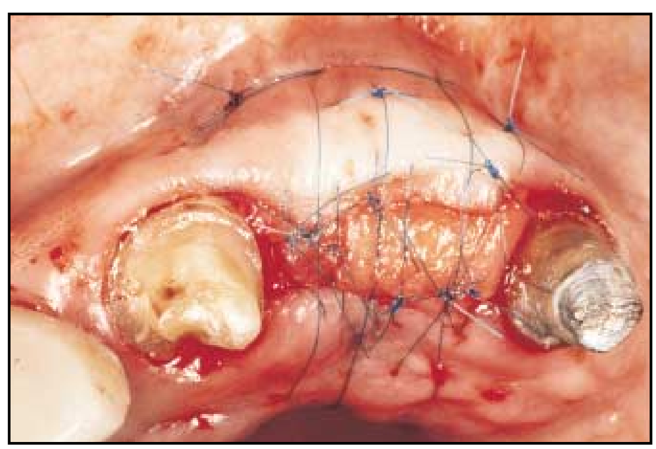

Figure 20. Occlusal view of wound closure over the site of the soft tissue augmentation.

Figure 21. Postoperative occlusal view 3 months following treatment.

Figure 22. Postoperative buccal view (at 3 months) during initiation of tissue sculpting.

Figure 23. Insertion of the metal-supported long-term provisional fixed partial denture to create papillae with continuous lateral pressure of the pontic to open the interdental spaces.

by Miller[26]) can be completely and aesthetically covered in one procedure. Plastic periodontal microsurgery also expands the treatment possibilities at localized extensive buccal recessions ("high-scalloped"), which thus far have only been treated with difficulty (Figures 15 and 16).

Since the 1980s, the free connective tissue graft, which is widely used for the augmentation of edentulous ridge defects,[10,11] appears to heal faster and cause less postoperative volume shrinkage when microsurgically modified (Figures 17 through 23). Several invasions are often necessary with type-III ridge defects (as classified by Seibert[9]) to yield sufficient tissue volume. Using microsurgical techniques, however, operative invasion can often be limited to a single surgery. With proper lighting and visualization of the operation area, mucosal flaps can be prepared in equal thickness under the OPM without the danger of a perforation at the flap basis or at the mucogingival junction. This is particularly important with double-split mucosal flaps, which traditionally place the highest demands on the surgeon.[27] Moreover, abundant fat parts at the graft can be removed with complete control under the OPM, and the connective tissue can be trimmed with ease and precision to the necessary size, which favors rapid vascularization.

Discussion

The field of periodontal microsurgery is still young, and present results are based on subjective statements of patients or observations of the attending clinicians. In order to objectify the aforementioned advantages, prospective studies are necessary to compare micro- and macrosurgical techniques. The advantages of the microsurgical approach in root coverage with free connective tissue grafts have already been demonstrated in a recent clinical study,[28] which used fluorescence angiography to verify that sites treated microsurgically achieved vascularization more rapidly than those that received macrosurgical care.

At present, how significantly the selection of magnification influences the result of the operation can only be speculated. The magnification recommended for surgical invasions ranges from $\times 2.5$ to $\times 20$.[29,30] In periodontal surgery, a magnification of $\times 4.5$ to $\times 5$ for loupe spectacles and $\times 10$ to $\times 20$ for OPM appears to be ideal. Loupes have the advantage over the OPM in that they have a reduced technique sensitivity, expense, and learning phase. The lighting of the operation field is often insufficient, however, which can be limiting with magnifications that surpass ×4. The OPM guarantees an ergonomic working posture, optimal lighting of the operation area, and freely selectable magnification levels. These advantages are countered by increased expense of the equipment and an extended learning phase for the assistant. In order to visualize lingual or palatal sites that are difficult to view, the OPM must have sufficient maneuverability. While this was once possible only by means of the loupe spectacles, recent developments (eg, pivotal objectives and slanted optics) have enabled direct viewing of oral operation sites. By means of these optical devices, it will be possible in the future to perform all periodontal invasion with the OPM.

The increased frequency of complications and postoperative pain has been demonstrated to correlate with the duration of the surgical invasion.[31] To restrict the duration of the surgical invasion and to optimally transfer the microsurgical technique into daily practice, it is recommended to first perform the exercises on appropriate operation models.

