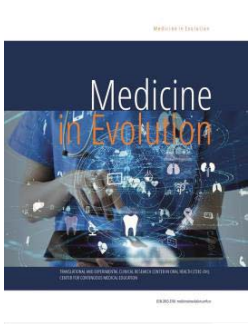
Use of Electronic Imaging Programs in Dental Practice



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Abstract

1.Background/Objectives: Digital radiography has continuously evolved as an innovative technology in dental imaging for nearly two decades. Digital radiography sensors are divided into: storage phosphor plates (SPPs) called photostimulable phosphor plates (PSPs), silicon devices such as charge-coupled devices (CCDs) or

complementary metal oxide semiconductors (CMOS). Digital imaging programs facilitate precise treatment planning by providing detailed images that can be easily manipulated and analyzed 2.Methods: The study period February to March 2025 with a study area of urban and peri-urban areaApproach method: 125 questionnaires were distributed to dentists practicing in urban and peri-urban area, 98 completed questionnaires were returned only 78 questionnaires remained in the study and 20 questionnaires were discarded due to incomplete completion or non-use of electronic medical imaging programs in current medical practice 3.Results: 46% of the doctors work in large private dental clinics, 40% in small private dental clinics and 14% in individual practices, Approximately 55% of respondents reported using electronic imaging programs frequently (more than 50% of the time) in the dental office on a daily basis, while 22% reported using them moderately (between 25% and 50% of the time), 12% use them always and 11% use them only occasionally (less than 25% of the time). 4.Conclusion: Electronic imaging programs offer numerous benefits, including enhanced diagnostic accuracy, more effective treatment planning, improved communication with patients, and streamlined image storage and retrieval.

Keywords: digital radiography, dental images, CMOS, PSPs, digital benefits

INTRODUCTION

Direct digital imaging was first introduced in 1984 by Dr. Frances Moujones. Since then, digital radiography, as a new technology in dental imaging practice, has been advanced relentlessly for almost twenty years [1]. Various imaging techniques have been used to retrieve the signal of interest from digital sensors, including charge-coupled devices (CCDs), complementary metal oxide semiconductor (CMOS), photostimulable phosphors (PSP), and aperture-regulated computed tomography (TACT) [2]. Digital radiography sensors are divided into: storage phosphor plates (SPPs) called photostimulable phosphor plates (PSPs), silicon devices such as charge-coupled devices (CCDs) or complementary metal oxide semiconductors (CMOS). Digital imaging programs facilitate precise treatment planning by providing detailed images that can be easily manipulated and analyzed [3]. Dentists can use these programs to assess the condition of teeth and surrounding structures, plan restorative procedures, orthodontic treatment, implant placement and oral surgery. The ability to accurately measure and evaluate anatomical features helps select the appropriate treatment approach and predict outcomes [4]. Digital imaging programs eliminate the need to physically store bulky X-ray films. Images can be stored securely in electronic databases, providing convenient access and reducing the risk of loss or damage [5]. Dentists can efficiently manage patient records, retrieve images for comparison over time, and easily share them with specialists or recommended colleagues when needed. Streamlined workflow improves efficiency and enhances patient care [6]. Digital imaging programs significantly reduce radiation exposure compared to traditional film radiography. The use of digital sensors or phosphor plates allows lower radiation doses while still producing high-quality diagnostic images [7]. This benefit is particularly important for pediatric patients and individuals who require frequent radiographic evaluations. Electronic imaging programs can seamlessly integrate with other dental technologies such as CAD/CAM systems, cone-beam computed tomography (CBCT) and intraoral scanners. This integration enables a comprehensive digital workflow, improving accuracy, efficiency and communication between different dental specialties [8]. The use of electronic imaging programs in dental practice offers numerous advantages that have greatly influenced the field of dentistry. Key advantages of using electronic imaging programs [9,10]: (i)Improved diagnostic accuracy: electronic imaging programs provide high-resolution digital images that offer superior clarity and detail compared to traditional film radiographs. Dentists can zoom, adjust contrast and brightness and manipulate images for more comprehensive analysis. This enhanced visualization helps to more accurately diagnose dental conditions, leading to improved treatment planning and better patient outcomes [11], (ii) time and cost efficiency: electronic imaging programs simplify the process of capturing, viewing and storing images, resulting in significant time and cost savings. Digital images can be captured instantly, eliminating the need for film processing. Furthermore, electronic storage eliminates the need for physical film storage, reducing associated costs and freeing up physical space in dental offices [12], (iii) reduced radiation exposure: electronic imaging programs use digital sensors or phosphor plates, which require lower doses of radiation than traditional film radiography. This reduced radiation exposure is beneficial for patients, especially children and people who require frequent imaging. It promotes a safer environment while maintaining high-quality diagnostic images [13].

