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ADVANCING CONSERVATIVE DENTISTRY AND ENDODONTICS: DIGITAL PARADIGM SHIFT-CURRENT STATUS AND FUTURE PERSPECTIVES.

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ABSTRACT Digital dentistry has revolutionized the field of conservative restorations and endodontics, enhancing precision, efficiency and patient- centered outcome. The integration of technologies such as intraoral scanners, CAD/CAM systems, 3D printing and other digital technologies including PSP and RVG has streamlined restorative workflows, improving marginal adaptation, fit and aesthetics of restorations. Advancements in CBCT imaging, digital impression techniques, and AI-assisted diagnostics have enhanced treatment planning, accuracy and clinical predictability. This review explores the current applications of digital dentistry in conservative and endodontic procedures. and examines their clinical applications, benefits and limitation . Additionally, future perspectives include the continued development of AI-driven treatment planning and bioengineered restorations to advance minimally invasive and personalized dental care. Clinicians must comprehend these developing technologies in order to maximize patient care and welcome the future of precision-driven, minimally invasive dentistry. Clinicians who want to provide excellent, evidence-based care in the digital age must comprehend and welcome these technological developments.

KEYWORDS : CAD/CAM, 3D Printing, Dental Radiovisiography, Dental impression techniques

INTRODUCTION

The rapid advancements in digital technologies have revolutionized the field of dentistry, particularly in the domains of conservative restorations and endodontics. These cutting-edge digital tools have not only enhanced the precision and efficiency of dental procedures but have also transformed the patient experience, ushering in a new era of personalized, evidence-based care. Despite their effectiveness, traditional procedures frequently have issues with accuracy, timeliness and patient comfort. In order to improve diagnosis, treatment planning and execution, digital dentistry has evolved as a solution.

Digital workflows have enhanced indirect restoration fabrication in conservative restorations, providing better durability, aesthetics and marginal adaptation. By doing away with the necessity for traditional imprints, intraoral scanners improve accuracy and patient comfort. Chairside restorations are also made possible by CAD/CAM technology, which shorten treatment times and boost clinical effectiveness.[1]

Digital innovations have also had a significant positive impact on endodontics. Accurate diagnosis and treatment planning are facilitated by the thorough image of root canal architecture provided by high-resolution CBCT imaging.[2]Additionally, guided endodontics have increased the accuracy of root canal instrumentation and access cavity preparation.[3]

Notwithstanding these developments, obstacles including cost , challenging learning curves, and the requirement for defined protocols prevent digital technologies from being widely used.

CURRENT DIGITAL TECHNOLOGIES IN CONSERVATIVE RESTORATIONS

The integration of digital technologies in conservative restorations has significantly improved the precision, efficiency and patient-centric approach to dental care. Following are the current digital technologies used in conservative dentistry.

Digital Radiography

The term "digital radiography" refers to X-ray imaging. It creates improved computer photographs of your oral structure using digital X-ray sensors. Dental problems are identified, tracked, diagnosed, and treated.[4]

Images produced by digital radiography might be direct, indirect, or semi-direct.

Direct method: An electronic sensor is inserted into the mouth to record the images.

Method that is only partially indirect:
This method uses both an X-ray film and an electronic sensor. Dental X-rays are converted into digital films using both of them.

The indirect method uses X-ray film to transform traditional x-rays into digital images. Digital radiography has revolutionized the diagnostic process in conservative restorations, offering enhanced image quality, reduced radiation exposure, and improved storage and retrieval of patient records.[5]

Photostimulable Phosphor (PSP) plates and Radiovisiography (RVG) sensors have been integral to digital radiography in dentistry for several decades. While these technologies were groundbreaking at their inception, they are now considered standard tools in modern dental practices.

a) Photostimulable Phosphor Plates

Photostimulable Phosphor (PSP) plates are a pivotal component in digital dental radiography, offering a bridge between traditional film-based methods and modern digital imaging. PSP technology utilizes plates coated with phosphor crystals that capture and store X-ray

images. When these plates are scanned by a specialized device, the stored energy is released as light, which is then converted into a digital image for diagnostic purposes.

Advantages Of PSP In Digital Dentistry:
Patient Comfort: PSP plates are typically thinner and more flexible than solid-state sensors, such as CCD or CMOS sensors, leading to increased patient comfort during imaging procedures.
Versatility: They are available in various sizes, accommodating different diagnostic needs and patient anatomies.

