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## REVIEW ARTICLE

# FUTURE OF ENDODONTICS

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**ABSTRACT**

Endodontics encompasses the study and practice of the basic and clinical sciences of the biology of the normal dental pulp and the etiology, diagnosis, prevention treatment of diseases and injuries of the dental pulp along with associated periradicular conditions. Endodontics has evolved tremendously in the past decade and its applications have immensely improved the quality of dental treatment. Hence exploring the different aspects of the principles of endodontics, tackling certain challenges will help to boost its development with the advantage of innovations in research and technology. This paper reviews the various advancements that can change the course of endodontics, as well as the challenges which when tackled can solemnize its future



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## INTRODUCTION

It is rightly said by the erudite, "Study the past if you would divine the future." Endodontics has evolved astoundingly from what was described by the Sumerians in 5000 B.C as tooth worms to the more complex quorum sensing in bacterial populations of contemporary studies. It definitely deserves to mention over here the pioneers in the field of endodontics from the ancient times who paved the path of advancement to open up avenues of better quality and prognosis of treatment. Hesy Re (2600 B.C.), an Egyptian was referred to as the first dentist. Hippocrates and Aristotle (500 -300 B.C.) along with Celsus (100 B.C.) wrote extensively on toothache and treatment measures. In 1210, The Guild of Barbers in France began to perform dental surgical procedures. Arzney Buchlein published the first book devoted to dentistry in 1530. Endodontics as a profession developed in the 18th century with the contributions of Pierre Fauchard. In 1768, the first dental advertisements were placed in newspapers. Edwin Maynard introduced the first root canal instrument in 1838 and in 1847 Edwin Truman introduced gutta percha as root canal filling material. In 1900, Price described the use of dental radiography whereas in 1908, Dr. Meyer L. Rhein introduced a technique for determining canal length and level of obturation. These are only some of the more important achievements of the pioneers of Endodontics, who made continual advances, with undoubtedly surprising results, considering their means and knowledge. Very rightly said that, change is the law of life and those who look only in to the past or the present are certain to miss the future. In 1987, American Association of Endodontics (AAE) defined Endodontics as that branch of dentistry concerned with the morphology, physiology, and pathology of the human dental pulp and periradicular tissues. Hence the future of endodontics lies in exploring the different aspects of the principles of endodontics, tackling certain challenges that this fraternity has to face to boost its development with the advantage of availaibility of advancements in research and technology. So let's explore all the possibilities which are going to be a platform of opportunities for Endodontics to flourish.

