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Review Article

Modern Science and Technology in Endodontics: A Review

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Abstract

Practical application of recent developments in science and technology in endodontics has changed endodontic practice in general a swift, painless and predictable dental procedure with accurate diagnosis and good prognosis. Modern technology is listed as: rotary nickel titanium NiTi instruments, apex locators, Ultrasonics, the dental operating microscope, bonded resin root obturation, Endovac irrigation techniques and mineral trioxide aggregates in tooth repair procedures. All of them are commercially available for practical use. The dental literature and update papers helps in make use of proven technology in practice. New technology makes endodontic treatment Faster, and safer. Cone beam computerized tomography (CBCT) and Optical coherence tomography (OCT) are necessary endodontic adjunct imaging procedures to study and locate root canals. In root canal instrumentation NiTi files, Protaper, Ferrous Polycrystalline Alloy, Self adjusting file are modern rotary shaping root canal instruments. In root canal irrigation, Endoactivator, Endovac, Light activated disinfection, made debridement of root canal and removal of biofilm predictable. Apexum device, Computed Tomography guided Endodontic surgery changed outcome of periapical lesions treatments and Osteotomies by protecting vital anatomical structures like alveolar nerve and mental nerve and foramen. MTA (mineral trioxide aggregate) is preferred than calcium Hydroxide in preserving pulpal vitality and repair procedures including perforations. This article addresses the few technological advances in endodontic treatment, and is separated into five categories: Diagnosis, Instrumentation, Irrigation, Surgery, and MTA cement. Dentists should up date and adapt new technology and materials in practice for the benefit of patients and profession.

Keywords: *Endodontics; Irrigation; Diagnosis; Tissue*

Introduction

Skill and art of identifying the underlying disease process combined with the diagnostic tests will help will help one to make the right diagnosis. In this procedure impact of more sophisticated diagnostic techniques is very important. Many investigators became aware of the limitations of dental radiographs. Two imaging techniques CBCT and OCT are introduced. The ideal endodontic instrument is yet to be invented. NiTi instruments have shortcoming of file breakage in rotary instrumentation system. Super elastic files made of ferrous polycrystalline shape memory alloy and it has practical approach in manufacturing of endodontic files because of minimum breakage. Another novel approach is to change design of file entirely, that led to introduction of self adjusting file. The goal of root canal treatment is total eradication of all bacteria from root canal before obturating it. Root canal irrigation and disinfection using latest technology made this goal easy. Computed tomography guided endodontic surgery made locating and preserving vital anatomical structures in mandible and maxilla easier. Mineral trioxide aggregate plays important role in maintaining pulpal vitality and regeneration calcified tissue and repairs of perforations.

Diagnosis: To assist in a pulpal diagnosis, tests such as biting, chewing, percussions, apical palpations, hot, cold and electric pulp tests are used. Intraoral radiographs have become a fundamental part of diagnosing disease of pulpal origin. They are used to determine the presence of multiple roots, canals, resorptive defects, caries, restoration defects, root fractures, and extent of root maturation and detection of pathosis. Intra oral periapical radiographs have limitations like detection of lesions in cancellous bone, and early stages of bone diseases. In addition the rerified area on the radiograph is not correlated with the amount of tissue destruction [1,2].

Two imaging technologies in endodontics are presented in this paper: Cone beam computerized tomography (CBCT) and optical coherence tomography (OCT). CBCT is necessary radiographic adjunct in endodontic treatment. OCT is emerging technology in dentistry but well established in Ophthalmology.

