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Development of a New Micro-endoscope for Odontological Application

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Abstract
Purpose: Development and introduction of a new micro-endoscope called *Visio Scope* for multidiscipline use in dentistry.
Methods: During the development of the new micro-endoscope called *Visio Scope* testings in the following dental disciplines were performed: endodontics, periodontology, implantology, perapical surgery, prosthodontics, and laser treatment. In this first report, flexible micro-endoscopes with an external diameter of 1.0 mm as well as of 0.34 mm were used.
Results: There is a significant improvement in all tested disciplines concerning handling and flexibility, verification of radiologically not detectable findings. In this context, the endoscope has proved itself clearly superior to conventional optical aids, above all the surgical microscope. The working canal facilitates specific application of medication and irrigation solutions.
Conclusions: The *Visio Scope* allows visual control of the extent of the bone defect and enables optical control after removal of concrements and granulation tissue, before possible regenerative measures. Root fractures and furcation invasion can be reliably documented. Optical control guarantees preoperative and postoperative success of treatment.

Key words: dental endoscopy, micro-endoscope, optical control, *Visio Scope*

Introduction

In dental surgery, endoscopes are routinely used for inspection and operation of the maxillary sinus. Since their development in the early 1990ies, microsurgical instruments have opened up new possibilities first of all in periapical surgery. Here, above all methods for retrograde root canal filling were refined [1, 2] and new procedures for retrograde endodontic sealing were developed [3]. In periodontology, endoscopic technology is still in its infancy. Further development of the micro-endoscopes (Gyrus®, Tuttlingen) with optics of an external diameter ranging between 0.34 mm and 1.00 mm and additional flexibility have opened up new perspectives for application in dental disciplines. For example, periodontal therapy under optical magnification allows a quick overview of possible root fractures or cariogenesis, thus supporting diagnosis, planning of therapy and verification of therapeutic success [4]. Furthermore, the control of all important working steps at the implant-abutment-supraconstruction junction is to be mentioned in this connection as a perspective for implantology.

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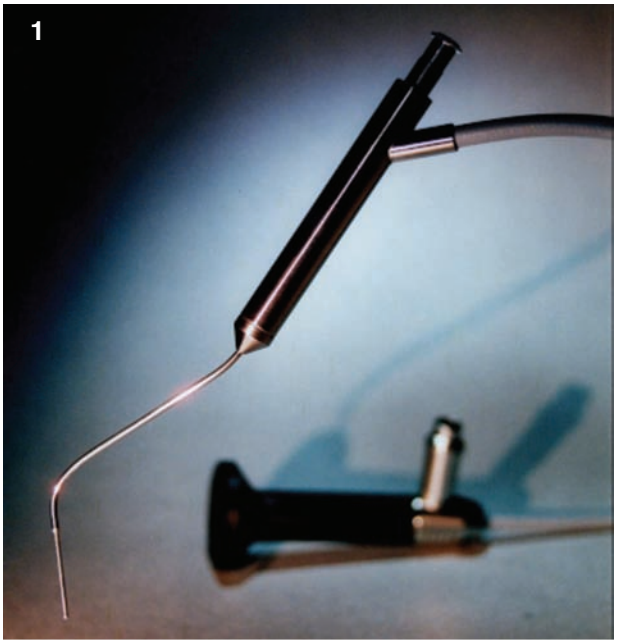
Material and Methods

In the present report, a 250 W halogen lamp served as light source. The fibre optic device consists of a high-speed rod lens system and an optimized fibre optic arrangement to obtain a bright, brilliant picture with high resolution and definition up to the margins for better identification of the details. The endoscope (Fig. 1) is exclusively made of "Medical Grade" stainless steel. Laser welded and soldered connections reliably rule out any capillary cracks and other leakage paths. Since elastomers susceptible to leaks are not used as sealant for the endoscope, hygienic preparation in the autoclave at 134 °C and 2.3 bar is possible. An integrated working canal enables specific application of medication or use of laser technology. The technical specifications are listed in Table 1. The operation is clinically documented on video or with digital technology.

