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Visualization Tools for Minimally Invasive Surgery in Periodontics

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ABSTRACT

In the last decade a special emphasis has been made on the design and performance of surgical procedures for periodontal regeneration. Specific surgical approaches have been proposed to preserve the soft tissues and to reach a stable primary closure of the wound in order to seal the area of regeneration from the oral environment. However, flap dehiscence at the regeneration sites is a frequent occurrence. Exposure and thus contamination of the regenerative material is a critical issue because it has been associated with reduced clinical outcomes. To overcome these disadvantages, the approach to periodontal therapy has been progressively modified. This has given rise to the idea of minimally invasive treatment with the general aim of minimizing the trauma of any interventional process. Minimally invasive technique for periodontal regeneration is based on the use of very small incisions to gain access to the periodontal lesion using sophisticated tools and instrumentation. Therefore this review article highlights the evolution and various magnification systems used for minimally invasive surgery in periodontics.

Key words: Periodontics, Microscopes, Surgical loupes, Tools

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INTRODUCTION

The definition of a minimally invasive procedure has been debated in medicine since the term was first coined in an editorial in the British Journal of Surgery in 1990 [1]. This is a more global term that need not be changed as the technology evolves. Over the years, minimally invasive surgery was defined as a surgical technique that uses smaller incisions to perform a surgical procedure that previously required larger incisions and achieves equal or superior results compared with the traditional or conventional surgical approach [2]. Previously from my research facility, a lot of work has been done on various topics in periodontology [3-15]. Therefore the present review article focuses on the visualization tools for minimally invasive surgery in periodontics.

HISTORY

All treatment for periodontal diseases is centered, at least in part, on the thorough debridement of the root surfaces. Without the removal of plaque, biofilm, and calculus from the root surfaces, most authorities agree that periodontal treatment whether aimed at ameliorating the disease process or the regeneration of lost periodontal tissue is doomed to failure. Remembering this objective, all periodontal surgical approaches are planned for permitting the specialist, improved access and perception to debride root surfaces and the periodontal injury.

Most specialists acknowledge Widman et al. for the main portrayals of periodontal surgery [16]. Everett credits Kirkland with describing the first periodontal surgical procedures that were aimed at regeneration and reattachment to the root surface [17]. Most traditional periodontal surgical procedures are modifications of these early techniques.

Schluger et al. was the first to depict periodontal osseous surgical procedures [18]. Osseous surgery had many similarities to the original procedure described by Widman but altered the treatment of the bone by reshaping the alveolar bone to include the removal of existing osseous defects.

Ramfjord et al. described what he termed the modified Widman procedure [19]. This procedure also had many of the elements of the original Widman procedure but utilized a much more conservative flap design and did not include the complete surgical removal of osseous defects. The emergence of surgery aimed at the regeneration of the supporting structures of periodontium that gave rise to a change in periodontal surgical techniques directing toward minimally invasive periodontal surgery. Most credit Hyatt et al. with the introduction of bone grafting techniques for periodontal regeneration [20]. The original surgical techniques for periodontal regeneration were very similar to those that were in use at the time for pocket elimination procedures. As regenerative surgical techniques became established, the size of the surgical access gradually became smaller and more localized. Often vertical releasing incisions were used to allow for a more localized access to an area of bone loss. However, relatively large localized flaps continued to remain the norm for most regenerative periodontal procedures.

One of the pioneer illustrations of a small flap procedure was termed mini flap [21]. A mini-flap, by definition, was the reflection of the papilla to allow for better access for root planing. The gingival papilla was reflected and root planing was performed with the assistance of fiber optic illumination. The papillae were repositioned with pressure from saline soaked gauze only. No sutures were used. The mini-flap procedure was regarded as amplification for root planing and as a method to completely remove the secular epithelium.

The first description of a periodontal surgical procedure as in debridement was described as minimally invasive in the year 1995 using very small access incisions. This minimally invasive technique was further developed over the next several years as a surgical technique for periodontal regeneration using bone grafts and other regenerative materials. The periodontal surgical technique was described as Minimally Invasive Surgery for periodontal regeneration and was referred to as MIS [22]. In 2007, another minimally invasive surgical technique for periodontal regeneration was described. This technique was based on the papilla preservation technique and was described as the Minimally Invasive Surgical Technique and is referred to as MIST [23].

The current minimally invasive surgical techniques that utilize small incisions for the treatment and regeneration of the destruction caused by periodontal disease can be seen as the result of an evolution that has occurred over the entire history of surgical periodontal treatment. Today, we are able to treat and regenerate periodontal destruction through surgical openings that would have been unimaginable as little as 30 years ago.

TOOLS FOR VISUALIZATION

The key to performing minimally invasive procedures is the ability to adequately see the site and, therefore, the ability to successfully complete the indicated surgical manipulations. With enhanced visualization, outcomes are improved.

Surgical microscope

The surgical microscope has been in use for over 50 years. It was developed and first used for surgery of the inner ear. Since that time, the surgical microscope has been applied to many types of surgeries. This device offers the advantages of high magnification, a bright light source, and an open field for surgery. The open field depends on the moderately long central separation between the magnifying instrument target and the surgical site. This permits the arrangement of instruments into the amplified field of the magnifying lens.