Cost-Effectiveness: PSP systems often have a lower initial investment compared to direct digital sensors, making them an attractive option for many dental practices.

Considerations:
Image Quality: While PSP systems provide high-quality images, some studies suggest that direct digital sensors like CMOS may offer superior image quality in certain diagnostic tasks.

Processing Time: PSP plates require an additional scanning step to digitize the image, which can increase the time from image acquisition to diagnosis compared to direct digital systems.[5]

Incorporating PSP technology into digital dentistry has enhanced diagnostic capabilities, improved patient comfort, and streamlined workflows. As digital dentistry continues to evolve, PSP systems remain a valuable tool, balancing the benefits of digital imaging with practical considerations for dental professionals.

b) Radiovisiography
This innovation utilized a charge-coupled device (CCD) sensor to capture dental images, allowing for immediate display on a monitor and reducing radiation exposure compared to traditional film-based radiography.

Advantages Of RVG In Digital Dentistry:
Immediate Image Acquisition: RVG systems provide instant visualization of radiographic images, enhancing diagnostic efficiency and patient communication.

Reduced Radiation Exposure: Studies have shown that RVG can reduce radiation exposure by up to 75% compared to conventional radiography, improving patient safety.

Enhanced Image Manipulation: Digital images obtained through RVG can be enlarged, colorized, and adjusted for contrast, aiding in detailed analysis and diagnosis.

Efficient Data Storage and Sharing: Digital images can be easily stored, retrieved, and shared electronically, facilitating better record-keeping and collaboration among dental professionals.

Considerations:
Sensor Rigidity and Size: RVG sensors are often more rigid and bulkier than traditional film or PSP plates, which may cause discomfort for some patients during intraoral placement.

Cost: The initial investment for RVG systems can be higher than that for conventional radiography equipment, potentially impacting adoption in smaller practices.

Dynamic Range: RVG systems may have a narrower dynamic range compared to PSP systems, which can affect the capture of images with varying densities. [5]

Incorporating RVG into dental practices has revolutionized diagnostic imaging by providing rapid, high-quality images with reduced radiation exposure. As digital dentistry continues to evolve, RVG remains a cornerstone technology, balancing the benefits of immediate image acquisition and enhanced diagnostic capabilities with considerations of patient comfort and cost.

DIGITAL IMPRESSIONS
Digital technologies, particularly digital impressions, have revolutionized restorative dentistry. Digital impressions have become a mainstay of contemporary dentistry procedures, taking the place of traditional impression materials with sophisticated intraoral scanners that produce accurate three-dimensional models of the teeth.[6] Research indicates that intraoral scanners precision and detail help provide a thorough grasp of the structure of the tooth, which facilitates the detection of diseases including dental caries and periapical lesions.[7] This technology provides a more accurate, efficient and patient-friendly experience, as it reduces the discomfort associated with traditional impression materials while producing immediate digital images leading to more precise and predictable restorations.[8]

3D PRINTING
One of the key advantages of digital dentistry in conservative restorations is the integration of 3D printing technology. This innovative technique allows for the rapid fabrication of customized dental restorations, such as crowns, bridges, and veneers, directly from digital files. 3D printing enables dentists to streamline the prosthetic workflow, reduce turnaround times, and offer patients a more seamless and efficient experience.[2]

CAD/CAM SYSTEM(Computer-Aided Design/Computer-Aided Manufacturing) Systems.
CAD/CAM technology uses computer software and milling machines to design and manufacture dental restorations.[9]

It helps in creating crowns, bridges, veneers, inlays and onlays using ceramics, composites and zirconia.[10]

The seamless integration of intraoral scanning with computer-aided design and computer-aided manufacturing has revolutionized the fabrication of dental restorations. [3]

The CAD/CAM workflow allows for the rapid design and production of custom-fitted restorations, reducing chairside time and improving the overall quality of restorative outcomes.

