A Videoscope for use in Minimally Invasive Periodontal Surgery

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Abstract

Introduction—Minimally invasive periodontal procedures have been reported to produce excellent clinical results. Visualization during minimally invasive procedures has traditionally been obtained by the use of surgical telescopes, surgical microscopes, glass fiber endoscopes, or a combination of these devices. All of these methods for visualization are less than fully satisfactory due to problems with access, magnification, and blurred imaging.

Clinical Innovation—A videoscope for use with minimally invasive periodontal procedures has been developed to overcome some of the difficulties that exist with current visualization approaches. This videoscope incorporates a gas shielding technology that eliminates the problems of fogging and fouling of the optics of the videoscope that has previously prevented the successful application of endoscopic visualization to periodontal surgery. Additionally, as part of the gas shielding technology the videoscope also includes a moveable retractor specifically adapted for minimally invasive surgery.

Discussion—The clinical use of the videoscope during minimally invasive periodontal surgery is demonstrated and discussed.

Conclusion—The videoscope with gas shielding alleviates many of the difficulties associated with visualization during minimally invasive periodontal surgery

Keywords
Videoscope; Endoscope; minimally invasive procedures; Periodontics; surgical procedures

Introduction

Surgical access to disease induced periodontal destruction has traditionally determined the incision size used for a procedure. The need to adequately see defects and provide access for instrumentation has dictated a certain incision size (length) and increased the amount of
elevation and retraction of adjacent healthy tissues. The additional tissue elevation and retraction necessary for visualization has probably contributed to the morbidity associated with surgical treatment. Thus, it stands to reason that a reduced access surgical site or minimally invasive approach should result in less morbidity for the patient.

The term minimally invasive surgery was first coined in an editorial appearing in the British Journal of Surgery (Wickham & Fitzpatrick 1990). The authors of the editorial described the revolution occurring in surgical techniques that were beginning to be applied in medicine. They argued against the common practice of the time that described surgical techniques based on the instrumentation that was used to perform the procedure. Examples of this would be “microsurgery” to describe surgery performed using a surgical microscope or “laparoscopic surgery” to describe abdominal surgery using a laparoscopic endoscope. Instead, they argued that a more global description of the surgical technique was needed which did not tie a surgical procedure to the rapidly changing technology being used for visualization during the surgery. They suggested the term minimally invasive surgery, which encompassed all surgeries that used an incision smaller than used for traditional surgical procedures.

The definition of minimally invasive surgery was further explored by Hunter and Sachier in the first edition of their pioneering procedure compendium (Hunter & Sackier 1993). Most of the introduction to this work was devoted to the definition of minimally invasive surgical procedures. Their conclusion was that a minimally invasive procedure was defined as the ability to perform a traditional surgical procedure and achieve the same or better outcomes utilizing a surgical opening that was smaller than traditional surgical access. They also described the reported advantages of minimally invasive surgery.

These generally included less post operative discomfort, more rapid healing, less morbidity, and equal or improved long term surgical outcomes. They attributed these benefits to the use of small incisions and the ability to minimize damage to the surgical tissue. They summed up the source of these advantages in the simple statement that the “wound is smaller”.

The application of minimally invasive surgery for the treatment of periodontal attachment and bone loss was first described by Harrel (Harrel & Rees 1995). This technique was termed MIS. Reports on the short and long term results of MIS were published over the next five years (Harrel 1998, 1999, 1999, Harrel & Wright 2000, Harrel & Nunn 2001). These initial multiple case series of MIS reported equal or improved long term surgical outcomes compared to traditional surgical approaches with significant improvements in attachment level, probing pocket depths, and radiographic evidence of bone formation.

Recently a long term prospective study by the same group reported on a two center study of 160 sites where MIS was used. (Harrel, Wilson, & Nunn 2005, 2010) The results of this study were reported as one year and six year post operative data. Initial probing pocket depths ranged from 5.0 to 12.0 mm. At one year, all treated pockets had a mean probing pocket depth of 3.10 mm, showed a mean improvement in attachment level of 3.57 mm, and a mean clinically undetectable recession of 0.01 mm. These results were maintained over time with a slight improvement in all clinical parameters noted at six years post operative compared with the one year data. No trend toward a return to pre operatively levels of probing pocket depth, attachment loss, or increased recession was noted in any of the 142 MIS sites evaluated at the six year post operative interval.