Aim and objectives

The aim of this study is to assess the level of satisfaction of dental professionals with the electronic imaging programs they use and gather information about the future role and potential developments of electronic imaging programs in dental practices.

MATERIAL AND METHODS

For the realization of this article, we conducted a, cross-sectional pilot study in order to follow the implementation and importance of imaging technology implementation in current dental practice. Study title: "Study on the use of electronic imaging programs in dental practices". The study period February to March 2025 with a study area of urban and peri-urban area. Approach method: 125 questionnaires were distributed to dentists practicing in urban and peri-urban area, 98 completed questionnaires were returned, only 78 questionnaires remained in the study and 20 questionnaires were discarded due to incomplete completion or non-use of electronic medical imaging programs in current medical practice. Survey instrument: questionnaire with questions on: socio-demographic elements, use of electronic imaging programs, time of use of the programs, type of programs used, challenges and disadvantages of using them, satisfaction with using these programs, perception of improved quality of patient care. The final sample consisted of 78 subjects, dentists, practicing in Timisoara or its peri-urban area and who use electronic medical imaging programs in their medical practice.

RESULTS

The gender of the dentists in the sample is predominantly male, with an average age of 39.7 ± 11.2 years, with a minimum of 26 years and a maximum of 59 years, an average length of service of 11.7 ± 7.2 years, with a minimum of 1 year and a maximum of 25 years.

32% of the dentists were endodontic specialists, 30% orthopedic and orthodontic dental specialists, 23% dento-alveolar surgery specialists and 15% general dental specialists.

Table 1. Compressed results of Questionaire

Category	Results of questionaire
Gender of Dentists	62% Male, 38% Female
Average Age	39.7 ± 11.2 years
Age Range	26 – 59 years
Average Length of Service	11.7 ± 7.2 years
Length of Service Range	1 – 25 years
Specializations	32% Endodontic specialists
	30% Orthopedic & Orthodontic dental specialists
	23% Dento-alveolar surgery specialists
	15% General dental specialists
Place of Work	46% Large private dental clinics
	40% Small private dental clinics
	14% Individual practices
Technology Adoption	Male and younger doctors more open to using electronic imaging programs
Usage of Electronic Dental Imaging	80% currently using electronic imaging programs
Duration of Program Use	13% Less than 1 year
	32% 1–3 years
	33% 3–5 years
	22% More than 5 years

46% of the doctors work in large private dental clinics, 40% in small private dental clinics and 14% in individual practices. From the sample it is observed that male and younger doctors are more open to the use of electronic medical imaging programs for the treatment of patients. 80% of the physicians who returned the questionnaires were currently using electronic dental imaging programs in their current medical practice. Concerning the duration of use: the majority of respondents had been using electronic imaging programs in their dental practices for 1-3 years (32%), followed by those who had been using them for 3-5 years (33%), more than 5 years (22%) and less than 1 year (13%). Regarding the types of programs used, most commonly used intraoral cameras (74.36%), extraoral imaging (55.13%) and extraoral imaging such as panoramic or CBCT (34.62%) and 7.69% intraoral digital sensors (Figure 3).