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### Technological avenues

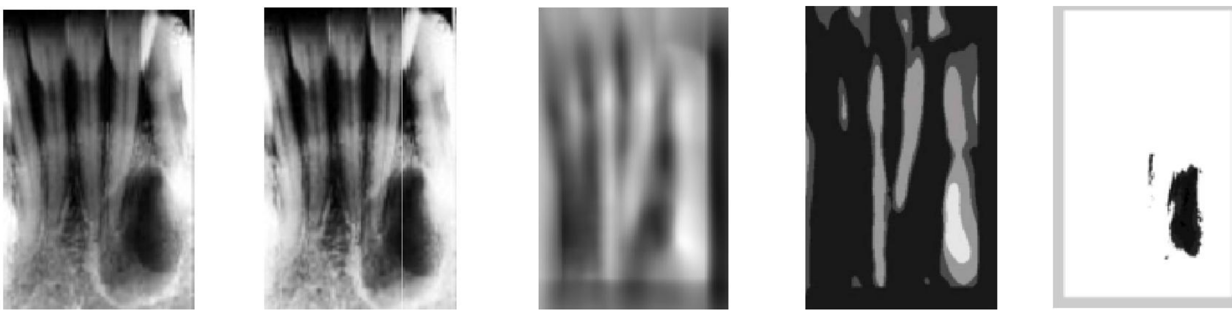
The basic dilemma that surrounds the endodontist when diagnosing periapical pathology is encountered when they have to differentiate between periapical granuloma and periapical cyst (Morse and Bhambhani, 1990). Right from the times of Schilder and Bender various hypothesis have been laid down to differentiate between the two. Methods such as polyacrylamide gel electrophoresis, dye radiography and different tests have been documented in history. Except for histological examination (Lin, Huang, and Rosenberg, 2007), till date no significant chair side diagnostic tool has been developed so far to detect a periapical pathology either as a cyst or granuloma (Gallego Romero *et al*., 2002). Hence the future calls for advancement in the field of diagnosis, which will definitely allow for better treatment planning and prognosis of treatment. Another issue that could be related to the above scenario is regarding the treatment of periapical cysts. There has been a lot of confrontation between endodontists and oral surgeons regarding the best treatment protocol to be followed for the treatment of periapical cysts(Morse and Bhambhani, 1990). As the endodontists feel that they can be successfully treated with non surgical endodontic treatment while the oral surgeons believe that it should be treated by surgical enucleation only (Yan, 2006). But there has been a lot of documentation on non surgical healing of periapical lesions treated successfully, the prognosis of which depends on the size of lesion (Fernandes and de Ataide, 2010). Several articles have validated the fact that the cystic lining undergoes apoptotic degeneration on removal of pathogenic microorganisms and their by products (Soares, Brito-Júnior, Silveira, Nunes, and Santos, 2008). Perhaps some joint conference can be held in the future between endodontists and oral surgeons so that a consensus can be reached regarding the treatment of periapical cysts.

Cone Beam Computed Tomography(CBCT) has developed as an emerging diagnostic tool in dentistry over the last decade (Scarfe and Farman, 2008). The suspense that revolves around presence of multiple roots and canals, tooth resorption, caries, restorative defects, fractures, the extent of root maturation and the detection of pathosis has been revealed munificently to increase the understanding of the treatment procedure (Tyndall and Rathore, 2008). Computed Tomography-guided Endodontic Surgery was first described by Dr. Stephen Buchanan in 2010. It is particularly useful for performing osteotomies close to anatomic structures very safely. Its growing knowledge and efficiency will definitely make it one of the indispensable tools to be used widely in the years to come. But perhaps the most disheartening fact when it comes to CBCT diagnosis is the amount of exposure to ionising radiation that the patient has to encounter and its potential to induce carcinogenesis. Hence The American Dental Association (ADA) Council on Scientific Affairs suggests that dentists should evaluate the benefits of CBCT against the consequences of increasing a patient's exposure to radiation. The American Association of Endodontics (AAE) recommends using the ALARA, which stands for as low as reasonably achievable. Another innovation in this field which can become the most sorted out tool of the future can be Optical Coherence Tomography (OCT) (Mortman, 2011). It has been used to image hard and soft dental tissue, enamel demineralization remineralization and early caries as well as hold benefits over ultrasound and magnetic resonance imaging which are not ideal for soft tissue diagnostic procedures. It is a promising imaging method and holds great potential for full in vivo endodontic imaging to assess intracanal anatomy, cleanliness of the canal after preparation and perforations. OCT scans can help in investigating the interface of the pulp-dentin complex and in the near future can be used in prevention of iatrogenicexposures of the pulp.

Another emerging technology that could revolutionize endodontics is Artificial neural networking (ANN). Basically it is a computational model that is inspired by the structure and/ or functional aspects of biological neural networks. It can be used for location of minor apical foramen, cystic lesion diagnosis and control system for rotary instruments(Barbosa, Devito, and Felippe Filho, 2009) (Saghiri *et al*., 2012) (Banumathi, Mallika, Raju, and Kumar, 2009) (Shankarapillai, Mathur, Nair, Rai, and Mathur, 2010). So let's pray that this technological marvel will create its niche in endodontics. Diagnosis in endodontics has achieved new heights after the introduction of magnification in endodontics. The dental operatory microscope has tremendously helped in disclosing the unseen areas of root canal system. The location of orifices or retrieval of separated instruments has never been aseffortless as under the microscope. (Kim and Baek, 2004) Future of endodontics is gleam without lasers, which today form a requisite part of endodontic apparatus. Nd:YAG, Er:Cr:YSGG, and Er:YAG are the widely studied lasers in dentistry (Myers and Sulewski, 2004).