In 2007, a similar minimally invasive surgical approach was reported. This approach was referred to as minimally invasive surgery technique (MIST) (Cortellini & Tonetti 2007, 2007, Cortellini et al 2008) The results of this procedure showed a mean one year post surgical probing pocket depth of 3 mm, a mean improvement in attachment level of 4.9 mm,
and recession of 0.4 mm. Additionally, very little discomfort and rapid healing was reported with the use of MIST. This minimally invasive approach was later modified to the modified minimally invasive surgical technique (MMIST) which includes a papilla sparing approach. (Cortellini & Tonetti 2009, Cortellinini et al 2009, 2011) Others have subsequently reported favorable results with these procedures. (Rabeiro et al 2011, 2011, Mishra, Avula, & Pathakota 2013)

Thus, separate and unrelated surgical centers in the United States and Italy have reported similar excellent results from the use of small incision approaches for periodontal regeneration. The results from both centers show better clinical results with improved probing pocket depths and improvement in attachment levels when compared to most reports where traditional (large incision) surgical approaches have been used. (Garrett 1996) Despite these independent corroborating results, minimally invasive surgical approaches have not become routine for periodontal treatment. This lack of acceptance may be associated with the difficulty in visualizing the surgical site when a minimally invasive approach is used.

MIS procedures reported to date have been performed using either high magnification surgical telescopes (loops) or a flexible fiber optic endoscope in a water filled environment. (Harrel, Wilson & Nunn 2005) Most MIST procedures are reported to have been performed using a surgical microscope. (Cortellini & Tonetti 2007) All of these visualization technologies are less than completely satisfactory. The use of a surgical microscope gives excellent magnification but has a relatively steep learning curve and many surgeons have difficulty using the microscope for some procedures. Surgical telescopes give direct visualization and allow for easy adaptation to patient movement but usually do not give the same level of magnification achieved with a surgical microscope.

A flexible glass fiber optic endoscope was introduced to periodontics as an instrument for performing non-surgical periodontal procedures. (Stambaugh 2002) This instrument uses a semi flexible glass fiber optic bundle that is inserted into a disposable sheath that has a sapphire lens designed to be placed into the intact sulcus. This instrument depends on a liquid filled environment with a constant flow of liquid to prevent fouling of the lens from blood and debris. This liquid filled environment is very difficult to maintain during minimally invasive procedures. Also, the liquid filled environment tends to obscure the surgeons vision. This problem, coupled with the inherently poor image quality obtainable from the glass fiber optics of the endoscope, has made this technology less than satisfactory for minimally invasive periodontal procedures.

**Clinical Innovation Report and Discussion**

This paper reports on the clinical innovation of a new visualization technology designed for use in minimally invasive periodontal procedures. This technology utilizes a flexible videoscope that can be used in an air or gas filled surgical environment.

A traditional “rigid” endoscope such as is commonly used for abdominal surgery utilizes multiple optically stacked prisms to carry the image from the surgical site to an eyepiece or camera that lies outside the surgical field. This type of endoscope is usually encased in a ridged stainless steel tube and must be used at close to a 90 degree angle to the surgical field. These features make this traditional endoscope difficult to use for periodontal treatment.

Glass fiber “flexible” endoscopes use multiple strands of optical glass fibers that carry an image from the surgical field to an external camera that then displays the image on a surgical monitor. The glass fibers are relatively fragile and cannot be sterilized. This
necessitates the use of a sterile sheath that must be placed around the fibers when the endoscope is used. While this type of endoscope is considered flexible, the glass fibers are extremely prone to micro fractures that limit the extent the fiber optic bundle can be bent. Even with care and minimal bending, the glass fibers are subject to fracture during normal usage and because of this the optical quality of the image produced tends to degenerate relatively rapidly over time.