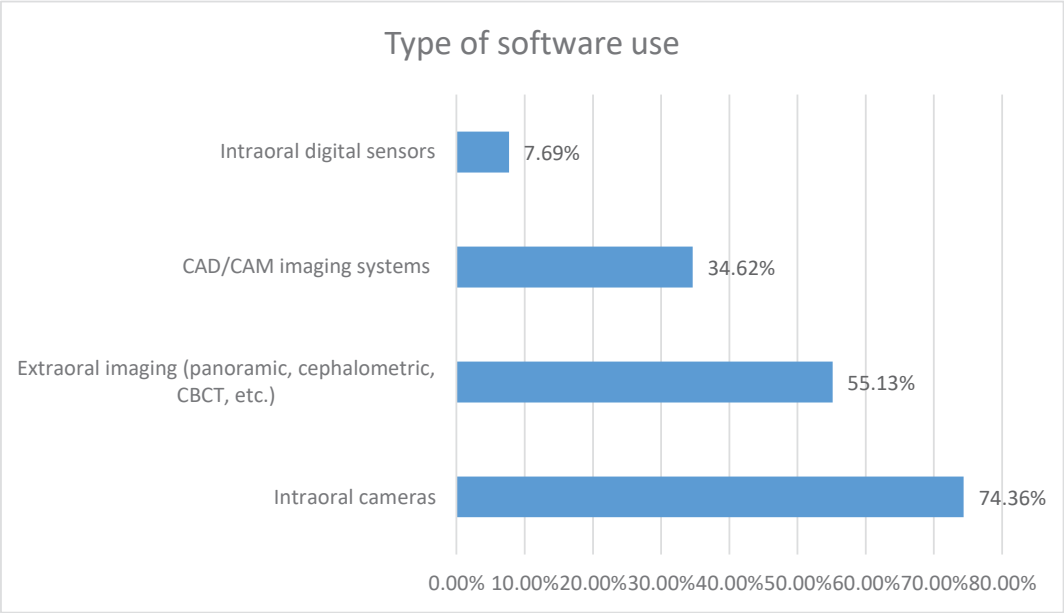

Figure 1. Type of software used

Frequency of use of electronic programs Approximately 55% of respondents reported using electronic imaging programs frequently (more than 50% of the time) in the dental office on a daily basis, while 22% reported using them moderately (between 25% and 50% of the time), 12% use them always and 11% use them only occasionally (less than 25% of the time).

