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"Seeing Is Believing" - Endoscopy In The Clinical Practice Of Dentistry: A Review Of Literature

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Abstract

Seeing is believing! There has always been a quest by clinicians to actually observe and visualize the clinical procedures being carried out by them so they can co-relate with their respective theoretical concepts. As the field of dentistry involves minute and intricate anatomical structures, the naked eye vision provides limited field of observation. This lead to the advent of advancements in the sphere of magnification and illumination. The Endoscope remains as one of the pioneering and most promising tool to achieve this objective. The literature has demonstrated dearth in the number of publications with respect to the applications of endoscopy but recently in the previous decade there has been a steady rise in the publications. One of the reasons responsible has been atributed due to the increased interest demonstrated by the dental professionals.

The Dental endoscope not only acts as a diagnostic, but also as a therapeutic adjunct to the various disciplines of dentistry including restorative dentistry, endodontics, periodontics, implantology, caries detection and a whole lot more. This communication throws light over some of the afore mentioned fields of applications, especially on their advent, usage and indications.

Key Words

Endoscopy, restorative dentistry, Endodontics, periodontics.

Introduction:

"Your vision will become clear only when you look into your heart. Who looks outside, dreams. Who looks inside, awakens."

This maxim as quoted by **Carl Jung** not only holds true with respect to human behaviour but also concurs with the field of dentistry. This is achieved by techniques that utilize greater magnification and illumination for the purpose of diagnosis and treatment of a wide spectrum of clinical situations.

Quite understandably, the development of the endoscopy of the oral cavity was somewhat delayed because the oral cavity can be well observed by a naked eye. However, it was not long before high-frequency currents found application in surgery in the form of light and heat.[1]

The term endoscopy is derived from the Greek language and is literally translated as endon (within) and skopion (to see), hence the meaning, "to see within."[2]

The definition as mentioned by the National Library of Medicine (MeSH) defines and entails the domain of endoscopy stating that "Endoscopy involves passing an optical instrument through a small incision in the; or through a natural orifice and along natural body pathways; and/or through an incision in the wall of a tubular structure or organ to examine or perform surgery on the interior parts of the body." [3]

Dental literature represented certain paucity on the applications of endoscopy but recently in the last decade due to the ascent of interest by dental professionals there has been a steady rise in the publications with regard to this diagnostic modality. Endoscopy now finds a host of applications encompassing the domain from detection of caries to endodontics and from periodontics to implantology.

The paper is based to present a focus of dental endoscopy as a diagnostic and therapeutic adjunct to the restorative dentist, endodontist, periodontist, oral implantologist, oral surgeon and with regard to caries detection.

Historical Perspective: - A Changing Paradigm

Early endoscopists such as Hippocrates in 377 BC used primitive tube-like instruments for endoscopy. Arabs in 900 AD utilized mirrors to illuminate body cavities, and Nitze in the 1870s incorporated lenses with an incandescent platinum wire loop for illumination. But all of these were restricted by the inability to transfer sufficient light distally into the body cavity, as well as the limited field of vision offered by the tube opening (bore).[4]

A breakthrough in optical quality was achieved in 1960 by Hopkins, who created a rod lens series that led to important advancements in the field of view, magnification, and focal length of the endoscope, resulting in a clearer image. During this time period, the convergence of image bundle fibers also advanced reducing to smaller bore devices of 2, 3, and 5 mm. [5] The addition of video systems has been attributed to Mouret in 1980s. These provided an enhanced image signal. By the late 1980s and early 1990s, flexible endoscopes that used fiber-optic bundles to transmit light and images were important instruments in the field of medicine. [6]

The field of endoscopy has recently expanded further with the introduction of the dental endoscope. This endoscope, with its uniquely small bore size of less than 1 mm, is ideal for use during minimally invasive dental surgical applications [7]

At the very end of the 20th century, endoscopy involves using the Orascope TM, a modified medical endoscope which utilizes fiber optics and made it portable. The advent of endodontic microscopy began in late 1990s and only a few clinicians demonstrated any interest in it.[1] Endodontic endoscopy utilized a fiber-optic probe to explore internal and external components of the root canal. Images taken via the probe are projected on a video monitor for evaluation purposes.