A videoscope differs from either the traditional rigid or flexible endoscope in the fact that a digital camera is placed on the end of a flexible insertion tube. In most medical applications the tip of a flexible videoscope is controlled by a joystick device that allows the camera to be directed at various angles during the surgical procedure. The image is not dependent on fragile optical glass fibers. The entire device can be sterilized and it is not necessary to use a sterile sheath. The videoscope’s flexible insertion tube allows for the placement of a full color high definition digital camera in close proximity to the surgical site.

A major problem encountered with all types of endoscopes and videoscopes is the fouling of the optics by blood and debris from the surgical field. In abdominal surgery where a gas filled surgical site is used, the optics of the endoscope or videoscope are often fouled from blood splatter or tissue debris from the use of an electro-cautery. This fouling necessitates the frequent removal of the scope from the surgical field to clean the optics. Orthopedic joint surgery is usually performed in a liquid filled field to minimize fouling of the optics. A joint such as the knee may be fill with Ringers lactate so that the tissue debris will not collect on and obscure the endoscope optics. This approach requires relatively rapid flushing of the field by flowing solution in and out of the surgical site. The liquid filled field tends to make visualization difficult and alters the colors and contours of the surgical anatomy when viewed on a monitor.

The videoscope used in minimally invasive periodontal surgical procedures is a medical videoscope designed for use in non surgical visualization of the calyx of the kidney. (Olympus Medical URF Type V) This videoscope has a 670 mm long flexible insertion tube with a high definition camera producing magnification of 10 to 40 X and self regulating fiber optic illumination. The camera and fiber optic illumination are contained in a tube that is 2.7 mm in diameter. The videoscope is shown in Fig 1 and 2. For minimally invasive periodontal procedures, the distal end of this videoscope is held in a handpiece that directs the camera at an angle that is convenient for visualizing all areas of the mouth and is specifically designed to access interproximal sites. The handpiece with the videoscope inserted is shown in Fig 3.

When a videoscope is placed directly into a periodontal surgical site without provision to protect the optics the lens will quickly become fouled with blood, water spray, and tissue debris. This makes it impossible to use the videoscope to visualize the surgical site. In order to overcome this, a device that uses a gas shielding technology has been developed for use in MIS. This device passes a low pressure stream of gas over the end of the videoscope. The flow of gas creates a “shield” over the optics of the videoscope that deflects splatter and prevents fogging and fouling of the optics (Figure 4). When the gas shield technology is used, it is possible to use the videoscope for extended periods of time and the necessity of clearing blood or debris from the lens is minimized. Additionally, the gas shield incorporates a carbon fiber retractor that can be rotated allowing for the correct placement of the videoscope in relation to the surgical site and the small flap used with MIS. The carbon fiber retractor allows for the gentle elevation of tissue while the videoscope is in use. The gas shielding allows for the improved optics of working in an air filled surgical field while keeping the videoscope lens clear of debris and eliminating the necessity of using a constant flow of liquid.
As is the case for many currently used medical procedures, periodontal procedures using the videoscope require the surgeon to visualize the surgical site on a monitor (Figure 5). This differs from the traditional approach to periodontal surgery that utilizes direct visualization and may require some practice for the surgeon to adapt to this change in technique. However, learning time is usually short and most surgeons quickly adapt to this change in technique.

Explanation and Illustration of the Use of a Videoscope During a Typical Procedure