The precise fit and superior marginal integrity achieved through digital manufacturing techniques have contributed to the enhanced longevity and clinical success of conservative restorations. [10]

DIGITAL SMILE DESIGN
Design Of Digital Smile
The goal of better outcomes has long included aesthetics, one of dentistry's pillars. Smile analysis and design have drawn a lot of attention in dentistry over the last ten years, requiring a thorough method of treating patients.[1] Beginning with the first generation, when hand drawings on printed patient images were used to convey information and explain the conclusion, it has now advanced to full digital drawings on a computer using DSD software.[11] DSD is a technical tool that is used to design and modify the smile of patients digitally and help them to visualize it beforehand by creating and presenting a digital mock-up of their new smile design before the treatment physically starts. Coachman and Calamita described DSD as a multi-use conceptual tool that can support diagnostic vision, improve communication, and enhance treatment predictability by permitting careful analysis of the patient's facial and dental characteristics that may have gone unnoticed by clinical, photographic, or diagnostic cast-based evaluation procedures. Digital tools already used in modern dentistry practices, such as a computer running DSD software, a digital SLR camera, or even a smartphone, are used to perform the 3DSD procedure. Additional technologies for a full digital 3D workflow include CAD/CAM, a 3D printer, and a digital intraoral scanner for digital impressions.[12]

DSD Software Types[1,12]
1. Adobe Systems Incorporated's Photoshop Cs6
2. Microsoft Office (Microsoft, Redmond, Washington, USA) PowerPoint
3. Dr. Valerio Bini's Aesthetic Digital Smile Design (ADSD)
4. Smile Design by Planmeca Romexis (PRSD) (Planmeca Romexis)
5. Keynote (Apple, Cupertino, CA, USA; iWork)
6. DentalCAD Exocad 2.3

It has a number of benefits, such as improving therapy predictability by helping patients envision the intended result prior to the actual course of treatment. Through computerized analysis of face, gingival, and dental anatomy, it improves clinical diagnosis and treatment planning by offering a visually appealing depiction of the patient's condition. A more aesthetically beautiful and confident smile is the outcome of actively integrating patients in the customization of smile designs. Improves communication among physicians, lab technicians, and members of the interdisciplinary team in addition to between the patient and the doctor.[13]

Digital Tools For Shade Matching:

Spectrophotometers And Colorimeters:

They are the tools that measure tooth color objectively, minimizing the irregularities that come with eye evaluations. A systematic evaluation emphasized the effectiveness of digital instruments under controlled conditions and found that they yield more consistent results than traditional methods.

Intraoral Scanners:

Contemporary intraoral scanners provide accurate measurements. Even though these scanners show a great degree of precision, a systematic evaluation pointed out that they might still need to improve in terms of shade determination accuracy.

Applications For Smartphones:

Using high-resolution cameras, colorimeter apps for smartphones offer a portable and affordable shade matching solution. Notwithstanding their potential, these apps accuracy and dependability are still being assessed, requiring additional research and improvement.

The Digital Smile Design (DSD) App exemplifies the integration of shade selection within comprehensive digital workflows. By utilizing preoperative intraoral scans, photographs, face scans, and videos, the DSD App facilitates precise treatment planning and enhances patient communication. This holistic approach underscores the importance of accurate shade selection in achieving optimal aesthetic outcomes.[14]

CURRENT DIGITAL TECHNOLOGIES IN ENDODONTICS

ELECTRONIC APEX LOCATORS

By identifying the location of the apical constriction, which has been found to have an electric resistance of 6.5 kilo ohms (kΩ), an electronic endodontic device known as an Apex locator can more precisely, accurately, and predictably determine the length of the root canal space. This particular feature is what led to the development of the Apex locator. The electrical resistance of various tissues serves as the foundation for the apex locator concept. It was discovered that the electrical resistance value (6.5 kΩ) between the mouth mucosa and the periodontal ligament remained constant.[15] The apex locator creates a direct electrical current with a known voltage, which travels through the endodontic file before being caught by a metal hook. When the file tip touches the periodontal ligament, which shows a "0" on its screen, the circuit is finished. Adaptive apex locators, the most recent and sixth generation, make use of multifrequency technology. They function precisely in both moist and dry environments, even when exudates are blood. It has the ability to continuously adjust to the root canal's humidity level. Additionally, the devices can emit various sounds to show how far along the file is in the root canal. Examples of this generation are ProPex Pixi (Dentsply, USA) and Raypex 6 Apex Locator (VDW). [16]

CBCT

Additionally, a digital radiography method that is now essential to endodontics is Cone Beam Computed Tomography (CBCT). CBCT offers three-dimensional pictures that provide an unmatched perspective of the tooth and its surroundings. This technology is especially helpful in situations that call for a thorough evaluation, like intricate root canal geometries or surgical endodontic operations. More exact diagnosis and individualized treatment plans are made possible by CBCT's precise imaging capabilities.[16] Digital radiography's incorporation into endodontics and restorative dentistry highlights how crucial technical developments are in influencing modern dental procedures. Reduced radiation exposure, instantaneous imaging availability and increased diagnostic precision are among the advantages. As radiography develops further, it has the potential to further simplify the planning and diagnostic stages, resulting in more effective and patient-centered dental care.The continuous advancements in digital technologies confirm their critical significance in the advancement of endodontics. [17]