Perioscopy was developed in 1999, with an irrigation system to view the periodontal sulcus after root scaling. A disadvantage of this method was that due to its small dimension of fiberscope, it had limited image quality and hence it could not be utilized in the other dental disciplines. [8],[9]

Literature has reported a technique to intraoperatively examine a prepared implant site using immersion endoscopy. In 2006, a Microendoscope (Visio Scope, Ulm, Germany) was introduced for multidisciplinary use in dentistry. [10]

Caries Detection:

The Laser supported dental endoscope (LSDE) is a combination of a customary intraoral camera with a laser as an illumination source and has been described in the literature. In particular, the monochromatism of the laser beam in combination with its high spectral density enables it to depict visual differences between sound and carious tooth enamel. It supports evidence of lesions which remain undiscovered during routine dental inspections. [11]

A laser beam of 530 nm is used to illuminate the tooth enamel. On this wavelength, the tooth enamel mainly scatters the incident light. Damaged areas are prominent either as dark or bright areas on the tooth surface. The phenomenon of dark areas has been widely described in the literature.[12] The LSDE can additionally be operated with a Ultra violet laser beam in order to test the adequacy of autofluorescence to depict carious areas of tooth enamel. Incipient lesions are described as the partial demineralizing of the tooth enamel, which is characterized by reduced surface hardness and interprismatic mineral deficiency [13]. The surface appears to be microscopically intact, as it is remineralized from "within" at the cost of the mineral content of the enamel on a deeper level. Demineralized areas, invisible to the naked eye, are characterized as incipient carious areas.[14] The development of clinically visible incipient caries either as a white opaque spot, the so-called "white spot", or as a brown enamel area, the so-called “brown spot”, is graded as advanced incipient lesions.[15] The conversion of the carious area to sound enamel was easily recognizable in the reduction of brightness.

Restorative Dentistry:

The dental endoscopic viewing system enhances the visualization of a new carious lesion, recurrent caries, inadequate restorations in proximal boxes or class V restorations, intrafurcal fractures, anatomic aberrations, (eg, a palatal groove on maxillary lateral incisors), residual crown and bridge cement, oral pathologic lesions, and root fractures/perforations.[16] Once the etiology is determined with the endoscope, then the practitioner can use the enhanced visualization and, with curettes, files, scalers, and explorers, treat the problem with either a surgical or nonsurgical approach.

The margins of a casting or restorations can be better evaluated for a precise fit by means of a dental endoscopy system. This provides in depth visualization as the naked eye inspection was limited to the supragingival areas. It was also used to visualize the abutment teeth and proximal areas with subgingival restorations.[17]

The endoscope can also provide diagnostic confirmation of a tooth with a suspected fracture by enhancing the visualization of the root surface.

Endodontics:

The very beginning of the 21st century brought a revolution to endodontics. [18] As practitioners began to see and understand endodontic etiology, it enabled endodontists to provide treatment based on visual confirmation rather than radiographic estimates. Historically loupes on eyeglasses allowed a magnification of 3- 4 power, but then in early 1990s, the Dental operating microscope was introduced providing a magnification ranging from 4 to 25X. Dentists today use endoscopy to instrument, irrigate, and obturate while viewing the root canal system in real time.

Equipment Development [1]

The endoscopes in endodontics permit the working diameters from 0.15mm, up to about 1 mm. But these provide only about 3000 pixels of resolution for the image guide due to space requirements; however, the applications demand higher resolutions with more than at least 10,000 pixels (e.g., 20,000, 30,000, 50,000).

Currently, there are five types of magnification devices and systems to be used in dentistry:

- Loupes
- DOM(Dental Operating Microscope)
- Orascopes modular
- Endoscope system (microendoscopes)
- A Miniature endoscope

The range of magnification of the dental loupes varies from x2 to x6. The DOMs provide magnification from 4X to 25X. While DOM is different, orascope and endoscope have some similarities.

Modular Endoscope System-

The Modular endoscope system (Sialotechnology Ltd., Ashkelon, Israel) is designed and manufactured based on the experienced gained from other surgical fields of small channels, especially from salivary ductal system. A rapid development in endoscopic digital and illumination miniaturization led to compact system that fits in a dental operatory. It consists of a camera, a video, a monitor, a light source, and an archive system. The endoscope is flexible due to special nitinol coating. The optical part which is 0.9 mm of diameter, is a piece of equipment that enables the practioner a magnification of up to 20 with clear picture with wide angle. This type of endoscope have a 3 channel instrument for endodontic instruments, suction and a channel for the telescope. The central channel contains the endoscope (0.9 mm endoscope 10,000 pixels 120° lens).

