Technical Note

Surgical Strategy of Endoscopically assisted Periradicular Surgery Using Novel Head-mounted Display System

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Abstract

A novel head-mounted display offers high quality of endoscopic imagery in front of the eyes, irrespective of the head position. We present an application of the head-mounted display system as a personal integrated multi-image monitoring system in endoscopically assisted periradicular surgery. Our head-mounted display system displayed multiple forms of information as integrated, sharp, high-definition endoscope, biological monitor, and X-ray image (such as panoramic and computed tomography images) synchronously using a picture in picture. In addition, this system can cope with both the endoscopic field of view and the direct field of view. While monitoring the patient's general condition with a head-mounted display, the surgery was performed with endoscopic animation. We could also switch to the direct surgical field and endoscopic field of view smoothly without moving the head and without surgical interference. The availability of a head-mounted display system during endoscopically assisted periradicular surgery enabled the provision of a comfortable and appropriate surgical environment for the surgeon.

Keywords: Endoscope, head-mounted display, periradicular surgery

Introduction

A periradicular surgery involves the surgical management of a tooth with a periapical lesion, which cannot be resolved by the conventional endodontic treatment, such as root canal therapy or endodontic retreatment. The use of a surgical microscope has been regarded as a crucial factor that contributes to excellent results. Meanwhile, since various endoscopic surgeries, including excision in the submandibular salivary gland,[1] fixation of mandibular condyle fractures,[2] implant surgery,[3] and facial tumor resection,[4] have been introduced in craniomaxillofacial surgery, it has become increasingly popular as a result of minimally invasive surgeries, safer treatments, and less surgical complications. Therefore, it has become widespread due to the several advantages of endoscopic surgery. Simultaneously, it has been reported that periradicular surgery using endoscope gives the same result as microscopic surgery.[5]

However, endoscopically assisted surgery has its limitations. Especially, in oral and maxillofacial surgery, it is mixed with endoscopic field of view and direct visual surgical operation.[4] In other words, it is necessary to switch between under image surgery through the endoscope view and the direct field of view. This switching operation interferes with smooth surgery. The head-mounted display developed recently can use high-quality images for wearable, and its effectiveness is reported for other surgeries.[6,7] Furthermore, this system can cope with both the endoscope field of view and the direct field of view.

Here, we have presented an application of the head-mounted display system as a personal integrated multi-image monitoring system in endoscopically assisted periradicular surgery.

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Technique

Representative clinical case

A 38-year-old Japanese woman reported pain and swelling in the area of the right maxillary lateral incisor. The right maxillary

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Figure 1: The head-mounted display system (HMM-3000MT; Sony Corporation, Tokyo, Japan). This equipment is a head-mounted display unit composed of a head-mounted image processor unit and a head-mounted display monitor, included a display

Figure 3: Both the surgeon and the assistant wear head-mounted monitors, while the assistant maneuvers the endoscope. During the entire operation, the team performed surgery without removing the head-mounted display and could perform the surgery smoothly without incurring stress due to a certain head position

lateral incisor was endodontically treated 8 years earlier and then retreated 11 months ago in the patient by a referring dentist. However, when the clinical symptoms did not improve after local dental clinic treatment, the patient received referral to our department. At her first visit to our hospital, a panoramic radiograph revealed a periapical lesion of the right maxillary lateral incisor. Computed tomography (CT) scan confirmed a cystic lesion measuring 17.0 mm × 11.8 mm × 8.4 mm in diameter, surrounding the right maxillary lateral incisor apex. Based on these findings, we diagnosed the condition as a radicular cyst of the lateral incisors. An endoscopically assisted periradicular surgery was accordingly planned as a highly predictable treatment. The patient signed an informed consent.

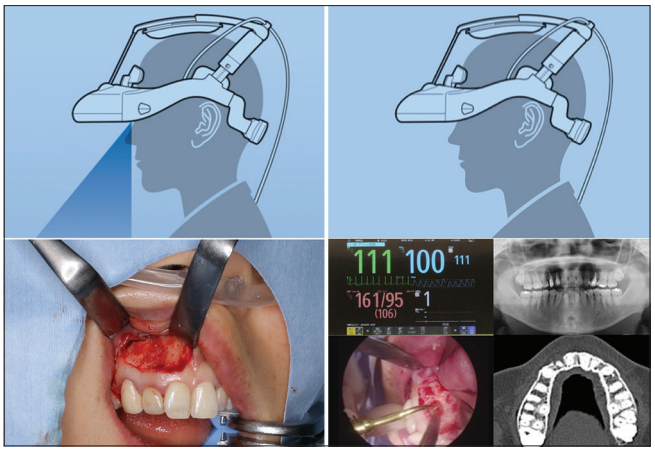

Figure 2: The high-definition endoscope video, biological monitor, and X-ray image (such as panoramic and CT images) are connected to the image processor. In this system, the operator can visually confirm various types of information through the head-mounted display, and the operator can freely select the necessary information. This system can cope with both the endoscope field of view and the direct field of view

Preparing the head-mounted display

The equipment used was a head-mounted display unit composed of a head-mount image processor unit (HMM-3000MT; Sony Corporation, Tokyo, Japan) and a head-mounted display monitor [Figure 1]. The equipment was set before the operation by both the surgeon and the assistant. A high-definition endoscope video, biological monitor (for monitoring blood pressure, pulse, heart rate, electrocardiogram, and percutaneous oxygen saturation), and X-ray image (such as panoramic and CT images) were connected to the image processor. In this system, the operator can visually confirm various types of information through the head-mounted display, and the operator can freely select the necessary information. In addition, this system can cope with both the endoscope field of view and the direct field of view [Figure 2].