3D GUIDED ENDODONTICS

The concept of "Minimally Invasive Endodontics" should be considered when preparing the access cavity. Avoiding the removal of extraneous tooth structure is always preferable.[1] To conserve more dental tissue, new ultraconservative (ninja) and conservative (contracted) access cavities were created. In many therapeutic settings, cautious access can be challenging. For instance, calcific deposits may cover the root canal orifices or obstruct the canal spaces in teeth with sclerosed canals or calcified coronal pulp chambers (pulp stones). Endodontic treatment of such teeth is one of the most challenging dental procedures. More recently, "Guided Endodontics," a ground-breaking technique for treating teeth with calcified pulp canals and apical disease, was introduced. This innovative technique's concept is to use a computer-aided guide to produce an exact access cavity utilizing calculated tomographic information. Guided endodontics requires the acquisition of surface scan data from an intraoral scanner and volumetric data from CBCT. Both sets of data are overlaid in computer-aided design (CAD) software to create a template and plan a virtual access cavity. The template is then made via 3D printing, and the cavity is prepared with drills.[1,18]

3D PRINTING IN ENDODONTICS

In endodontics, three-dimensional printing is used for more than only guided access cavity preparation. Initially, 3-D printing was known as additive manufacturing, which is the process of creating an object by progressively accumulating the desired material. Numerous techniques are employed in 3-D printing applications, such as fused deposition modeling, digital light processing, stereolithography equipment (SLA), polyjet printing, multi-jet printing, selective laser melting, and more. Stereolithography equipment was the first and is currently the most widely used technology in dentistry. Copies of teeth are made for autotransplant applications using 3-D printing, and they are inserted into the recipient bone prior to extraction. Pre-fitting improves the outcome of treatment by cutting down on operating time and preventing stress on the transplanted teeth's periodontal ligament.[17]

COMPUTER AIDED ROOT CANAL IRRIGATION

Root canal irrigation is essential for removing debris, biofilms, and bacteria from the root canal system. Traditional syringe-based irrigation has limitations, including inconsistent irrigant flow, inadequate penetration, and apical extrusion risks. Computer-aided irrigation systems integrate digital control, AI-driven fluid dynamics, and automation to optimize the effectiveness and safety of irrigation.

Gentle Wave System

The GentleWave® System represents a significant advancement in endodontic therapy, integrating digital dentistry principles to enhance root canal treatment outcomes. Developed by Sonendo Inc., this technology employs AI driven Multisonic Ultracleaning™ to deliver a thorough cleaning and disinfection of the root canal system.

Mechanism Of Action:

The GentleWave System utilizes a combination of sound waves and fluid dynamics to navigate the intricate anatomy of root canals. This approach effectively removes bacteria, debris, and infected tissue from areas that traditional mechanical instruments might miss, thereby reducing the risk of reinfection. [18]

Advantages:

Enhanced Cleaning Efficiency: The system's ability to reach complex canal anatomies ensures a more comprehensive cleaning process.

Minimally Invasive: GentleWave preserves more of the natural tooth structure compared to conventional methods, contributing to the overall strength and longevity of the tooth.

Patient Comfort: Patients often report reduced discomfort during and after the procedure, with many treatments completed in a single visit.

The GentleWave® System is a fully computer-based endodontic technology, using digital automation and AI to enhance root canal irrigation and disinfection. It is one of the most advanced computer-aided irrigation systems in modern endodontics.

Other Examples of computer based irrigation systems :

EndoVac® (Kerr Dental) – Utilizes negative pressure irrigation to enhance apical cleaning while preventing extrusion.

Function: Uses digitally regulated vacuum suction to deliver irrigants and remove debris without apical extrusion.

AppliVac® (Vista Dental)

Technology Used: Digitally controlled irrigation pump.

Function: Maintains a consistent and controlled positive pressure flow for irrigation.

SmartLite Pro EndoActivator (Dentsply Sirona)
Technology Used: Digitally controlled sonic activation of irrigants.