A Miniature endoscope-
It includes a handpiece which further consists of three segments, mainly:

- A semi-flexible examination probe
- Flexible optical fiber connections for light transmission and image transmission
- Rigid eyepiece with a cold light source connection and coupler for a high-quality CCD camera.

For illumination, a bundle of randomly arranged optical fibres is employed, which transmits the light from the external cold light source to the distal tip of the endoscope.

Working options [1]
The procedure is to be performed using standard root canal equipment, which includes endodontic hand and rotary files, irrigating and the video endoscopy equipment. The optical cavity in endodontic endoscopy is created with a negative pressure. The suction removes condensation, fluids and particles from the surgical field, resulting in a clear picture.

Other applications of endodontic endoscopes
Transillumination- As a fiberoptic light source, it is an excellent tool for fracture detection as light may refract along fracture line. [19],[20]

Apical surgery- The surgical procedure is performed under the inspection of the endoscope with intermittent irrigation. The curvature of the hand-piece enables the practitioner to visualize the hidden parts of the cavity preparation, and to inspect for cracks and root fractures in the apical retrograde preparation. [21],[22]

Endodontic Observations:
Lateral canals and microscopic root cracks are usually detected with high accuracy, providing better intraoperative judgment and facilitating adequate treatment.[23] Another observation during treatment might be a color change in the canal. The apical one third of the root appears red, probably because of the presence of the vascularized tissue (periodontal ligament) and the trans-illumination effect. [24]

Periodontics:
Orthogonal polarization spectral imaging (OPS), capillaroscopy andintravital microscopy are the three methods that can produce an image of microcirculation.[25] Literature has described a variation of calliroscopic system that allows direct imaging of gingival sulcus and periodontal pocket microcirculation.

The periodontal endoscope allows for subgingival visualization of the root surface at magnifications of 24X to 48X. This is accomplished through a .99 mm fiber optic bundle that is a combination of a 10,000-pixel capture bundle surrounded by multiple illumination fibers. This fiber is delivered to the gingival margin coupled into an instrument called an "explorer."[26]

Equipment:
Imagefiber, has a core system with coherent fiber optics. A fiber of diameter of 950um gives an image circle diameter of 790um with 30.000 pixel picture elements. The fiber can be used as a flat tipped fiber(FTF), used without lenses. The resolution power of imagefiber is theoretically limited to 0.5 line pairs per fiber diameter (4.3um) and the picture quality is relatively poor. [25]

The combination of capillaroscopy with endoscopy has been demonstrated too provide an image of periodontal microvasculature in gingival crevice and periodontal pocket and should prove useful in the further study of pathological processes in the region

Implantology [10]
The main goal of the endoscopic-assisted dental implantation is to increase the longevity of oral implants by securing proper implant placement into bone of sufficient density.

The Modular Dental Implant Endoscope can perform several tasks including the planning of surgery. The bone conditions can be accurately evaluated without causing any pressure necrosis of the bone. In complementary procedures, the endoscope can assist in sinus lifting intervention, and during the operation, endoscopic observation can further assess bone density and implant stability.

Until now, the number of reports on the application of endoscopy in dental implantology has been minimal. [27],[28] At the same time, these publications have reported that endoscopic assistance resulted in minimal invasive surgery, low intraoperative trauma, good implant stability upon placement, few postoperative symptoms, and high success rates after years of loading.

Future Developments:
In the 21st century, as long as basic principles of endodontic therapy are followed, the equipment and tools available to clinicians increase the chances for a higher success rate. New materials, techniques and instruments are entering the marketplace to assist dentists in providing patients with more predictable and reliable treatment.

The introduction of microsurgical principles in endodontics involving techniques used for canal treatment has tremendously improved visualization of the operating field. At the same time, the advent of microsurgical instruments and dental operating microscope has brought about advantages in root canal instrumentation and the application of root canal filling materials.

Conclusion
In the end it can be concluded that, "the clinical scenarios are more the rule than the exception. With the use of the endoscope, generally inaccessible anatomic considerations can be observed, diagnosis can be enhanced, and treatment planning can be improved."

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