The applications of lasers are abundant and the count still goes on as more and more research has been directed towards maximizing benefits. It has already proved its mettle in caries detection, detection of crown fractures, light curing of resins, bleaching agent activation, cavity preparation, treatment of hypersensitivity, etching of enamel surface, pulp vitality testing, pulp capping and pulpotomy, modification of canal walls, photon induced photo acoustic streaming, hard tissue removal and soft tissue manipulations during periapical surgery and treatment root fractures (Kimura, Wilder-Smith, and Matsumoto, 2000) (Stabholz, Sahar-Helft, and Moshonov, 2004) (Gentil, 2009). With so many applications to its credit, lasers will define a new future for endodontics. As the search goes on for the ideal endodontic instrument, there has been a shift from carbon and stainless steel instruments towards NiTi rotary instruments that has transformed foreverthe visage of endodontic instrumentation(Baumann, 2004). But as we know that - all that shines is not gold!!It's a wonderful technology but with its own limitations. The clinicians have always been perturbed due to NiTi file breakages as the torsional stress and cyclic fatigue deteriorate the NiTi instruments. Hence a lot of research is directed towards improving these properties. Various metallurgical variations and manufacturing dynamics have been introduced such as increasing the pitch length, M-wire technology, electropolishing, thermal nitridation and twisting the NiTi metal rather than milling it (Ruddle, 2009) (Gambarini *et al.,* 2011). As a result of a lot of research in this field, metallurgical experts have developed a new alloy, which can change the fate of endodontic instrumentation forever. Termed as Ferrous Polycrystalline Shape-memory Alloy, it has enormous superelasticity as compared to NiTi alloys. Research has been undertaken already to determine its applications in endodontics. On this premise it would be necessary to mention another revolutionary instrument which exhibits uniqueness and exemplanary evolution over other endodontic instruments known as the self-adjusting file (SAF system) which is a hollow, thin cylindrical NiTi lattice that suitably adapts to the root canal configuration (Metzger, Teperovich, Zary, Cohen, and Hof, 2010).