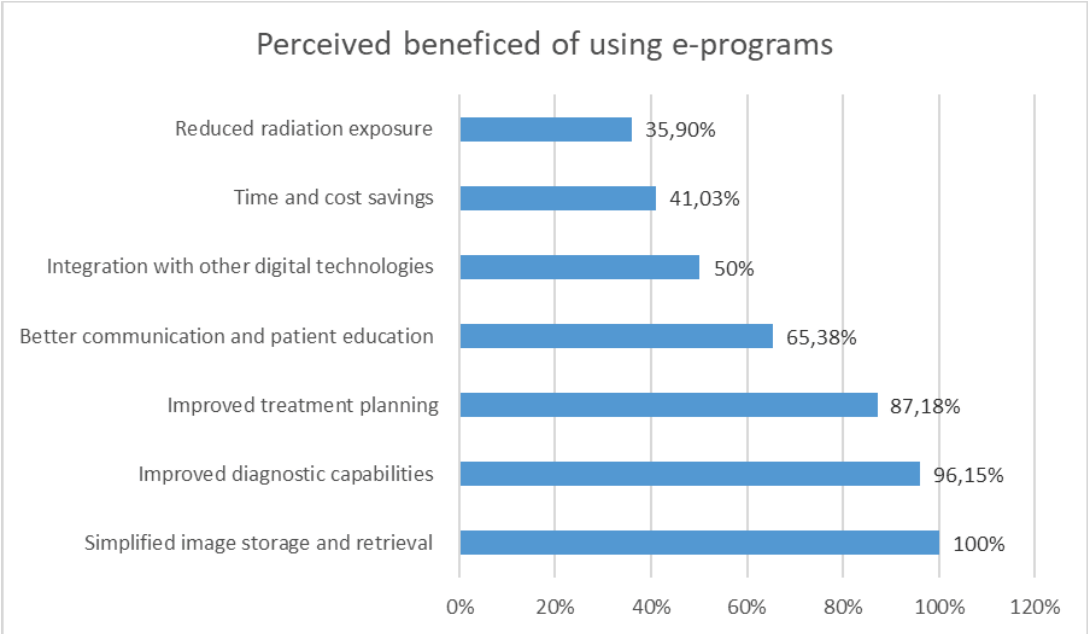

Figure 2. Perceived benefits of using e-programs

Key benefits observed from the use of electronic imaging programs include improved diagnostic capabilities (96%), improved treatment planning (87.18%), time and cost savings (41.03%), better patient communication and education (100%), reduced radiation exposure (35.9%), simplified image storage and retrieval, and integration with other digital technologies (50%). The main challenges reported by respondents include upfront cost and investment (50%), technical problems or equipment failures (35%) and compatibility issues with other systems or software (25%) (Figure 4).

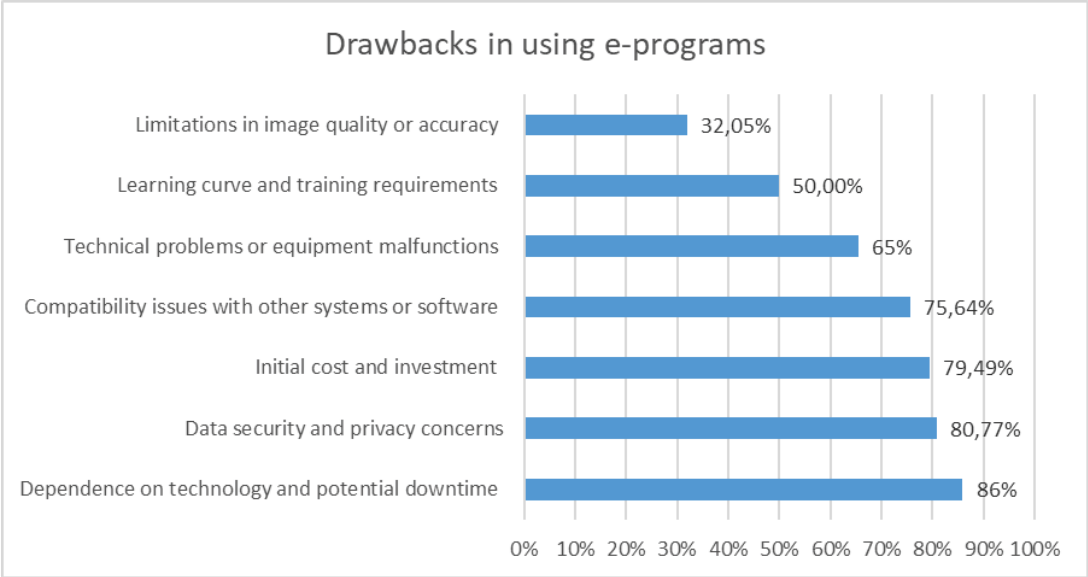

Figure 3. Drawbacks in using e-programs

Satisfaction: The majority of respondents (49%) expressed a very high level of satisfaction with the electronic imaging programs they currently use in their dental practices, 34% somewhat satisfied, 8% neutral and 4% very dissatisfied. The perception on the

improvement of patient treatment by using electronic programs is good by 66% of subjects and unclear by (20%). The perception of the future role of programs in dental practice is considered absolutely necessary by 74% of the subjects and an increasingly clear direction of help (26%). The recommendation to use electronic imaging programs in current dental practice is safe in 81% of subjects.