In periodontal surgery, the magnifying lens has discovered successive applications in periodontal plastic and soft tissue grafting procedures. The anterior segment of the mouth and the facial aspect of the anterior teeth and gingiva are the areas where the surgical microscope is most easily used. This segment of the mouth allows for an unimpeded straight-line view of the surgical field. The surgical microscope has allowed for many improvements in the handling of facial tissues and the suturing of tissues during esthetic procedures.

Using surgical microscopes in the posterior and in lingual areas requires a great deal of skill and the use of mirrors to compensate for the straight -line viewing field of the surgical microscope. Another concern with the surgical microscope is the necessity to refocus the microscope if the patient moves. In general, it is not possible to move the microscope to compensate for small movements of the patient such as swallowing or normal micro head movements. It is usually simpler to return the patient to their previous position. This can often be carried out with minimal disruption of the procedure; but if the patient is uncooperative, nervous, sedated, or has difficulty holding a fixed position, this can add considerably to the length of time necessary to perform a procedure.

However, while a surgical microscope can be used for magnification, the present configuration of these microscopes makes their use troublesome. During MIPS, it is often necessary to visualize the defect from several angles to verify the debridement areas of the osseous defect or the root surfaces. It is difficult to move a surgical microscope from one visualization angle to another rapidly. The easiest method to achieve a good magnification of the surgical field is a head-banded microscope, which could be placed on the head of the surgeon and can be easily directed during surgery. An appropriate lightning can be also added to the head-band [24].

Surgical telescopes (Loupes)

In the early reports of minimally invasive surgery, surgical telescopes or loupes were used for magnification. Loupes are magnifiers that are usually clipped or attached to eyeglasses. Surgical telescopes work by magnifying a portion of the surgical field. Looking over the top of the telescope allows the surgeon to view a larger surgical field with no magnification. Magnification with surgical telescopes is usually from 2x to 7.5x. The most commonly used telescopes are in the range of 3x to 5x. Surgical telescopes also come in a range of focal distances that allow the surgeon to sit in a comfortable upright position while maintaining focus on the surgical site. The focal length of the telescopes is selected to fit the surgeon's personal preferences. Often, a high intensity light will be integrated into surgical telescopes. The light can be halogen or LED and can usually be focused to a very narrow diameter. The ability to place a bright focused light on the field that is magnified is a major advantage when small incisions surgeries are performed.

One of the advantages of a surgical telescope over a surgical microscope is that the surgeon is in complete control of where the magnification and illumination is centered. This means that the surgeon can look quickly at several areas within the surgical field without having to move any external piece of equipment such as a surgical microscope. In addition, if the patient moves, redirecting of the magnification is the natural movement of the surgeon's head. The use of surgical telescopes has become standard in many areas of dentistry.

Surgical telescopes have several disadvantages over other methods available for magnification. The most obvious is that much greater magnification is available with other devices. These alternate devices generally have magnification potential in the 10x to 60x range. Surgical telescopes that magnify beyond the 7.5x range can be heavy and difficult to use. Another disadvantage of surgical telescopes is the fact that the surgeon is limited to direct vision. This means that there will be blind spots where a mirror is necessary to see the surgical area of interest. An example is the distal of a second molar or an interproximal site. This is a disadvantage that surgical telescopes share with the surgical microscope. The endoscope and videoscope offer significant advantages in these areas.

Surgical telescopes are an excellent, but limited tool, for minimally invasive surgery. They are particularly useful for a surgeon just starting to make the transition from traditional periodontal surgery to a minimally invasive approach.

Dental endoscopy

During periodontal surgery, dental endoscopy has the capacity to expose or reveal deposits that the surgical microscope or dental magnifying loupes fail to do. Dental microscopes have magnifications from 2X to 20X. At the highest magnifications, the slightest movement can affect the image due to the distance between the objective lens of the microscope and the actual image in the oral cavity that is considered quite long. There is also restricted visualization distal to the posterior teeth. The periodontal endoscope is in close proximity to the root surface and hence the image can stay within the focal depth of field with a good depth of magnification [25].

There are many endoscopic systems available for use in dentistry. The DV2 Perioscopy System and the Perioscopy System have great use in minimally invasive nonsurgical periodontal diagnosis and therapy. These systems have six main features or components explained briefly as follows:

Camera Light Source.

Monitor.

Endoscope Fiber.

Sheath.

Explorer.

Water delivery device.

The Camera Light Source in the DV2 Perioscopy System is the master control unit (MCU) and imparts real-time video images. The light source is an arc lamp that creates intense, focused light fiber optically delivered to the working field. The Perioscopy System consists of a CCD/ LED camera and light coupling device to aid in viewing and emitting light from the endoscope fiber to the monitor through a controller system. The controller has window, gain control, white balance, and illumination settings that are optimized for dental endoscopy. A handpiece contains the camera and LED along with a focus knob.

The DV2 Perioscopy System color LCD video monitor provides real-time, high definition and detailed color images of the procedure site as viewed by the attached endoscope. The image is 25% larger, and the resolution is a significant improvement over the DV2 System.