Figures 6 through 12 illustrate the surgical use of a videoscope with gas shielding in minimally invasive periodontal surgery as it is performed in an ongoing clinical study of MIS. With MIS all flap reflection is performed with sharp dissection using a small angled blade. Incisions are usually made under direct vision without the use of the videoscope. No blunt dissection with a periosteal elevator is used as it is felt this unnecessarily traumatizes the tissue and damages the underlying blood supply. The videoscope makes the routine use of a palatal or lingual access approach straightforward and can usually avoid the necessity of reflecting the facial tissue. This minimizes the risk of recession and papilla loss on the esthetically sensitive facial aspect. The carbon fiber retractor surrounding the videoscope is rotated and positioned to gently displace the small palatal flap enough to allow the insertion of the videoscope. Figure 8 through 11 shows a surgical site as seen in the videoscope monitor. The granulation tissue is removed with small curettes while visualizing the surgical site with the videoscope. Various stages of debridement of the surgical site are illustrated. Small islands of calculus (noted by an arrow in figure 10) may be noted on the root surfaces after mechanical root debridement. These tiny islands of calculus are often not easily visible except with the videoscope. The areas of calculus not removed with curettes are usually removed by the use of EDTA after root planing has been completed. Following debridement of the bony lesion and root surface, regenerative material may be placed into the site. Previous MIS studies have used enamel matrix derivative (EMD) and/or demineraized freeze dried bone allograft. Membranes are not usually placed during MIS because of the small surgical access opening and they seem to be unnecessary for good surgical results. In most cases, the surgical site is closed with a single modified vertical mattress 4-0 plain suture. A video of one of the surgical procedure illustrated in these figures is available online (Video S1). Pre operative and nine month post operative views of the procedure in the video are shown in figures 13 through 16.

Case Series

The videoscope and gas shielding technology has been developed over several years with funding from the US National Institute of Health/ National Institutes of Dental and Craniofacial Research (NIH/ NIDCR). The videoscope is currently being used in a large NIDCR sponsored university based clinical study. The NIDCR sponsored evaluation of MIS using the videoscope is ongoing at this time and data collection is not complete for all cases. A case series consisting of sites that have been completed and where six month postoperative finding are available is reported here to illustrate the preliminary findings from this study. The results from this subset of data are shown in Table one.

The current MIS surgical approach used in the current study is similar in most instances to previously published studies (Harrel, Wilson, Nunn 2005 and 2010). In these previously reported studies, the minimally invasive surgical approach described by Harrel (Harrel 1998) was used with the addition of Enamel matrix derivative (EMD). The current study utilizes the standard MIS approach and use of EMD but the videoscope with gas shielding is used for visualization as opposed to the use of surgical telescopes and glass fiber endoscopes.
that were used in the previous study. The results of this ongoing study appear to be similar to previously reported results from the use of MIS or MIST/MMIST procedures. All patients entering the study had root planing performed at least three months before the MIS procedure was performed. Mean post root planing pocket probing depths were 6.4 mm. At six months post operative all pocket probing depths have been reduced significantly with no post surgical pockets greater than 3.4 mm (mean 2.5mm). The most notable difference over past MIS results is that there was an improvement in recession over initial levels. Some amount of recession has been reported with almost all periodontal regenerative periodontal surgery, including MIS and MIST/MMIST. In the current study of MIS using the videoscope no postoperative recession is present and this preliminary data shows an improvement in root coverage. While this gain is not statistically significant in the reported subset of 29 surgical sites, it may be an indication that with the videoscope post surgical recession will be minimal to nonexistent and it may be possible to correct some gingival recession that existed preoperatively. This would be a welcome clinical improvement in esthetically sensitive areas that have experienced bone loss due to periodontal disease.

Conclusion

The videoscope with gas shielding is designed to allow for improved visualization during all types of small incision periodontal surgery. This technology helps simplify visualization during the performance of periodontal surgery where minimally invasive techniques are used by allowing for close visualization of the surgical site in real time.

It is hoped that the improved and simplified visualization afforded by the use of the videoscope with the addition of gas shielding will simplify the performance of minimally invasive approaches and help make the use of small incisions the standard for periodontal regenerative therapy.

Acknowledgments

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References


Clinical Relevance

Scientific Rationale
The described videoscope with gas shielding is designed to improve visualization during minimally invasive periodontal procedures. The clinical innovation of combining a high resolution videoscope camera with gas shielding to prevent fouling of the lens allows for improved visualization of the minimally invasive surgical site.

Principal Findings
The use and improvement in visualization is demonstrated with clinical documentation.