Movement unsharpness is a typical endoscopic feature. However, this is of secondary importance for the operators themselves, since they have not necessarily to operate under endoscopic conditions. They may as well apply only measures of control and documentation. Reflections also occur after so-called white balance adjustment with strong contrast between dental enamel, root cement as well as concrements and in case of contamination with blood. The handling requires some routine on the part of the operator. It is helpful to adjust the working distance to 1-2 mm. In periodontology, the endoscope is to be applied in the non-contact mode, whereas in endodontology, contact may be possible, i.e. during inspection for diagnosis, control of working steps in the root canal and final check [5].

Results

Periodontology: The endoscopic investigation was carried out to monitor conditions in the closed periodon-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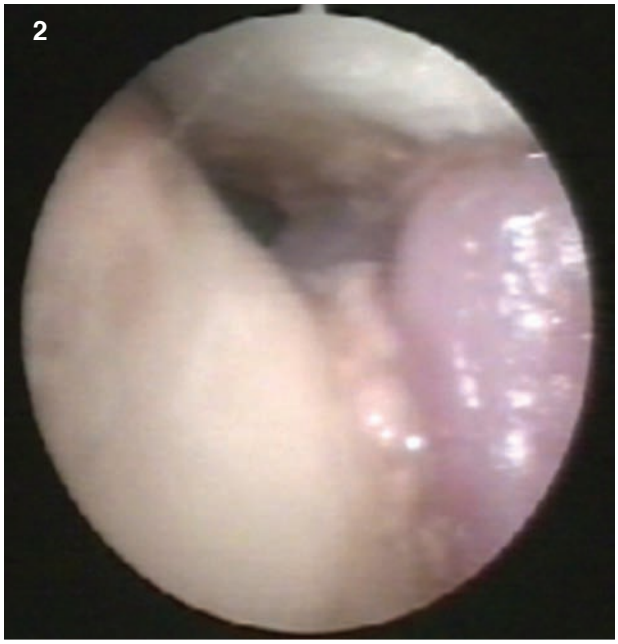
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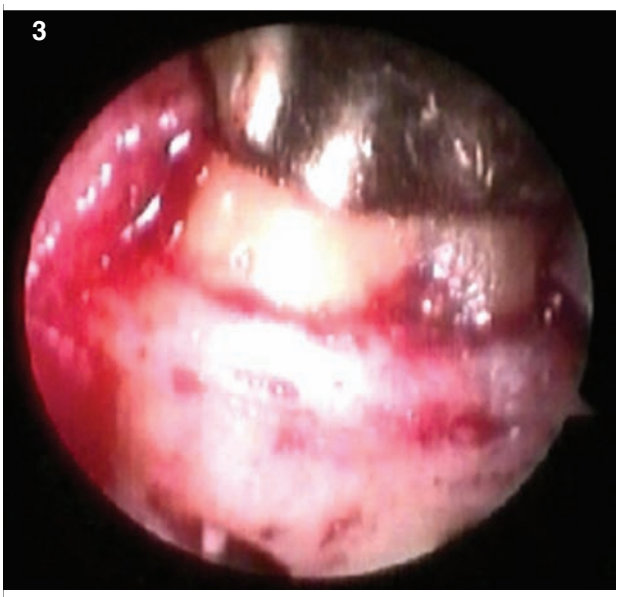
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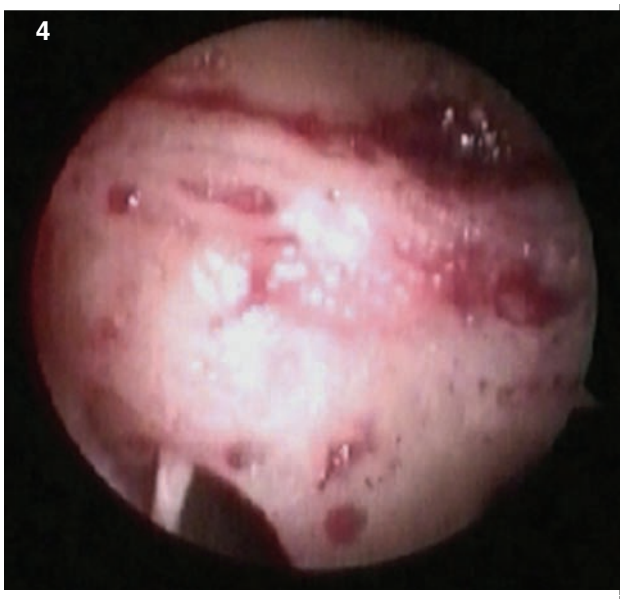
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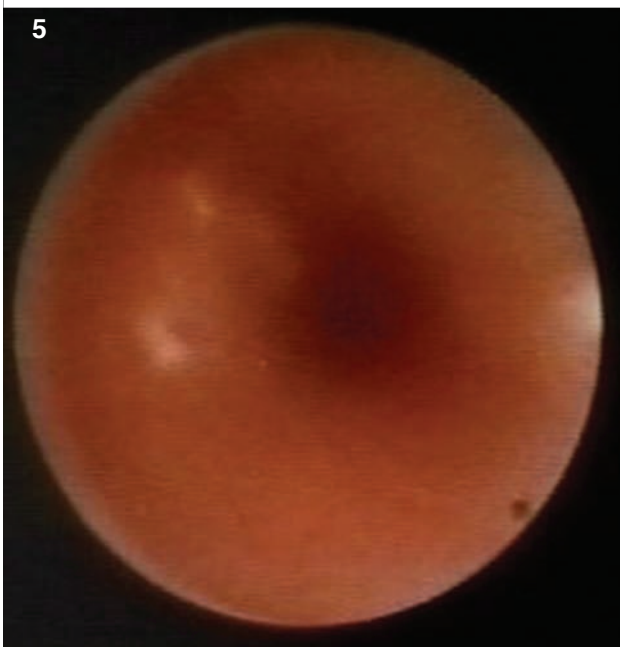
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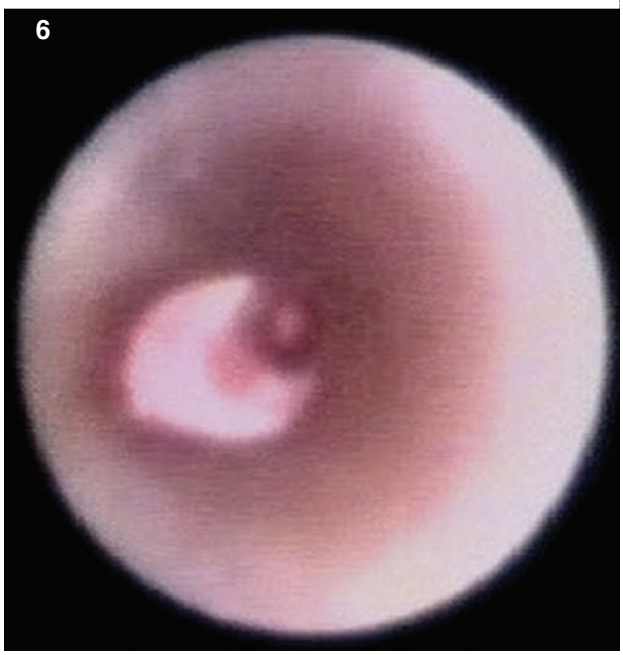
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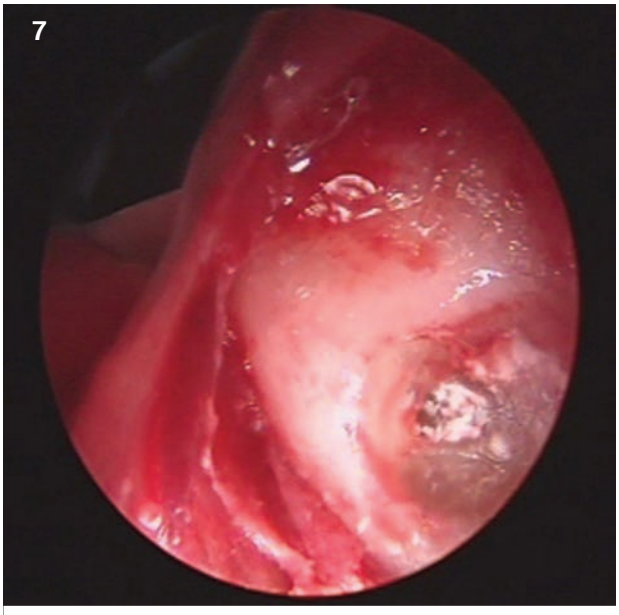