The dental endoscope (or fiber) is a device for use with the dental endoscope family of dental instruments. The fiber consists of a very thin, flexible shaft containing both viewing and lighting capabilities. It provides a detailed and magnified image of the working area, after being inserted into the sheath and explorers.

The microscope lens system enlarges the image obtained by the fiber-optic probe and creates intense, focused light that is fiber optically delivered to the working field. This reusable fiber-optic endoscope is 1 mm in diameter and 1 m long containing 20 different fibers and 19,125 μm light guides that transmit light to the surgical field. They surround a 10,000 pixel image guide made up of fused 2 μm fibers to capture the image. The end of the probe has a hand micro polished gradient index lens and provides a 3-mm wide field of view.

The magnification is 24x to 48x depending on the closeness to the lens. The fiber does not require routine sterilization when used with the endoscopic sheath.

The sheath: A one-time—use disposable sheath is designed for water irrigation to keep the endoscope lens clear, eliminate the need to sterilize or disinfect the fiber between cases, and to provide a significantly longer fiber life. The Bilumen construction is a unique feature that consists of a plane tubing that completely covers the endoscopic fiber and blue tubing that carries the water for irrigation to the surgical site. Each sterile sheath has a sapphire window, a window cell (a stainless steel tube with sapphire lens), a precision tip seal, and dual Luer–Lock connectors for water and fiber connections. These components create a fluid-tight seal that secures a precise positioning to the working tip of the endoscopic explorer.

The fiber is placed into a sterile sheath and is then placed into an endoscopic explorer. The fiber –sheath–explorer complex is then placed into the sulcus by the clinician for subgingival viewing. Dental endoscopic explorers can be sterilized and hold the sheath/fiber complex, permitting better intraoral use. The endoscopic explorer possesses a shield that diverts the periodontal pocket soft tissue away from the lens of the camera, thereby producing a visually accessible root surface.

The water delivery device contains pressure and is attached to the dental endoscopic system. It not only constantly flushes the pocket during an endoscopic procedure but also keeps the lens devoid of debris such as blood and soft tissue, providing a clear video image. The water delivery device connects to a standard in-office airline and operates by a rheostat pedal through an air-operated valve.

SURGICAL VIDEOSCOPE

The videoscope has a different method of transferring the image to the monitor unlike the traditional medical endoscope. With a videoscope a very small camera is placed at the end of the scope and the camera is placed within the surgical field. The image is then transferred to the monitor by an electrical signal through a wire. This avoids the possibilities of degeneration of the image that may occur during transmission of the image from the surgical site through optical fibers to an external camera. In general, the image viewed on the videoscope monitor is in true color and is of much higher quality than that one obtained with a glass fiber endoscope.

A videoscope that was initially designed for the nonsurgical examination of the kidney has recently been modified for applications in videoscope-assisted minimally invasive periodontal surgery (V-MIS). The modifications consist of the adaptation of the camera end of the insertion tube of the videoscope to a handle that 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 is designed to retract the very small flaps associated with VMIS.

This carbon fiber retractor can be rotated in a manner that will allow the surgeon to retract V-MIS flaps on the buccal or lingual aspect of the periodontal defect. As with all endoscopic or videoscopic instruments, a major concern is keeping blood and surgical debris from obscuring the optics of the instrument. Without an effective method to keep the optics clear, it is impossible to use an endoscope or videoscope. It is not practical to continuously flow water over the lens of the videoscope, nor is it possible to keep an open surgical field filled with liquid as is used for nonsurgical minimally invasive treatment of periodontal disease with the glass fiber endoscope. A technology that uses a constant flow of surgical gases or air over the lens has been developed to overcome this problem during periodontal use of the videoscope. This technology is described as gas shielding of the optics.

Its application to a videoscope used for periodontal MIS procedures allows the videoscope to be used continuously without the need to clean or clear the optics. The modified videoscope with gas shielding has been used in a university based study of minimally invasive periodontal surgery. Preliminary results have shown good visualization with improved attachment levels and pocket depths that are similar or improved over other published results for small incision surgeries [26,27]. The use of the videoscope appears to allow for a reduction in post -surgical recession.

LIMITATIONS

The endoscope does not come without limitations. The clinician must consider root morphology and severity of inflammation. The complexity of multi rooted teeth makes it difficult to see the entire root surface and access every curve and indentation. Roots can be close together creating a furcation that is narrow and inaccessible with the tip of the endoscope or scaling instrument. If the tissue has severe inflammation, it can completely block the view of the fiber-optic tip of the endoscope. The tissue folds around the shield, which holds the fiber optic, obstructing the view. Bleeding can also block the view of the tooth surface. When the disease is generalized, most clinicians experienced in endoscopy find it helpful to do closed subgingival scaling and root planing a few weeks prior to the use of the endoscope to minimize inflammation and bleeding, therefore optimizing the field of vision.

Areas where periodontal endoscopic debridement is difficult include:

Very inflamed pockets.

Abscesses.

Distal furcation of maxillary molars.

Narrow furcation’s and class III furcation’s.

Curved roots.

Close root proximity.

Grossly over contoured restorations.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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