CBCT: Cone Beam Computerized Tomography(CBCT) is more sensitive in detecting apical periodontitis compared with periapical radiographs [3]. It is reliable method to detect MB2 canal in the maxillary first molars and aids in determining severity of root canal curvature. CBCT scans are also effective for detecting vertical root fracture of different thickness. A CBCT scan seems useful in the evaluation of inflammatory root resorption and its diagnostic performance is proved to be better than that of periapical radiography. CBCT scans are not useful in differentiating radicular cysts from granulomas. The CBCT can detect an apical radiolucency that may not readily show up in Periapical radiograph, because of minimal erosion of cortical plate. The additional information provided by a CBCT scan is invaluable in determining the prognosis of an endodontic retreatment. CBCT may be future standard to determine if periapical disease has resolved after completion of root canal treatment. Ionizing radiation such as dental radiographs has enough energy to damage DNA in cells, which may lead to cancer. Dental radiography is also associated with low infant birth weight.

OCT (Optical Coherence Tomography): OCT is essentially an optical ultrasound that emits no radiation yet provides detailed information to the operator. It is widely used to obtain high resolution images of the retina and the anterior segment of the eye. It is indicated for morphologic tissue imaging at a high resolution.OCT is first mentioned in the dental literature in 1998.It is used to image hard and soft dental tissue, enamel remineralisation and demineralization, and early caries.OCT is useful in non invasive approach on periodontal diagnosis, and to help visualise periodontal ligament changes in orthodontic movement.OCT is promising non-destructive imaging method for the diagnosis of vertical root fractures and in vivo endodontic imaging to assess intercanal anatomy, cleanliness of the canal after preparation and perforations. OCT scans help determine the interface of the human pulp dentin complex, and may be used in the future to prevent iatrogenic exposures of the pulp. Optical coherence tomography was used in the laboratory to investigate apical micro leakage after laser assisted endodontic treatment.

OCT is an optical signal acquisition and processing method. It captures micrometre resolution and three dimensional images from within optical scattering media. At present there is no commercially available product for use in dentistry. Future applications of OCT in dentistry include caries detection, periodontal probing, digital impression making, cancer screening and endodontic imaging.

Root canal Instruments: Ideally it should be a single instrument that would navigate the canal to working length with ease. It would not break, ledge, or perforate the canal, as well as remove all the canal contents and preserve the dentin. NiTi rotary instrumentation has forever changed root canal instrumentation. It is better than carbon and stainless steel instruments. Perhaps the most frustrating shortcoming of NiTi instruments is file breakage. Torsional stress, cyclic fatigue is two reasons for instruments separation in root canal. Torsional failure which may be caused by using too much apical force during instrumentation occurs more frequently than flexural fatigue which may result from use in curved canals. Manufactures have come up with novel ways to prevent file breakage, such as increasing the pitch length, elctropoloshing, thermal nitridation, M wire, and twisting the NiTi metal rather than milling it. NiTI rotary files have limitations and we need to move away from Niti and investigate other metals.

Ferrous Polycrystalline Shape memory Alloy: Ferrous polycrystalline shape memory alloys shows huge super elasticity. The Iron alloy has twice the maximum super elastic strain obtained in NiTi alloys. The stress level is high so the alloy can be made in to a thin wire that can reach the inner part of the body like the brain to deliver stents. Investigations are under way to determine if this metal has a practical application in endodontic rotary instruments.

Self adjusting File: Another novel approach is to change the instrument design entirely. The self adjusting file (SAF) (ReDent-Nova Inc Israel) was first introduced in the dental literature in April 2010.It is a hallow thin cylindrical NITi lattice that adapts to the longitudinal and cross section of the root canal. The file is elastically compressible from a diameter of 1.5mm to dimensions to those of a number 20 stainless steel K file. Rather than drilling or reciprocating action, the SAF is operated with a transline (in and out) vibrating hand piece with 3000 to 5000 vibrations per minute. This action has scrubbing sandpaper like effect on the canal walls. The hallow design allow for constant irrigation throughout the procedure. Studies showed that the SAF operation resulted in root canal walls that were free of debris.

In addition smear layer free surface is observed in 80% of root canals. A limitation is the pre-establishment of a glide path equivalent to a size 20K file before using the SAF. Over all The SAF seems to have an advantage in cleaning and shaping oval canals and may be a great adjunct to existing NiTi rotary instrumentation technologies.