DISCUSSIONS

The survey results indicate that electronic imaging programs have become an integral part of dental practices, with the majority of respondents having been using them for more than one year. This suggests widespread adoption within the dental community. The high frequency of use further emphasizes their importance as a daily tool in dental diagnosis and treatment planning [14]. The reported benefits align with the advantages commonly associated with electronic imaging programs [15]. The improved diagnostic capabilities and enhanced treatment planning reflect the higher resolution and versatility of digital images compared to traditional film radiographs. These programs have also proven effective in facilitating patient communication and education, allowing dentists to visually demonstrate conditions and treatment options. In addition, simplified image storage and retrieval capabilities help improve workflow efficiency [16]. The reported benefits align with the advantages commonly associated with electronic imaging programs. However, the challenges reported highlight some areas of concern. Cost and initial investment may present barriers, particularly for smaller dental practices or clinics with limited budgets. Addressing these financial considerations and offering cost-effective solutions may encourage wider adoption of electronic imaging programs [17]. Technical problems and compatibility issues are other challenges to be addressed through proper maintenance, technical support and software integration - improved diagnostic capabilities and planning. Electronic imaging programs provide dental professionals with high-quality, detailed images of patients' teeth, jaws and surrounding structures. These images enable the accurate and efficient diagnosis of dental conditions such as cavities, gum disease, impacted teeth or bone abnormalities [18].

Intraoral digital sensors (IODS) are medical equipments that measure with the help of 3D measurement to reproduce the creation of detailed 3D models of teeth and oral soft tissues. This technology enables a complete digital representation of the mouth's anatomy [19, 20]. The mechanism of IODS is tepresented by a proiected light source onto the dental structures, including prepared teeth and implant scan bodies. The imaging sensors capture the reflected data, which is converted by the scanning software into point clouds. Ultimately these are subsequently triangulated to form a 3D surface mesh—a digital counterpart to traditional plaster models [21, 22]. This type of equipment represents inovative method that could be used in the fields of orthodontics and implantology, as well as in several diagnostic fields, such as the evaluation of dental erosion [23]. Nevertheless, the main diagnostic área is dental wear involving functional problems such as chewing, increased tooth sensitivity, temporo-mandibular joint dysfunction and headackes [24].

CAD–CAM (Computer-Aided Design and Computer-Aided Manufacturing) technologies have been also frequently use in various areas of modern dentistry. These techniques are valuable in the planning of maxillofacial surgeries, as well as in the design and fabrication of surgical splints and guides for the precise placement of dental implants [25]. Additionally, CAD–CAM systems facilitate the creation of guides for temporary anchorage devices (TADs), such as miniscrews, enhancing both the accuracy and predictability of orthodontic and surgical procedures. The dentist area where CAD-CAM sistems are applied are in implantology and prosthetic dentistry [26]. Furthermore, in orthodontics, CAD–CAM

procedures are used in design and fabrication of customized orthodontic appliances, including personalized brackets, archwires, and indirect bonding trays [27].

Cone-beam computed tomography (CBCT) influenced the outcome in field of endodontics by offering multi-plane dynamic navigation, data correction by adjusting brightness and contrast and adjustment of volume parameters such as slice-thickness and slice interval [28, 29]. CBCT has positively influenced a large group of dentistry areas: Endodontics, Surgery, Implantology, Orthodontics, Periodontics, temporomandibular disorders and diagnostic imaging especially in Endodontics where it increases the precision of diagnoses of apical periodontitis and inflammatory root resorption [30-32]. Also in Implantology, the use of CBCT provides anatomical information on bone density, nerve path ways, and sinus anatomy, enhancing the precise implant placement, in orthodontics, it spimlified the evaluation of impacted teeth and craniofacial anomalies [33, 34]. With the help of CBCT preoperative planning, intraoperative navigation, and postoperative evaluation of fractures, pathologies, and reconstructive procedures aiding the overall succes and safety of surgical operations.