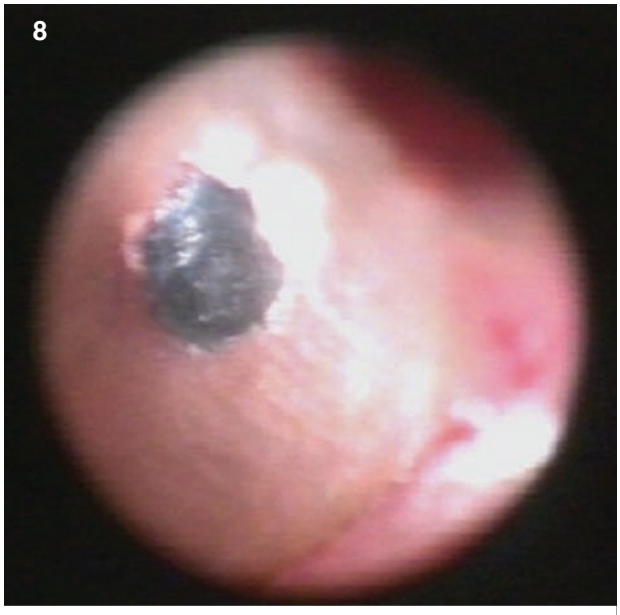

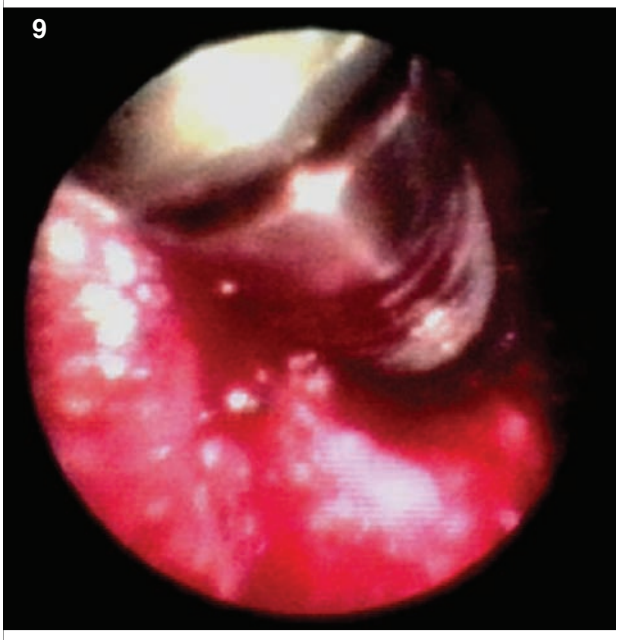

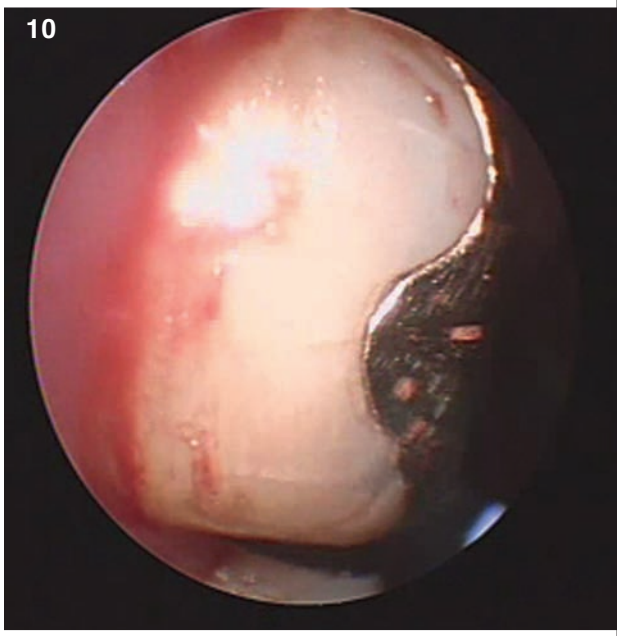

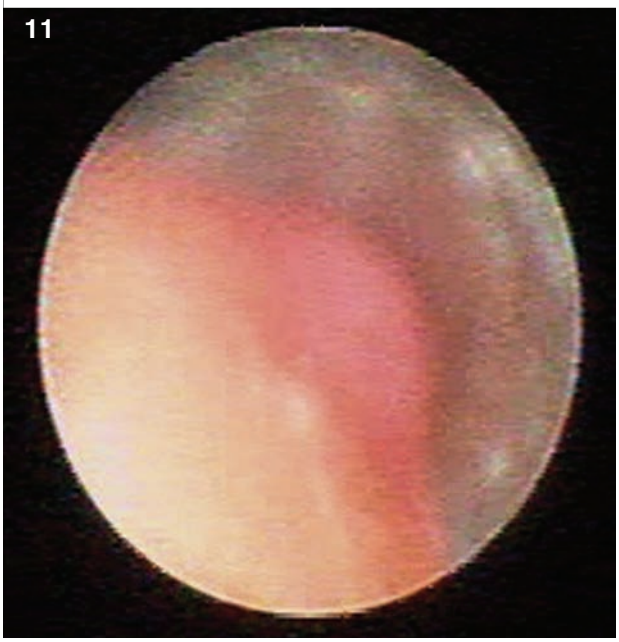

Fig. 1. Micro-endoscope '*Visio Scope*' according to Dr. M.-A. Geibel.

Fig. 2. Preoperative endoscopic finding.

Figs. 3 and 4. Endoscopic control in periapical surgery.

Figs. 5 and 6. Inspection and revision during root canal treatment.

Figs. 7 and 8. Exclusion of root canal fractures: overview and detail.

Fig. 9. Periimplantitis Regio 35.

Figs. 10 and 11. Supra- and subgingival surface inspection of a cracked tooth.

Table 1. Technical characteristics of the micro-endoscope.

Technical Specifications	Model No. 810900	Model No. 810901
image control system	6,000 pixels	1,600 pixels
visual direction	0°	0°
visual field	70°	70°
light	integr. fibre optics 900 mm in length	integr. fibre optics 900 mm in length
external diameter	1.00 mm	0.34 mm distal end
working length	60 mm straight	60 mm total
hand-piece proximal	30° bent upwards	-
	50 mm straight	50 mm straight
	100° bent downwards	-
	25 mm straight	25 mm straight
distal inflections	-	-
working canal	0.27 mm	-
suction / irrigation canal	-	-
luer lock for working and irrigation canal	+	+
incl. tool holder	+	-
autoclavable	autoclavable	
gas/plasma sterilization	+	+
insertability	+	+
additional parts	laser fibre 200 μm	-

tal pocket before and after supragingival and subgingival scaling and root planing and within the scope of an open periodontal surgery treatment. The furcations and roots affected were optically documented by combining a 200 μm fibre with a 1.00 mm optic. The new endoscopic technique helped to diagnose much more precisely in patients compared to examinations carried out with conventional optical aids such as loupe spectacles. Figure 2 shows the endoscopic situation of a 64-year old male patient with massive concrements before periodontal surgery

In contrast to the microscope, flexible handling allows the use of the endoscope also in the posterolateral tooth region. Figures 3-4 show the intraoperative finding of an acute apical periodontitis with suspicion of insufficient root filling and furca invasion.