Apexum Device: A new device developed by Apexum Ltd (Or-Yehuda Israel) is based on minimally invasive removal of periapical chronically inflamed tissues through a root canal access. The apexum device consists of two instruments: The Apexum NiTi ablator and Apexum polyglycolic acid (PGA) ablator. The Apexum NiTi ablator is composed of a hollow tube and sheath are inserted in to the canal to within 1mm of the tooth apex. The NiTi precurved metal wire goes through the hallow tube in to the periapical lesion. When the apexum NiTi ablator is rotated at 250 revolutions per minute(rpm) using slow hand piece it breaks up the periapical tissues. The second instrument, the apexum PGA ablator is a bio absorbable filament, which is inserted through the sheath in to the periapical tissues. This instrument whips into periapical tissue lesion 7000 rpm for 30 seconds and liquefies its contents to be rinsed and then suctioned out.

This technology is to enhance healing kinetics with no adverse effect. The apexum device requires the root canal preparation to be open to a number 40 master apical file. The idea of having another instrument in our armamentarium that can help patients heal faster with low morbidity, makes this instrument worthy of more study.

Lasers: No article on the technological advances in endodontics is complete without the mention of lasers. In the endodontic literature the neodymium:yattrrium-alumiminium-garnet (Nd:YAG), Erbium:Chromium:yattrium-scandium-gallium;garnet (Er:Cr:YSGG) and the Erbium:yattrium-aluminium-garnet (Er:YAG) are the lasers that are most studied. The Nd:YAG laser has been shown to significantly reduce the number of bacteria, and reduced apical micro leakage after root canal obturation. The Nd:YAG laser can soften guttapercha for endodontic retreatment. Disadvantage is that temperature rises on the root surface ranging from 17^0C to 25^0C can occur. But any increase in temperature above 10^0C can be detrimental to attachment apparatus.

The Er:Cr:YSGG laser is used to remove smear layer and debris from the root canal and reduce bacteria. This laser can be used for an apical preparation in root end surgery. The Er:YAG laser might be suitable for clinical application and it effectively removes bacterial biofilm from infected root canals. It has photon induced photo acoustic streaming .Because pulsed laser create pressure waves in irrigant fluids within the root canal, the potential for extrusion of fluid from the apex should be considered when assessing intracanal laser treatments in endodontics. Most endodontic studies have used the laser for cleaning, shaping, and disinfection of the root canal system.

Root canal Irrigation: The goal of root canal treatment is total eradication of all the bacteria from the canal system before obturation. Irrigation helps with the removal of debris, destruction of microorganisms, dissolutions of organic debris, removal of the smear layer, and disinfecting areas inaccessible to endodontic instruments. There is no single irrigating solution that alone sufficiently covers all of the functions required from an irrigant. This section discusses 3 new ways to help reduce the number of viable organisms in the root canal system using as adjuncts to irrigation.

EndoActivator: The endoactivator (Advanced Endodontics, Santa Barbara CA USA) is the device that agitates the irrigating solutions subsonically. 30 seconds of NaOCl subsonic agitation with the Endoactivator seems to be more effective in reducing bacterial load from root canal compared with NaOCl irrigation alone. The Endoactivator provides better irrigation of lateral canals and it extrudes less irrigant beyond apex.

EndoVac: Unlike conventional irrigation that uses positive pressure; the EndoVac system (Discus dental Culver City CA USA) is a negative pressure device. It consists of a disposable Syringe, macrocannula and microcannula. After a complete instrumentation of the root canal system the endovac system is first applied to flush the chamber with an irrigation /suction tip attached to a disposable syringe. Gross debris in the canal is removed with the macrocannula with continuous adding dental irrigation to the chamber of the tooth. Subsequently microcannula is inserted to the working length; irrigation is again added to pulp chamber. The irrigation is then suctioned down the canal through the holes in the microcannula causing an apical negative pressure. The endovac is adept at penetrating NaOCl to the working length in a closed system, removes more debris from narrow isthmi. Less post operative pain because of extrusion of irrigant to the beyond the apex with EndoVac.