**Fig. 1. Optical Coherence Tomography**



**Cystic lesion diagnosis with ANN**

**Real time working length determination with ANN**

**Fig. 2. Artificial Neural Network**

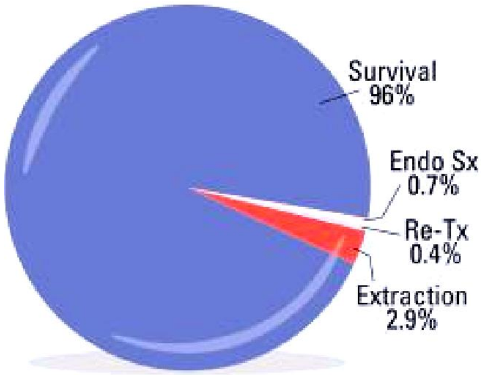



**Fig. 3. Survey of treatment outcome**

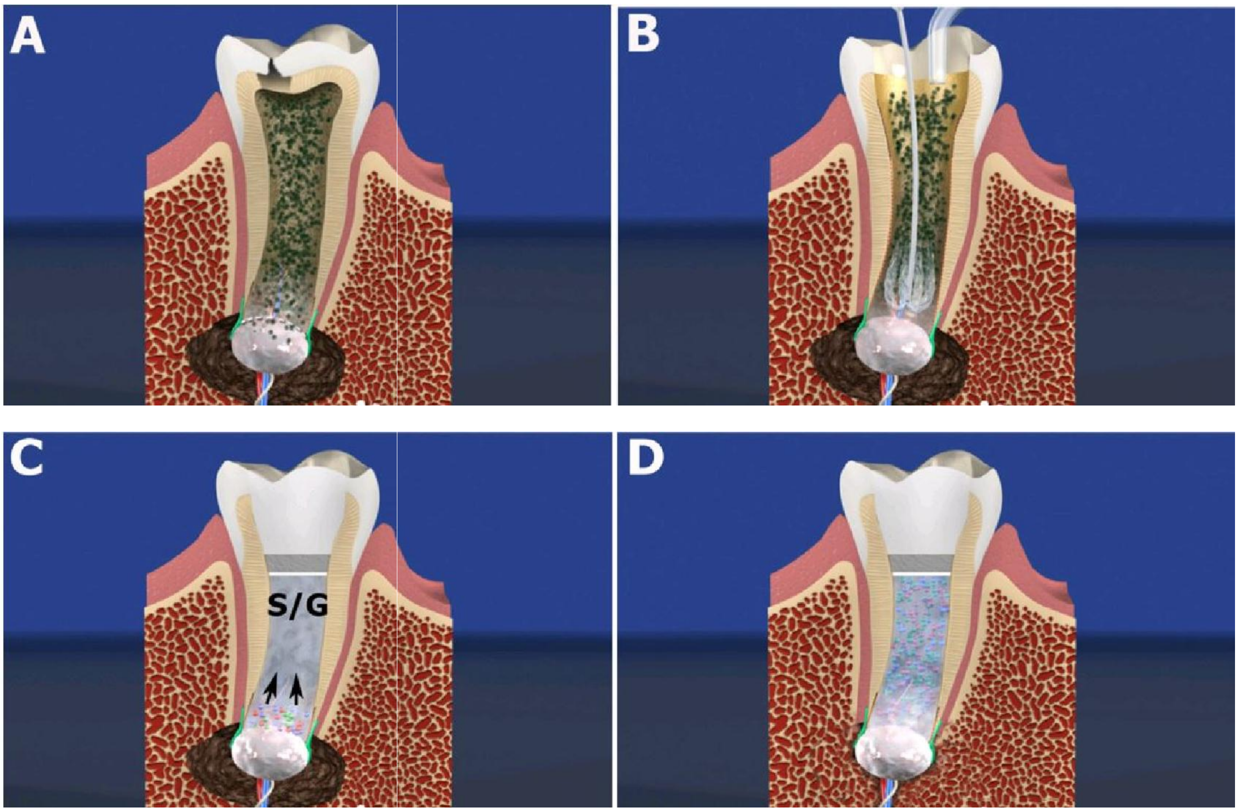



**Fig. 4. Cell homing approach – (A) An immature premolar with necrotic pulp and apical lesion is disinfected (B), followed by placement of a biodegradable scaffold (S) containing growth factors (G) to allow progressive proliferation and migration of apical stem cells into the canal space (C) leading to the population of the canal space with stem cells concomitantly with vascular supply and tissue organization (D)**

| Current techniques of endodontic regeneration |
|---|
| Root canal revascularisation - open up tooth apex to 1mm to allow bleeding into root canals |
| Stem cell therapy – autologous or allogenic stem cells are delivered to teeth via injectable matrix |
| Pulp implant – pulp tissue is grown in laboratory and implanted surgically |
| Scaffold Implant – pulp cells are seeded into a 3 D scaffold made of polymers and surgically implanted |
| 3 D cell printing – ink-jet like device dispenses layers of cells in a hydrogel which is surgically implanted. |
| Injectable scaffolds – polymerizable hydrogels, alone or containing cell suspension are delivered by injection. |
| Gene therapy – mineralizing genes are transfected into the vital pulp cells of necrotic and symptomatic teeth avoiding the need of cleaning and shaping. |

Its distinctive sandpaperlike effect on the canal walls along with its internal irrigation system provides maximum shaping of canal walls, removal of debris, less chance of file breakage, perforation, ledging while maintaining the innate contours of the canal simulating a more natural cleaning and shaping procedure. This innovative system is a boulevard towards a more conservative approach for endodontics (Metzger, Teperovich, Cohen *et al.*, 2010) (Hof, Perevalov, Eltanani, Zary, and Metzger, 2010).