In plastic periodontal surgery, the aesthetic and functional results are equally important. Due to microsurgical techniques, optimal aesthetics can be obtained in mucogingival surgery when numerous parameters are maintained: the theoretical and practical training of the surgeon, the necessary viewing aids, the instruments, and the suture technique. As microsurgical procedures evolve, the suturing technique will gain greater prominence.

Conclusion

Periodontal microsurgery not only improves the results of free connective tissue grafts with the split-flap technique, it is similarly advantageous to periodontal diagnosis and therapy (eg, pocket surgery). Magnification of the structures and favorable lighting improve the recognition of subgingival elements, judgment of pocket tissue, facilitate optimal flap adaptation, and enable passive primary wound closure to be achieved. These techniques, therefore, decrease the length of the healing period, the resorption of the connective tissue graft, and patient pain and discomfort. While microsurgical modification of accepted periodontal operations appears to improve the predictability and aesthetics of this therapy, microsurgery also establishes innovative methods of planning for plastic periodontal surgery.

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Continuing Education (CE) Exercise No. 6

6
CONTINUING EDUCATION

To submit your CE Exercise answers, please use the answer sheet found within the CE Editorial Section of this issue and complete as follows: 1) Identify the article; 2) Place an X in the appropriate box for each question of each exercise; 3) Clip answer sheet from the page and mail it to the CE Department at Montage Media Corporation. For further instructions, please refer to the CE Editorial Section.

The 10 multiple-choice questions for this Continuing Education (CE) exercise are based on the article "Utilization of the surgical microscope for advanced plastic periodontal surgery" by Rino Burkhardt, DMD, and Markus B. Hürzeler, DMD, PhD. This article is on Pages 171-180.

Learning Objectives:

This article describes the application of the surgical microscope to provide enhanced perioplastic treatment. Upon reading this article and completing this exercise, the reader should:

- Demonstrate an enhanced understanding of the required optical devices utilized during microsurgery.
- Understand the differences between traditional and innovative microsurgical approaches.

1. Periodontal microsurgery requires all of the following EXCEPT:

a. Adapted instruments and suture materials.
b. A surgical microscope.
c. Systematic laboratory training.
d. Exquisite tactile sensitivity.

2. Which type of graft is most successful for root coverage?

a. Free connective tissue grafts.
b. Pedicle tissue grafts.
c. Fascicular tissue grafts.
d. Avascular tissue grafts.

3. The surgical microscope consists of all of the following EXCEPT:

a. The lighting unit.
b. The binocular tubes.
c. The eye convergence unit.
d. The magnification changer.

4. The following advantages can be attributed to the microsurgical approach EXCEPT:

a. Improved recognition of subgingival elements.
b. Enhanced primary wound closure.
c. Increased and more accurate view of the surgical field.
d. Optimal flap adaptation.

5. Microsurgical instruments must have:

a. A round handle in order to execute finely controlled rotating movements.
b. A short handle to decrease the weight per instrument.
c. No colored coating surface.
d. A lock with a maximum locking force of 250 grams.

6. Working by means of multiple magnification:

a. Diminishes the influence of tactile sensitivity.
b. Requires minimal training.
c. Diminishes the influence of visual sense.
d. Results in enhanced hand movements.

7. Mucogingival surgery includes:

a. Primarily papilla and mucosal reconstructions and modifications.
b. Pocket surgery only.
c. Surgical treatment of periodontal, peri-implant, and mucosal problems.
d. Only surgical treatment of traumatic deformations.

8. A relaxed stereoscopic view is dependent upon all the following EXCEPT:

a. The working distance.
b. The convergence of loupe spectacles.
c. The viewing angle.
d. The divergence of loupe spectacles.

9. Which type of needle minimizes tissue trauma during periodontal microsurgery?

a. Reverse cutting needles with precision tips.
b. Reverse cutting needles with microtips.
c. Round-body needles with precision tips.
d. Round-body needles with microtips.

10. Which one of the following statements about microsurgical suture materials is correct?

a. Natural resorbable threads limit inflammatory reactions.
b. Dark-colored threads are most visible under microscopic illumination.
c. Light-colored threads are most visible under magnification.
d. Nonresorbable monofilament threads limit hydrolytic change.