Intraoral cameras (IOC) systems consist of video display, processing unit and intraoral camera with light source. An increasing number of models are available on the market with specific modifications for intraoral cameras, including macro (magnification) mode, polymerization light for composite, LED lights, photo or video recording, fluorescence for detecting different stages of caries, plaque and gingival inflammation. These intraoral camera features are useful in providing treatment and to communicate with experts regarding diagnosis, treatment decisions and protocols. They help to increase patient compliance and motivation before, during and after dental treatment, patient knowledge and awareness of various common oral conditions, as well as enabling effective communication between the patient and the dentist remotely of various oral health conditions [35]. It is used in aproximately all fields of dentistry, it has diverse applications in oral health care and can effectively support dentists, dental hygienists, and other oral health care providers in clinical assessment, diagnosis, patient education and it has a high percentage of use in dental practice.

By improving visualization and magnification capabilities, electronic imaging software supports accurate treatment planning, helping to develop effective treatment strategies [36]. Electronic imaging programs improve communication between dental professionals and patients. With the ability to display and manipulate digital images on chairside monitors or computer screens, dentists can visually illustrate dental conditions, treatment options and expected outcomes. This visual aid helps patients better understand their oral health problems, facilitating informed decision-making and promoting active participation in treatment discussions [37,38]. Electronic imaging programs streamline dental workflows, saving time for both dental professionals and patients. Images can be captured and displayed instantly, eliminating the need for film processing [39]. Digital images can be easily shared with specialists or referenced during treatment procedures, promoting efficient collaboration and reducing the need for additional appointments or referrals. This helps improve patient satisfaction and optimize practice management [40]. Software-based digital imaging programs significantly reduce radiation exposure compared to traditional x-ray film methods. Electronic imaging systems require lower doses of radiation to capture high-quality images, prioritizing patient safety and minimizing potential health risks associated with radiation exposure. This makes electronic imaging programs a safer alternative, especially for pediatric patients or people who require frequent imaging [41]. The use of electronic imaging software in dental practice has revolutionized the field of dentistry, offering numerous benefits for both dental professionals and patients. Electronic imaging programs use advanced technology to capture, store and manipulate dental images, offering a wide range of applications and benefits. However, there are challenges, including initial cost and

investment, technical issues and compatibility issues. Overcoming these challenges through financial planning, technical support, and improved software integration can facilitate effective implementation and use of electronic imaging programs [42].

Within the dental practice the inclusion of digital devices will significantly improve the clinical side through more accurate diagnoses and efficient medical practice. However, there are cost and infrastructure barriers in accessing these technologies, which promise vast advances, leading to limited accessibility. A major future direction of development are real-time feedback systems, based on real-time artificial intelligence, designed to assist doctors during procedures. These system can continuously process imaging data in real time, identify anomalies, refine scan settings and support in-the-moment decision-making. Integrating them into clinical project can improve operations.

CONCLUSIONS

By harnessing the power of digital imaging technologies, dentists can provide higher quality care, enhance patient experiences, and achieve improved clinical outcomes in various dental procedures. Based on the results of the questionnaire and discussion, the following conclusions can be drawn regarding the use of electronic imaging programs in a dental practice: Electronic imaging programs have gained widespread adoption in dental practices, with the majority of respondents using them for several years. This indicates their importance as a diagnostic and treatment planning tool in modern dental practice. The main benefits of electronic imaging programs include improved diagnostic capabilities, improved treatment planning, better communication with the patient, and simplified image storage and retrieval. These advantages contribute to more accurate diagnoses, improved treatment outcomes and efficient workflow management.

Acknowledgments

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Conflicts of Interest

The authors declare no conflict of interest.

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