Irrigation of the root canal system has always been the most researched and dynamic topic studied in endodontics. The future of irrigation endodontics lies in developing the most biocompatible irrigantwith maximum antibacterial efficacy and ability to mechanically flush the canals. Antibiotic based irrigants like MTAD and Tetraclean have attracted a lot of research as well as new irrigants based on phytotherapeutic agents are on their way towards development (Torabinejad, Cho, Khademi, Bakland, and Shabahang, n.d.) (Naik, Ataide, Fernandes, and Lambor, 2015). Propolis, green tea, Morinda Citrifolia, have created a hope as these natural bioactive extracts can be utilized towards obtaining an effective irrigation protocol (Zehnder, 2006) (Kandaswamy and Venkateshbabu, 2010). Till now no single irrigant has been developed which can fulfil all the properties of an ideal irrigating solution so the search goes on!

The technology stands no behind when it comes to irrigantactivation devices. A plethora of sophisticated equipments based on various mechanisms have been developed. A few to name will be Endoactivator (Sonic irrigation), Endovac (negative pressure irrigation), Vibringe (Sonic irrigation), Photoactivated disinfection, laser disinfection, Ozone disinfection (de Gregorio *et al*., 2012) (Rödig, Bozkurt, Konietschke, and Hülsmann, 2010) (Haapasalo, Shen, Qian, and Gao, 2010). But yet the search still continues towards developing the best irrigant activation system. Restorative and obturation materials have seen a tremendous surge in the past years. Gutta percha has been the most reliable obturation material used for more than a 150 years in endodontics. Considered as the gold standard in root filling material, yet gutta- percha does not completely fulfil the functions of an ideal root filling material. Studies have questioned the ability of preventing microleakage, dimensional stability, biocompatibility and flow characteristics. Mineral Trioxide Aggregate which was introduced around a decade back has attracted all the attention (Parirokh and Torabinejad, 2010). Modifications of MTA have been developed and so also newer root repair materials such as Biodentine, Endosequence, Bioaggregate, Bioceramic putty, Geristore, Quickset, Capasio and still more under research (Camilleri, Sorrentino, and Damidot, 2013) (Naik *et al*., 2015) (Ma, Shen, Stojicic, and Haapasalo, 2011). With the concept of monoblock, newer materials came into market and resins became more popular as obturation materials. Resilon is based on polymers of polyester with improved flexural strength and contains bioactive and highly radiopaque fillers. When used in conjunction with a resin-based sealer, offers excellent bonding potential. Resilon forms the basis of Epiphany™ Obturation System and RealSeal™ (Pawińska and Kierklo, 2006). Future calls for more advancement and complete eradication of gutta percha as the obturation material. Newer materials with antibacterial and tooth mineralising properties are sure to win the hearts of endodontists.

## Challenges to Endodontics

### Non surgical root canal treatment v/s implants

There has always been a debate regarding long term success of nonsurgical root canal treatment v/s implants. There are various opinions regarding whether to opt for a root canal treatment or extract the tooth and replace with an implant. Delta Dental insurance executed a survey of outcomes of root canal treatment in its insured patients which comprised of more than 1,400,000 root canal-treated teeth and at 8 year recall, 97 percent of the teeth were retained. Study by Doyle *et al*. compared the outcomes of 196 post- endodontically treated teeth with 196 matched, single-tooth implants under standardised protocols and concluded that both groups had 94 percent survival rates. There are various factors that govern the placement of implants and its preference over root canal treatment such as location of bone, quality of bone, periodontal status and tissue type, restorability and systemic factors. Hence root canal treatment can be in most of the cases a better treatment option than implants (Zitzmann, Krastl, Hecker, Walter, and Weiger, 2009) (Iqbal and Kim, 2008).