Function: Uses precisely calibrated sonic energy to improve irrigant penetration and activation.
EDDY® (VDW)
Technology Used: Piezoelectric ultrasonic activation with digitally controlled frequency.

Function: Uses ultrasound-driven microstreaming to enhance disinfection.[18]

VIRTUAL REALITY (VR) AND AUGMENTED REALITY(AR)
Virtual reality (VR) and Augmented Reality (AR) are becoming revolutionary components in endodontic diagnosis providing cutting-edge instruments that improve dental simulation, education, and visualization. These technologies give endodontists immersive experiences for fine-grained imaging of dental anatomy and root canal system. Augmented Reality helps with real-time visualization during processes by superimposing digital data onto the physical world. Conversely, Virtual Reality produces completely immersive virtual worlds that let professionals study and move through three-dimensional simulated dental structures.

This degree of visibility is very helpful for planning difficult endodontic procedures and comprehending complex root canal geometries.[3]

Used for:
- Student and specialist preclinical training.
- Planning and treatment simulations.

How It Operates:
- AR provides real-time navigation guidance by superimposing CBCT data on actual teeth.
- Interactive endodontic training simulations are made possible by VR.

Examples:
- augmented reality for treatment planning in endodontics with the Microsoft HoloLens.
- Virtual reality-based endodontic training is provided using the Virteasy Dental VR Simulator.

CURRENT CHALLENGES AND LIMITATIONS

1. Expensive upfront and ongoing costs
Expensive Equipment: 3D printers, intraoral scanners, CBCT, and CAD/CAM systems all demand costly financial outlays.

Ongoing Maintenance Costs: The necessity for software upgrades, calibrations, and repairs for digital systems raises operating costs.[19]

2. Technical Expertise Required: Understanding AI-based diagnostics, CAD/CAM software, and CBCT interpretation requires additional skills.

3. Digital Workflow: Data Storage and Security: To safeguard patient data when managing massive amounts of digital patient records and radiographs, secure storage solutions are needed.[20]

4. Digital Tool Accuracy and Limitations: Digital impressions may contain errors or distortions in deep subgingival regions.
- Not every intraoral scanner can reliably record settings with a lot of moisture.
- CBCT Imaging: Patients are exposed to higher radiation doses from CBCT than from conventional X-rays, despite its high accuracy.
- Restoration-related metal artifacts may cause CBCT pictures to become distorted.

5.Ethical and Legal Concerns
Data Privacy Risks: Storing digital patient records increases the risk of cybersecurity threats and data breaches.[21]

Future Perspectives

With its many benefits, the development of digital dental impression technology signals the beginning of a revolutionary era in dentistry. Digital impressions improve patient comfort and satisfaction while simultaneously expediting surgery time. Their effectiveness and decreased discomfort signal a paradigm shift in dentistry treatment , research shows that overall efficiency and patient experiences have increased along with fewer remakes and returns.[22] Digital impressions are positioned to become the cornerstone of modern dental treatment, setting a new standard in accuracy and patient-centricity as a result of these developments that are changing dental processes. There are numerous advantages to combining digital dental impression technology with CAD/CAM systems and 3D printing.[23]

A major development in conservative dentistry that has the potential to completely change clinical procedures is the incorporation of digital dental impression technology. Digital impressions outperform conventional methods in terms of patient comfort, convenience, and efficiency. Dental clinics are expected to adopt digital technologies as regular practice, thus it's critical to understand the learning curve for practitioners to make the most of their abilities in order to attain the best possible healing results.[24]

CONCLUSION

In conclusion, the field of digital dentistry offers many potential uses and a bright future. Clinical practice and current and future research should be integrated for improved results. Digital smart data technology however, shouldn't be viewed as a danger to individuals or their capacity for patient empathy. Unfortunately, in order to give patients greater results and satisfaction with more reasonably priced healthcare, the benefits of digital technologies will enhance human attributes and skills. Digital radiography, electronic apex locators, digital impressions, CAD/CAM technology and other digital technologies has brought about a new age of accuracy, effectiveness, and cooperation in endodontic diagnosis and restoration planning. Adopting this technological advancement is essential to maintaining the highest standards in contemporary dentistry and not just a choice. criteria for patient happiness and care.

