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Short Communication

3D digital technology – A revolution in endodontics

Ramya Gollamudi[1], Devendra Chaudhary[1], Jasmohan Singh Sidana[2], Beena J Dev[1], Nikhil Daniel[1], Divya Yadav[3]

Departments of [1]Conservative Dentistry and Endodontics, [2]Oral Medicine and Radiology, [3]Oral and Maxillofacial Surgery, Maharaja Ganga Singh Dental College and Research Centre, Sri Ganganagar, Rajasthan, India.

***Corresponding author:**
Ramya Gollamudi,
Department of Conservative Dentistry and Endodontics, Maharaja Ganga Singh Dental College and Research Centre, Sri Ganganagar, Rajasthan, India.

drramya07.gollamudi@gmail.com

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ABSTRACT

Cone-beam computed tomography (CBCT) is a formidable technology that has made its place in the field of dentistry for over a decade now. The advancement in the field of digital 3D modeling and 3D printing combined with CBCT is transforming the way dental treatments are planned and executed. The aim of this article is to bring out various modalities of CBCT, its integration of 3D printing, and 3D virtual planning with a paradigm shift in the method of diagnosis, treatment planning, and execution.

Keywords: 3D imaging, 3D printing, 3D virtual planning, Cone-beam computed tomography scan, Computed tomography scan, Haptic technology

INTRODUCTION

The field of endodontics has undergone a remarkable transformation in recent years, driven by advancements in 3D imaging, 3D printing, and 3D virtual planning technologies. These innovative tools have empowered endodontists to achieve unprecedented levels of precision, efficiency, and personalization in patient care.

3D imaging modalities, such as cone-beam computed tomography (CBCT), provide endodontists with a detailed and comprehensive view of the internal anatomy of teeth, including the intricate network of root canals and any anatomical variations.[1] This unparalleled visualization enables dentists to accurately diagnose complex cases,[2] identify potential procedural challenges,[3] and plan treatment strategies with greater confidence.[4]

3D printing technology has revolutionized the fabrication of surgical guides and obturators in endodontics.[5] Surgical guides, created from 3D-printed models of the patient's teeth,[6] ensure precise access to root canals, minimizing the risk of procedural errors and perforation.[4] 3D-printed obturators, customized to fit the exact shape of the root canal system,[1] provide superior obturation, preventing leakage of bacteria, and enhancing the long-term success of endodontic treatment.[2]

3D virtual planning software allows endodontists to create a digital replica of the patient's tooth and simulate the entire endodontic procedure before treatment.[3] This virtual simulation enables dentists to optimize the treatment plan, determine the optimal length and curvature of root canals, and anticipate potential complications.

BACKGROUND

The evolution of 3D imaging technology in endodontics traces its roots back to the historical progression of conventional radiography, initiated by Wilhelm Roentgen's discovery of X-rays in 1895.[7] Traditional dental radiography, encompassing two-dimensional techniques, achieved milestones with periapical and panoramic radiography, providing valuable insights for endodontic diagnosis and treatment planning. However, limitations such as image distortion and the inability to capture intricate 3D anatomy posed challenges.[8]

The pivotal shift toward 3D imaging in endodontics occurred with the advent of CBCT technology in the late 20th century.[9] Addressing the shortcomings of traditional computed tomography (CT) scanners, CBCT utilized a cone-shaped X-ray beam to capture high-resolution, isotropic 3D images of the oral and maxillofacial region, marking a paradigm shift in offering endodontists a comprehensive view of dental anatomy and root canal systems. CBCT, initially introduced for maxillofacial imaging, found rapid application in endodontics due to its ability to provide detailed, distortion-free images crucial for precise diagnosis and treatment planning.[10]

3D IMAGING

The field of endodontics has undergone a significant transformation with the advent of 3D imaging technology. This innovative approach provides dentists with a comprehensive and detailed visualization of the intricate internal anatomy of teeth, enabling more accurate diagnosis and treatment of complex endodontic cases. The two primary 3D imaging modalities employed are CBCT and micro-computed tomography (micro-CT). The CBCT utilizes low-dose X-rays to generate a high-resolution 3D image of the teeth and surrounding bone structures.[1] Its rapid acquisition and superior image quality make it a widely used technique in endodontic practice, while the micro-CT offers unparalleled resolution, enabling the meticulous examination of minute anatomical details within teeth. While not as commonly employed in clinical endodontics as CBCT, micro-CT proves invaluable for investigating rare anatomical variations and conducting research. Various applications of 3D imaging in endodontics are enhanced diagnosis, precision treatment planning, and treatment evaluation.[3]

3D PRINTING

3D printing technology has emerged as a transformative force in the field of endodontics, revolutionizing treatment approaches and enhancing patient care. This innovative technique enables the fabrication of customized dental structures and surgical guides with unparalleled precision, opening up a world of possibilities for endodontic practitioners.[4,5] 3D printing has revolutionized endodontics by offering a wide range of applications, including the fabrication of surgical guides, custom obturators, 3D modeling for educational purposes, and regenerative endodontics procedures, facilitating the fabrication of scaffolds for tissue engineering and stem cell delivery.[6] This technology holds immense promise for regenerating damaged tooth structures and revitalizing non-vital teeth.

3D VIRTUAL PLANNING

This innovative approach leverages advanced software to create a virtual representation of a patient's dental anatomy, enabling dentists to meticulously plan and execute complex endodontic procedures with unparalleled precision. The adoption of 3D virtual planning in endodontics offers a multitude of benefits, such as enhanced diagnosis, precision treatment planning, and improved patient education.[1]

3D virtual planning has revolutionized endodontics by offering a wide range of applications,such as complex root canal treatment, retreatment of failed endodontic procedures, surgical endodontic procedures, and pre-operative evaluation of anatomical variations. 3D virtual planning is rapidly evolving in endodontics, with advancements in software capabilities and hardware integration. As the technology matures, we can expect to see even more widespread adoption and integration into routine endodontic practice. In addition, the integration of artificial intelligence and machine learning into 3D virtual planning tools has the potential to further enhance diagnostic accuracy and treatment planning precision.

CONCLUSION

3D imaging, 3D printing, and 3D virtual planning have revolutionized the field of endodontics, making it more precise, efficient, and personalized. 3D imaging provides a detailed view of teeth, 3D printing creates customized surgical guides and obturators, and 3D virtual planning allows dentists to simulate procedures before treatment. These technologies have improved patient outcomes and set a new standard for endodontic care.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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