Practical Implications
The videoscope with gas shielding helps provide an improved method of visualizing minimally invasive surgical procedures. This should allow for greater acceptance of this surgical approach.
Figure 1.
The videoscope used for MIS. This videoscope is designed for use in non-surgical treatment of the kidney.
Figure 2.
The 2.7 mm tip of the videoscope pictured in Figure 1. Visible in the tip are a camera port, an access port for biopsies, and two self-regulating fiber optic light sources.
Figure 3.
The handpiece used to hold the videoscope in Figure 1 for use in MIS. A handle positions the videoscope so that it can be placed in the minimally invasive surgical site. Gas enters the gas shield through the side tube and circulates around the optical tip of the videoscope. The moveable carbon fiber retractor is also shown. This retractor functions as part of the gas shield system.
Figure 4.
Schematic of Gas Shield technology This drawing demonstrates the application of the Gas Shield. Air or gas enters the tube (arrows) surrounding the videoscope insertion tube, flows around the tip of the videoscope, and forms a protective bubble or shield of gas around the optics of the videoscope. The rotating carbon fiber retractor is an integral part of the gas shielding application.
Figure 5.
When the videoscope is utilized, visualization of the surgical site is indirect. As is currently the case in a large percentage of medical procedures, this requires the surgeon to utilize a monitor to perform some portions of the surgical procedure.
Figure 6.
Incision In this case, only a palatal split thickness incision is made. A specially modified knife is used. No blunt dissection (periosteal elevation) is performed. This helps maintain the blood supply by preserving the periosteum. The buccal tissue and papilla are not incised or elevated.
Figure 7.
The videoscope is placed into the MIS site. The videoscope is held in place by the handpiece while the carbon fiber retractor is rotated into a convenient position to gently retract the small flap.
Figure 8.
The surgical site as visualized with the videoscope. At this point only a small amount of the granulation tissue has been removed. Some calculus is visible as white raised areas on the root surfaces.
Figure 9.
Site debridement. Granulation tissue is removed with small curettes (arrow) and the root surfaces are debrided while visualizing the site with the videoscope.
All granulation tissue has been removed. The unreflected intact buccal papilla can be seen on opposite side of the surgical field. Very small islands of calculus (arrow) remain in a nearly microscopic groove on the root surface. These islands of calculus are often only visible with the videoscope.
Figure 11.
Final root preparation The islands of calculus have been removed with EDTA. The site is now ready for the placement of regenerative materials such as enamel matrix derivative and/or bone graft material.
Figure 12.
Suturing The surgical site is closed with a single vertical mattress suture (arrow) through the base of the flap. The tips of the papilla are approximated with finger pressure only. In MIS, the tips of the papilla are not sutured.
Figure 13.
Buccal preoperative view of the surgical site illustrated in the online video (Video S1).
Figure 14.
Lingual preoperative view of the surgical site illustrated in the online video (Video S1)
Figure 15.
Nine month postoperative buccal view of the surgical site illustrated in the online video (Video S1). No detectable soft tissue recession is noted.
Figure 16.
Nine month postoperative lingual view of the surgical site illustrated in the online video (Video S1). No detectable soft tissue recession is noted.
### Table One

Change in measurements at six months post operative for MIS sites that fit the study inclusion criteria of pockets greater than 5 mm following non surgical periodontal therapy.

<table>
<thead>
<tr>
<th></th>
<th>Initial*</th>
<th>6 Month PO</th>
<th>Improvement at 6 Mo.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pocket ProbineDepth</td>
<td>6.4mm SD±0.6</td>
<td>2.5mm SD±0.9</td>
<td>3.9mm</td>
<td>&lt;0.001</td>
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<tr>
<td>CAL</td>
<td>7.1mm SD±1.2</td>
<td>3.0mm SD±1.1</td>
<td>4.1mm</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Recession</td>
<td>0.7mm SD±1.0</td>
<td>0.5mm SD±0.8</td>
<td>0.2mm</td>
<td>0.46</td>
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</tbody>
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n=29

* Three months post non-surgical treatment