Surgical procedure

First, the surgery was performed by observing the surgical field directly. A full mucoperiosteal tissue flap was raised. Then, surgical access to the root apex was made through the cortical bone using a round bur at a low rotary speed. Shaving of the bone was performed by the brush stroke approach with constant sterile water irrigation. The surgeon stood on the operating side, and the assistant director used a 4-mm endoscope [(VISERA ELITEII VIDEO SYSTEM, Olympus, Tokyo, Japan) and (7230BWA, 30° HOPKINS Telescope, KARL STORZ Germany)] from the other side. We visualized the operating field using endoscopic imaging through the head-mounted display. The periradicular lesion was, thereafter, removed with angled periodontal curettes and sharp bone curettes. The curetted tissue was placed in 10% formalin solution for pathological diagnosis later. After exposure of the end of the root, we inserted an ultrasonic device (Piezosurgery Touch, Mectron, Italy) in a handpiece perpendicular to the long axis of the root and shaved away 3 mm of the root end.

Cavities (2.5–3 mm deep) were prepared under constant copious irrigation with sterile water using an ultrasonic device retro-tip with angled shaft (Retrograde Microsurgery, Mectron, Italy) driven by an ultrasonic device. Then, the root-end cavities were dried and were examined carefully with the endoscope to detect any morphological alterations of the root face, such as marginal chipping. The white Pro-Root MTA® (Dentsply Maillefer) was mixed according to the manufacturer's instructions and then, was inserted into the root-end cavities. The excess filling material was removed. Finally, the surgeon observed the surgical field directly. The reflected tissues were re-approximated to their original position, compressed, stabilized, and sutured with absorbable silk 4–0 (Surgisorb 4–0; Nitcho Corporation, Tokyo, Japan). During the entire operation, the surgeons performed the surgery without removing the head-mounted display and could perform the surgery smoothly without the stress incurred with a certain head position [Figure 3].

There was no recurrence of pain and swelling after the surgery in the patient, and the recovery is taking a good course.

Discussion

The change from performing surgery without using the conventional magnifying field view with the introduction of microsurgical techniques had brought about a huge revolution in endodontic surgery. The use of high-quality magnification devices in dentistry is becoming more common in attempts to improve the quality of treatment.[5] The use of microscope for the magnifying effect earlier contributed to extremely good clinical results. However, a microscope possesses some challenges in this surgery.

However, endoscopically assisted endodontic surgery can overcome this issue. Because of not being a fixed field of vision, the endoscope allows the treatment field to be viewed at various angles and from various distances without losing the depth of the field and focus.[8] Since endoscopes are extremely easy to operate, the operator can examine the morphological aspects of the teeth root from almost any direction in a short time. In addition, it is possible to observe the back of the roots to confirm the presence of periradicular lesions and to remove them. This process is much more complicated when the operator has to use retro mirrors in the microscope.[5] Endoscopically assisted surgery is extremely easy to use and is very useful for obtaining a field of view from various directions.

Although the endoscope provides a wonderful operative field, it is used with a monitor. In general, the monitor is located in a direction different from the surgical field. Therefore, to see the image of the endoscope, the surgeon and the operator have to look up and back. This action of looking is a great stress for the operator. In the working condition of the surgeon, it should be possible to minimize the muscle tension and allow the surgeon to perform the operation in a relaxed position.[9] Looking at the monitor by moving the face, in as far as a considerable misalignment of the eye–hand–target axis during task execution, significantly affects the postural comfort[10] and interventional safety.[11] Using a head-mounted display monitor in this case, we could finish surgery without moving our head positions. The second assistant and the surgical nurse can share the endoscopic image on the large screen with the operative field. The head-mounted device also allows both the surgeon and the assistant to view both the endoscopic image and the surgical field of view without interrupting the flow of surgery. This action contributes to the rapid surgical operation, resulting in minimally invasive surgery.

Occasionally, the surgeon has to perform not only the surgery but also intraoperative systemic management. Multimodality of patient information is important in such cases. Multimodality medical information fusion and processing have developed rapidly in the recent years.[12] This head-mounted display system allows the integration of preoperative radiological findings with monitoring of real-time endoscopic images and patient's vital signs. Using the head-mounted display system, the surgeon can view multiple images in one view using a split screen, regardless of the head position. This technology facilitates safe surgical management.

Conclusion

This is the first report of endoscopically assisted periradicular surgery using a head-mounted display system. The availability of a head-mounted display system during endoscopic periradicular surgery enables the provision of a comfortable and appropriate surgical environment for the surgeon.

Patient consent

Written informed consent to publish clinical photographs was obtained from the patients.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understand that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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