### Endodontic retreatment v/s implants

When an endodontically treated tooth begins to fail, many practitioners are quick to suggest its extraction and replacement with an implant. According to the ADA Council on Scientific Affairs, "It is important for the clinician to provide a comprehensive assessment, information, realistic outcomes of each proposed treatment modality, with or without implantation therapy. This will allow the patient to make an informed decision." Hence an endodontist would be the best person to evaluate and determine the best treatment protocol in case of a failed root canal treatment. Dental implants are competent treatment options, but then natural tooth is still the best implant. This is why re-treatment of an endodontically treated tooth also can be a resourceful service for the patient. Hence the priority should be given to retention of natural dentition. Also case selection plays a pivotal role in determining the prognosis of retreatment. Certainly it can be a very complex issue, which is why using all the varied resources of the dental team is so imperative. Retreatment either surgical or nonsurgical can be initiated in case of a failed root canal treatment and all attempts should be made to save the tooth. Only in case the prognosis of the retreated tooth is poor or highly questionable than the implant option is to be considered which is again dependant on various factors (Hannahan and Eleazer, 2008). The observations of Aristotle in 500 B.C. of the lizard growing its tail led to the development of the concept of regeneration. Regenerative endodontics is one of the most thrilling developments in endodontics. The AAE's Glossary of Endodontic Terms defines it as "biologically-based procedures designed to physiologically replace damaged tooth structures, including dentin and root structures, as well as cells of the pulp-dentin complex." Regenerative Endodontic procedures are aimed at harnessing the regenerative potential of the pulp. These procedures can be expected to change in the near future, with the inclusion of better-suited scaffolds and chemical cues such as growth factors. Last 20 years have seen a great surge in clinical cases adopting the principle of regeneration. It is a harmonious culmination of stem cells and growth factors embedded in a scaffold matrix.

Tissue regeneration and engineering is the most exigent part of a tissue regeneration program. The regenerated tissue must be able to deliver vascularity, similar cell density and architecture of ectomesenchymal cells, give rise to new odontoblasts lining dentin surfaces, and produce new dentin matrices that become mineralized and be innervated. However, the science is still not able to allow clinical procedures to be performed routinely in animals or in humans. The AAE deserves appreciation for its contribution to enthusiastically promote Regenerative Endodontics as the future of the profession. Till now the researchers have been able to develop only ectopic dental pulp like tissues in tooth slices or fragments in vivo. Despite the initial assurance, it has encountered considerable barriers in clinical rendition. Platelet rich fibrin concentrates and the seal bio concepts are the practical applications utilising regenerative endodontics (Cehreli, Isbitiren, Sara, and Erbas, 2011) (Murray, Garcia-Godoy, and Hargreaves, 2007). Currently it has been used routinely for the procedures of apexogenesis, direct pulp caping, revitalisation of teeth with necrotic pulp (Mao *et al*., 2012).

The above compendium is clearly suggestive of, Endodonticsbeing a vast and a highly researched subject with a lot of scope for further development. Dental research teams in collaboration with biomedical engineering can truly change the fate of Endodontics. A lot has already been achieved in terms of technological advancements in materials, equipment and still a lot has to be achieved in the field of regeneration and improving biocompatibility of materials. It is one such branch of dentistry, which forms the core of all other branches since most interdisciplinary treatment casesal ways requires endodontic consultation. This faculty would always have a demand in future because the preservation of the natural is the best treatment for the patient, which is the principle of endodontic treatment. With so much of research and advancement carried out in this field we can proudly say that future of endodontics is indeed vivid and exciting.

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