Light Activated Photo disinfection (LAD): Light activated photo disinfection is also known as photodynamic antimicrobial chemotherapy, photodynamic therapy, and photo activated disinfection in the literature. The Photosensitizer can be toludine blue dye, methylene blue dye. Nanoparticles based endodontic therapy using poly (lactic -co-glycolic acid)(PLGA) nanoparticles loaded with methylene are used for root canal disinfection. The photosensitizer binds the surface of a microorganism. After light activation the photo sensitizer absorbs the light which affects the oxygen present .The oxygen molecule is split in to reactive oxygen specimen the destroys microbial cell walls and other structures. The light source is usually a laser, white light, red light, or light emitting diode. Bacterial growth modes play a vital role in influencing the susceptibility to LAD in a dose dependent manner. The nature of photosensitizer formulation influences the susceptibility of biofilms to LAD.

The treatment modality is to fully instrument and irrigate the root canal system. The canal is then filled with a photosensitizer and then illuminated with a light source. The root canal is then dried and obturated. The only commercially available unit is the Fotosan (CMS Dental Aps, Copenhagen , Denmark). This unit may serve as an adjunct un a multistep irrigation and disinfection protocol in the future.

Computed Tomography guided Endodontic Surgery

Dr Stephan Buchanan demonstrated computed tomography (CT) guided endodontic surgery in the San Diego convention centre for the American Association of Endodontists annual meeting in April 2010. Using treatment planning soft ware Simplant R (Materialise Dental, Glen Burnie MD, and USA) and a surgical stent, Dr Buchanan performed a precise osteotomy and apicoectomy. A study by Pinsky and colleges introduced the use of computer generated surgical guide allowed for periapical surgery. The apex was more precisely and consistently localized using computer guidance. CT guided endodontic surgery can be particularly useful for performing osteotomies close to anatomic structures such as the inferior alveolar nerve and mental foramen.

MTA (Mineral Trioxide Aggregate): MTA (Dentsply Tulsa Dental, Tulsa. OK, USA) highly researched material that is proving successful in more endodontic procedures. MTA a material that is composed of calcium, silica, bismuth comes in powder form that is activated with addition of sterile water. MTA has been used in pulp capping, pulpotomies, one step apexification, Perforation, repair, and root canal filling procedures. MTA is biocompatible, and contributes to the possible mechanism of dentin bridge formation and tissue repair. MTA seems to be more effective than calcium hydroxide for maintaining long term pulp vitality after direct pulp capping. MTA is currently the choice of material for a primary tooth pulpotomy. MTA has been used in non vital pulp therapy as well. MTA cement has the potential to heal a partially necrotic pulp; this can be beneficial for the continued root development of immature teeth. MTA has recently been incorporated in to a sealer. Sealer based on MTA had comparable sealing ability to a pulp canal sealer (Sybron Dental Specialities, Orange CA, USA). When in contact with a stimulated body fluid the MTA sealer releases calcium ions in solution that encourage the deposition of calcium phosphate crystals. Fluoride doped MTA showed stable sealing during a period of up to 6 months. This finding was significantly better than conventional silicate MTA cements and comparable with AH-PLUS (Dentsply International Inc Johnson City, TN USA).

The main drawback of MTA include potential discolouration, presence of toxic elements found in the material makeup, difficult handling characteristics, long setting time, high material cost, absence of known solvent for this material and complexity of its removal after curing.

Summary

This article addresses the technological advances in endodontics pertaining to new and emerging technology. CBCT and OCT are 2 new technologies that can assist the practitioner in the diagnosis of pulpal disease. The SAF and the Apexum device can be used for instrumentation and bulk debridement of an apical lesion respectively. Laser, EndoActivator, EndoVac and LAD may assist the practitioner in cleaning the root canal system. CT guided surgery shows promise in making endodontic surgery easier, as does MTA cement for regenerative endodontic procedures.

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