Endodontology: Here the endoscope may be employed to find the pulp chamber after trepanation of the pulp roof and pulpectomy. The magnification helps to find cracks on the floor of the pulp chamber and extra canals more easily than with loupe spectacles. Compared with the comparable optical magnification of the dental microscope, the flexibility of the endoscope facilitates application in the lateral tooth region. The 25 mm DIN ISO size is sufficient to prepare the root canal for inspection (Fig. 5). The focal depth of 10 mm allows insight into the apical region at an early stage in straight canals. This system is hence suitable for revision of root filling materials (Fig. 6). It is also possible to detect broken instruments under visual control. Additional intraoperative radiological checks can be avoided and the radiation load for the patients reduced. The root canal can be irrigated conventionally. However, before visual control the canal must be dried with paper points to avoid disturbing reflections.

Periapical surgery: Care must be taken that haemostasis is adequate during endoscopic control of the apical region in order to avoid contamination with blood and thus smearing of the optics. Severe haemorrhages, which were impossible to stop with H_2O_2, were treated with Expasil. Methylene blue was used to dye the periapical anatomy after resection and fractures were excluded (Fig. 7). The method, where the operator guides the endoscope while the dental assistant evacuates and withholds the soft tissue, has proved to be effective, as the operator is able to freely move the endoscope for apical inspection (Fig. 8).

Implantology: The endoscope may be used to visually control the course of treatment and to insert locking screws, abutments or prosthetic supraconstructions. So the patient is spared repeated radiological checks. In periimplantitis treatment, the use of the endoscope gives an exact picture of the extent of the osseous resorption at the implant. In regenerative periimplantitis treatment, contaminated implant surfaces might be identified and cleaned under visual control. Figure 9 documents an advanced periimplantitis in Regio 35.

Prosthodontics: Handling of the endoscope is simplified by first concentrating on the anatomical structures such as dental crown or cementoenamel junction and then focussing on the periodontal pocket or on the root surface (Fig. 10 and 11). On the root surface of

already scaled teeth, concrement residues are present that can be detected only with endoscopic inspection and are not identifiable by scalers, dental explorers or curettes.

Discussion

The use of the endoscope has become generally accepted in all medical disciplines. Today, the minimally invasive procedure is a prerequisite for rapid wound healing with fewer complications and shorter resting times. In some cases (arthroscopy, laparoscopy), it was not until the introduction of the endoscopic technique that a transition from inpatient stay to ambulant surgery was achieved [6]. In odontology, the use of optical aids has become accepted above all in endodontology or oral and maxillofacial surgery for inspection and operation of the maxillary sinus. Working with binocular loupe and the surgical microscope is a common method in endodontology. In periapical surgery, operation under optical magnification has established itself as quality standard [7]. In implantology, subantroscopic laterobasal sinus floor augmentation (SALSA) is gaining increasing importance [8]. A further advantageous feature of the endoscopic surgical procedure is that complication management can be optimized. Endoscopic support during periodontal surgery facilitates enhanced verification of findings such as caries (radiologically not detectable), concrement residues, root fractures, root cracks and insufficient coronal margins and permits an enhanced therapeutic procedure. In surgery, the minimally invasive technique reduces danger of contamination and disturbances of wound healing.

Simple handling and flexibility allow the use of the endoscope in lateral tooth regions that are otherwise difficult to reach. In this context, the endoscope has proved itself clearly superior to conventional optical aids, above all the surgical microscope. The working canal facilitates specific application of medication and irrigation solutions.

The *Visio Scope* allows visual control of the extent of the bone defect and enables optical control after removal of concrements and granulation tissue, before possible regenerative measures. Root fractures and furca invasion can be reliably documented. Optical control guarantees preoperative and postoperative success of treatment. Its application in surgery remains unquestioned.

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