REFERENCES

1. Mandlik, Jyoti & Dhavan, Shiksha & Gir, Rushikesh. (2022). Digitization in Conservative Dentistry and Endodontics: A review. Journal of Pharmaceutical Negative Results. 13. 410-414.
2. Kumar, Yadav. (2024). Digital Innovations in the Field of Endodontics: A Review. Clinical Medical Reviews and Case Reports. 11. 10.23937/2378-3656/1410457.
3. Alshargawi, Waleed & Toras, Faidallah & Almutairi, Wafi & Fatiny, Fahad & Alhabashi, Yousef & Alyahya, Faisal & Felimban, Asma & Alshehri, Ayed & Almalki, Saja. (2024). The Use of Digital Technologies in Endodontic Diagnosis and Restorative Planning. JOURNAL OF HEALTHCARE SCIENCES. 04. 154-161. 10.52533/JOHS.2024.40301.
4. AK Tomer, AA Raina, F Ayub, M Bhatt. Digital Dentistry. Int J Appl Dent Sci 2019. Available from: www.oraljournal.com
5. Sharma, Anamika & Singal, Vineeta & Agarwal, Mrinalini. (2022). REVIEW ARTICLE DIGITALIZATION IN DENTISTRY. 5. 5302-5304.
6. Dave, R.D. (2024). Revolutionising conservative dentistry: Exploring the impact and evolution of digital impression techniques in contemporary dental practice. *IP Indian Journal of Conservative and Endodontics*.
7. Bilir H, Ayguzen C. Comparison of Digital and Conventional Impression Methods by Preclinical Students: Efficiency and Future Expectations. J Int Soc Prev Community Dent. 2020;10(4):402–9.
8. Seelbach P, Brueckel C, Wöstmann B. Accuracy of digital and conventional impression techniques and workflow. Clinical oral investigations. 2013;17:1759 64.
9. Beuer, Florian & Schweiger, Josef &Edelhoff, Daniel. Digital dentistry: An overview of recent developments for CAD/CAM generated restorations. British DentJ. 2008;204:505-11.
10. Abdullah AO, Muhammed FK, Zheng B, Liu Y. An Overview of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) in Restorative Dentistry. Journal of Dental Materials & Techniques.
11. Coachman C, Calamita M. Digital smile design: a tool for treatment planning and communication in aesthetic dentistry. Quintessence Dent Technol. 2012;35:103–111.
12. Coachman C, Yoshinaga L, Calamita M, Sesma N. Digital smile design concepts. The Technologist. 2014.
13. Thomas, PriyaAnn & Krishnamoorthi, Divya & Mohan, Jayashree & Raju, Ramesh & Rajajayam, Sasikala & Venkatesan, Sashikant. (2022). Digital Smile Design. Journal of Pharmacy And Bioallied Sciences. 14. 43. 10.4103/jpbs.jpbs_164_22.
14. Fung L, Brisebois P. Implementing Digital Dentistry into Your Esthetic Dental Practice. Dent Clin North Am. 2020;64(4):645.
15. Khadse A, Shenoi P, Kokane V, Khode R, Sonarkar S. Electronic apex locators-an overview. Indian Journal of Conservative and Endodontics. 2017;2(2):35-40.
16. Sonal Soi SM, Vinayak V, Kaur P. Electronic apex locators. J Dent Sci Oral Rehabil. 2013:24–7
17. Meer WJ, Vissink A, Ng YL, Gulabivala K. 3D computer aided treatment planning in endodontics. J Dent 2016;45:67–72.
18. Keskin C, Kele A (2021) Digital applications in endodontics: An update and review. J Exp Clin Med 38: 168-174.
19. Dabrowski W, Puchalska W, Ziemlewski A, Ordyniec-Kwanica I. Ordyniec-Kwanica I. Guided Endodontics as a Personalized Tool for Complicated Clinical Cases. Int J Environ Res Public Health. 2022;19(16):9958. doi:10.3390/ijerph19169958.
20. Masri R, Driscoll CF. Clinical applications of digital dental technology: Wiley Online Library; 2015.
21. Dhir P, David CM, Keerthi G, Sharma V, Girdhar V. Digital imaging in Dentistry: An overview.
22. oda T, Bornstein MM, Jung RE, Ferrari M, Waltimo T, Zitzmann NU. Recent trends and future direction of dental research in the digital era. International journal of environmental research and public health. 2020;17(6):1987.
23. Haidar ZS. Digital Dentistry: Past, Present, and Future. Digital Medicine and Healthcare Technology. 2023.
24. Khalifa N (2021) Digital impressions. In: Jain P, Gupta M, Digitization in dentistry. Springer, Cham, 169-187