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REVIEW ARTICLE

Digital Innovations in the Field of Endodontics: A Review

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Abstract

Dentistry has had one of the fastest and largest advancements in digital technology. There have been significant developments in endodontic technology over the past few decades. The digitalization of endodontics has unquestionably improved practitioners' daily clinical practice. These innovations have not only simplified and increased the accuracy of dentistry but also eased many difficulties for dentists. As a result, many technical techniques must be used to ensure the predictability and prognosis of endodontic preparation and obturation.

Keywords

Endodontics, Digital innovations, Digital dentistry

Introduction

The morphology, physiology, and pathology of diseases influencing the human tooth pulp and periradicular tissues in connection to their factors, diagnosis, treatments, and prevention are the focus of endodontics research [1]. By correctly preparing, cleaning, and filling the root canals, endodontic procedures can retain the pulp's health, preserve and restore the pulp-less tooth, or use biologically based techniques to restore hindered tooth structures [2]. Because root canal morphology and peri-radicular structures must be highlighted using digital 2-dimensional (2-D) radiography and cone-beam computed tomography (CBCT). Current advancements in digital applications have also made it possible to develop therapeutic treatments such as guided cavity preparations and artificial intelligence-aided diagnosis that can provide access directly to root canals even in damaged roots [3]. This review article discusses the uses of digital technology in endodontics.

Making an accurate diagnosis is essential for managing a problem effectively. Many advancements have been made over time that make diagnosis and the development of our treatment plan easier. In order to arrive at a diagnosis, there is a definite procedure to follow that involves using the clinical diagnostic techniques piecemeal.

Professional dental procedures have been used for many years with success and are still useful today. But digital dentistry has a lot of potential for keeping up with the latest technological advancements and for a faster, more accurate, and more productive workday. Several procedures are covered by digital dentistry, and many more are constantly being researched. Some of the techniques that are regularly used are listed below:

Digital radiography

Digital radiography is the term used to describe X-ray imaging. It uses digital X-ray sensors to build enhanced computer images of your oral structure. Digital radio graphing is used to identify, monitor, diagnose, and treat dental issues [4].

Digital radiography can create indirect, direct, or semi-direct images.

Direct method: The images are recorded by inserting an electronic sensor into the mouth.

Technique that is only partially indirect: This approach combines the use of an electronic sensor and an X-ray film. With both of them, dental X-rays are transformed into digital films.

With the indirect method, conventional x-rays are converted into digital images using X-ray film.

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CBCT

A paradigm shifts from a 2-D to a 3-D approach for a range of applications, including intraoperative guiding of surgical operations, was brought about by the introduction of CBCT in 1998. CBCT was created specifically for the imaging of dental and maxillofacial structures [5]. CBCT differs from conventional CTs by rotating the detector and X-ray source around a stabilized subject. The benefits of CBCT over CT include reduced radiation exposure, less expensive equipment, a smaller scanning space, and faster scanning times. Depending on the region of interest, the field of view (FOV), sometimes referred to as the X-ray beam's cone shape and cylindrical data volume, can be chosen. For the examination of dental structures, CBCT has reportedly produced images of superior quality than medical CT.

Computer aided diagnostics (CAD)

Despite advancements in imaging technology, treatment planning and ultimate diagnosis are still left up to the clinician's judgement, which is subject to human error. The clinician may not select the best course of treatment because of human error. Using computer algorithms, CAD seeks to carry out a quantitative examination and offer an impartial report. The use of CAD in dentistry is very new, despite its widespread use in medical radiography. A caries detector software was developed in the late 1990s that analysed the radiography of the tooth and reported on the existence of caries, whether it was fully carious or only decalcifying, and whether or not it needed restoration [6]. For the purpose of diagnosing interproximal carious lesions on periapical radiographs, neural network models have been created [7]. Additionally, CAD has been created for intraoperative usage in combination with an intraoral camera to detect root canal orifices in real-time [8]. Software for orifice detection has been shown to have high sensitivity, which can help novice practitioners and students find more canal orifices [8].

3D printing

Three-dimensional printing in endodontics is not only employed for guided access cavity preparations. When 3-D printing first emerged, it was referred to as additive manufacturing, which describes the method of producing an object by gradually piling the material of choice. Applications for 3-D printing involve a variety of methods, including selective laser melting, multi-jet printing, polyjet printing, stereolithography equipment (SLA), digital light processing, and fused deposition modelling [9,10]. The original and still most used technology in dentistry is stereolithography equipment.

Guided endodontic access, autotransplantation, endodontic surgery applications, educational simulations, and research have all benefited from the use of 3-D printing [11-15]. Applications of guided endodontics have already been discussed in this article. Using 3-D printing, copies of teeth are created for autotransplant applications and fitted into the recipient bone before being extracted. This pre-fitting reduces operation time and avoids stress to the periodontal ligament of the transplanted teeth, improving the treatment's results [11,14,16].

Endodontic surgery

Over the past 20 years, endodontic surgery has undergone a number of notable breakthroughs. Some of the key developments include the use of magnification (such as the surgical operating microscope and endoscope), ultrasonic tip root-end preparation, micro tools, and novel retrofill materials. In a study by Tsesis 2006 [17], the authors found that when compared to conventional endodontic surgical procedures, current surgical endodontic therapy using magnification and ultrasonic tips greatly improved the outcome.

Obturation

Newer wireless gadgets like the Endotec II (Medidenta International Inc.; Woodside, NY) and DownPak (EI, Hu-Friedy, Chicago, IL) are battery-operated and provide convenience during the obturation procedure. It reduces the requirement for high temperatures during obturation by using heat and vibration for vertical and lateral condensation. The most widely used tools for thermoplasticized gutta-percha are the Obtura 3 (Obtura), Calamus (Tulsa, Dentsply), and Ultrafil 3D (Hygienic-Coltene-Whaledent, Akron, OH). With this approach, vertical compaction in between increments is necessary to ensure greater gutta-percha compaction. Many businesses have released integrated devices with handpieces for down pack and backfill (flow) methods (Calamus Dual, Dentsply Tulsa Dent Specialties; Elements obturation Unit, Kerr). A carrier coated with GP is used in the carrier-based procedure, another heat-based obturation method [18].

The DIAGNOdent laser

The DIAGNOdent laser, a variation of the QLF system, was first introduced in 1998 by Hibst and Gal. It uses a straightforward laser diode to compare the refection wavelength to a well-known healthy baseline in order to detect decay utilising infrared laser fluorescence of 655 nm for the detection of occlusal and smooth surface caries. With the Diagnodent, we can discover degradation at an early stage that would not have been seen with conventional diagnosis. You will receive better care thanks to smaller, less expensive restorations. Also, you are able to keep more of your own natural teeth, which will improve the restoration's long-term benefits [19].

Ultrasonography

Although the ultrasound caries detection method (UCD) was first proposed more than 30 years ago, it has only recently become more popular as a means of identifying early carious lesions on smooth surfaces [20]. The idea is that reflected sound waves can be used to capture photographs of tissues. The ultrasound pulse-echo technique is used to measure the demineralization of natural enamel. It has been found that there is a clear association between the relative variations in echo amplitude and the mineral content of the lesion's body [21].

Laser dentistry [22]

Due to the wavelength of lasers being optimised for interactions with human tissue, they have become incredibly popular. Initially, soft tissue surgical procedures like excisions and incisions were the main uses of dental lasers. Then, instruments for use on both hard and soft oral structures developed. As photobiomodulation (PBM) has been demonstrated to have a positive impact on living tissues, it is now routinely employed as a non-invasive alternative to low-level laser therapy in the treatment of a variety of pathological illnesses. Based on its excitation source, dental lasers can operate in one of two fundamental emission modes:

1. Continuous wave mode, in which the laser energy or beam is continually sent so long as the laser is turned on. This is how carbon dioxide, argon, and diode lasers work.
2. Free-running pulse lasers only work in a certain pulsed mode, never continuously, and emit light in pulses as small as a few microseconds, followed by a long period of inactivity. Devices using Nd:YAG, Er:YAG, and Er,Cr:YSGG run as free-running pulsed lasers.

In dentistry, the following lasers are frequently used:

1. The photonic energy from CO_2 lasers has a very high affinity for water and causes hemostasis and the quick clearance of soft tissue. The depth penetration is not very deep. For both hard and soft oral tissue, a recently developed model of CO_2 with ultrashort pulse length can be used.
2. Nd:YAG Laser: This wavelength has a strong absorption in pigmented tissue, making it adequate for coagulating and cutting oral soft tissues with high-grade hemostasis. Nonsurgical periodontal treatment is one more usage.
3. Erbium Laser: Erbium wavelengths have the strongest water absorption of any dental laser wavelength and a secondary affinity for hydroxyapatite crystals. It is the preferred laser for treating dental hard tissues and can also be used to remove soft tissue because dental soft tissue contains a lot of water.
4. Diode laser: The diode laser is a solid-state semiconductor that produces diverse laser wavelengths that range from roughly 445 to 1064 nm. It contains varied combinations of aluminium, gallium, arsenide, and occasionally indium. These wavelengths are insufficiently absorbed by hydroxyapatite and water, and are mostly taken up by the tissue pigments haemoglobin and melanin.

Digital impressions

Benefits of digital impressions include the lack of a requirement for impression-making materials, which improves patient comfort and results in little to no gag reflex. Because the positive image of dental preparation is visible on the computer screen, castings are avoided, and modifications are simpler. The rubber dam can be used with digital impressions, needs no cleaning other than to remove plaque from the tip, is simpler to store, and most importantly, the dental restoration can be provided the same day as digital scanning thanks to CAD/CAM technology [23].

Pulp testers

The best measure of pulp viability, according to recent study, is blood circulation rather than innervations since it can clearly distinguish between viable and necrotic pulp tissue.

The dental pulp's vascular supply, which is the real barometer of the pulp's vitality, is examined using vitality pulp tests to determine a variety of its properties.

Pulp testing techniques based on optical technology include Laser Doppler flowmetry, Transmitted Laser Light, Laser Speckle Imaging, Pulse Oximetry, Transmitted Light Plethysmography, and Dual Wavelength Spectrophotometry. They are completely non-invasive, painless, and impartial (require no subjective response from the patient). The vitality pulp tests with the greatest research and the best clinical outcomes are pulse oximetry and laser doppler flowmetry [18].

Apex locator

The development of apex locators was motivated by the discovery that the apical constriction has an electrical resistance of 6.5 kilo ohms (k), which is used to determine the position of the apical constriction and measure the length of the root canal space more accurately, precisely, and predictably. The electrical resistance of various tissues is the foundation of the apex locator's operating theory. It was discovered that the electrical resistance value (6.5 k) between the mouth mucosa and the periodontal ligament was constant. Examples of this generation are ProPex Pixi (Dentsply, USA) and Raypex® 6 Apex Locator (VDW) [18].

Conclusion

Digital dentistry has a bright future and a variety of uses. Future and current research should be merged with clinical practise for improved results. But, individuals and their capacity to sympathise with patients shouldn't be perceived as being threatened by digital smart data technologies. Nonetheless, the benefits of digital applications will complement human skills and talents in order to offer patients better and more inexpensive healthcare.

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