Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 10s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Enhancing Traditional Dental Care Practices through Modern Technologies and Medical Devices: A Systematic Review

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Cite this paper as: Yousef Radhi K Alanazi, Sattam Saad Dughayyim Alharbi, Mohammed Abdullah Ali Alsultan, Fahad Ayed Bandar Alharbi, Omar Abdullah Saleh Alharbi, Saleem Ali Qasem Atiah, (2025) Enhancing Traditional Dental Care Practices through Modern Technologies and Medical Devices: A Systematic Review. *Journal of Neonatal Surgery*, 14 (10s), 728-735.

ABSTRACT

New technology has dramatically influenced the practice of dentistry, ushering in more effective and conservative treatments for patients. This systematic review aimed to provide a comprehensive view of the technologies most widely used as the treatment of choice in the dental office. The goal was to identify the typical applications of state-of-the-art technologies in dentistry. By extracting relevant data from databases such as PubMed, Web of Science, and Scopus, we sought to enroll the most common cutting-edge technology utilized by dentists between 2015 and 2024. Adopting more modern technology into conventional dentistry practices can significantly enhance clinical outcomes, the satisfaction of practicing dentists, and career opportunities, ultimately leading to improved patient care and safety, instilling a sense of reassurance and optimism in the audience.

Keywords: *Advanced Technologies, Medical Devices, Dentistry, Dentist, AI, Dental Imaging. .*

1. INTRODUCTION TO GUT MICROBIOTA AND PERSONALIZED MEDICINE

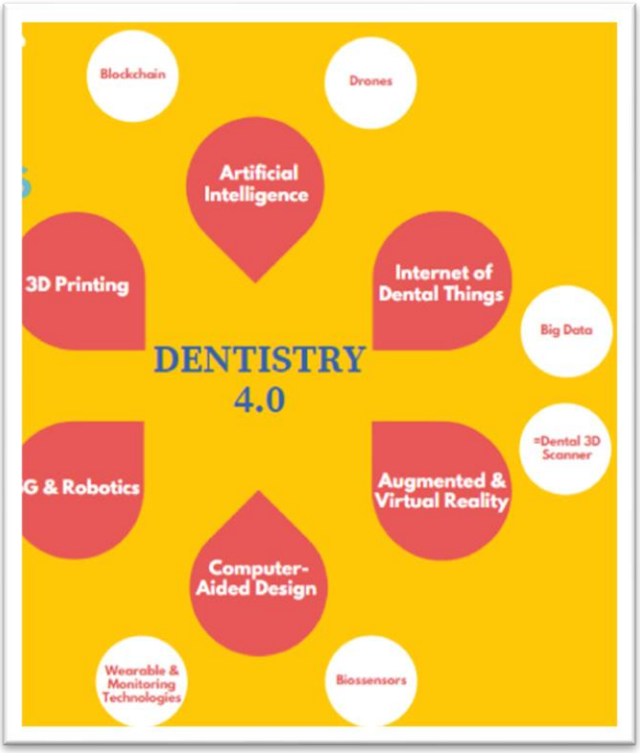
Any technological advancement all around the globe has always remained 'Human-Centered in this regard; it can also be stated that apart from warfare, education, and minimizing the human effort, maximum innovation has taken place in the healthcare system. **Gracco et al. (2023)** These technological advances in health care are related to diagnosis, imaging, scanning, healing, drug delivery, and even 3-D printing of some vital body parts. The processes that have provided a boost to such development in the field of healthcare are robotics, machine learning, and artificial intelligence. From early diagnosis of fatal diseases to 100% cure of chronic patients, it is becoming a routine life process, and the internet is playing an essential role in spreading information among the general public. As technology advances, more and more physical labor will be automated over the next few decades. **Grischke et al. (2020)** Both practitioners and researchers are promoting digital process redesign as a practical way to improve overall care quality and reduce practice variance. Students can gain practical experience by learning about these cutting-edge devices in dentistry schools. Consequently, students have a deeper comprehension of the subject matter, enabling them to provide their future patients with the best care possible. **Alkahtany et al (2023); Bassyouni et al (2021)**

By delegating tasks to robot assistants, employees can focus on human-interaction-intensive tasks such as direct patient interaction or tasks requiring high cognitive ability. Robot assistants, being industrious and capable of repeating tasks indefinitely, allow employees to concentrate on these crucial aspects of their jobs. Another intriguing area is the use of robotic technology in dental education. Universities are now training students in essential skills for future dentists using sophisticated simulation, mechanical device interface, and occasionally full-body robotics personnel **before they interact with actual patients. This practical application of AI and robotics in dental education underscores their potential.**

From the above-mentioned areas of technological advancements, dentistry is one field of healthcare where most innovations like robotics, machine learning, artificial intelligence, etc., are used in greater amplitude, and the results are also coming in

the same proportion, mostly the positive ones. Most of the time, a blend of AI and robotics is used in clinical settings worldwide. The training and experience of doctors cannot be challenged with any advancement, but then again, technology can provide a better experience for the sake of diagnosis, cure, pre and post-seizure assessment, and tracking of the medical history of a given patient in the long run and that too anywhere in the world. Here, the best thing is that the robotic-assisted equipment does not face stress or fatigue and does not even experience the lack of ergonomic work environments; this adds value to the combination of humans and technology, where the sole target is to provide better and long-lasting cures to the patients. **guilar-**

Díaz (2021); Lombardoet al (2023)



Source: Javaid et al. (2021)

Figure 1: Dentistry 4.0 Technologies Applied in Dentistry

Technological advances have revolutionized dental treatment, making it safer, more accurate, and more patient-friendly. Digital X-rays and the use of 3D printing are two ways that dental care has changed significantly. Unkovskiy et al. (2021); Stupar et al. (2023). Unkovskiy et al. (2021); Stupar et al. (2023). Three-dimensional printing has revolutionized the manufacture of dental prosthetic restorations, like crowns and bridges. Dentists can now plan and build custom dental restorations using 3D-printed models of their patient's teeth that are unbelievably realistic. This process has made procedures more efficient and significantly cost-effective, reducing the hours required for production. The extra techs, such as robotics, AI, and machine learning, may support New Digital Dental Techniques Development. These 'extra techs' refer to additional technologies that complement and enhance the capabilities of digital dental techniques, such as robotics for precise surgical procedures and AI for predictive analytics. Potential Applications for the Robotics & Dental Allies of Tomorrow De Stefani et al. (2022) Shetty et al. (2018)

This study seeks to provide insight into recent trends in dental care, with special emphasis on technological development and applications.

Objective of the Study

The purpose of this study is to assess the notable technological advancements in the domain of dental care and to specifically emphasize key aspects of orthodontics for which additional solutions in the form of AI, robotics, etc., have provided enormous value to the complete dental care ecosystem.

Research Process

Focus Areas

The key focus areas and assessable study components were:

Dental care technology developments

Use of digital technology

Any assessment compares new technology with standard processes.

Current use of state-of-the-art technology in Dentistry

Benchmarks Included

for Studies

Based on some of the earlier research and according to the requirements of this research, the author has formulated some of the inclusion criteria or standards for the inclusion of the previous studies. Some of the standards are mentioned here:

- The researcher has included only those research studies that were presented or published in English, assuming that the audience for this present study understands English well.
- Only the results of controlled clinical trials were included in the study, considering that dental experts approved those trials' results.
- Some of the case reviews, case studies, and ongoing orthodontic experiments were included, and they discussed the advanced technologies used in diagnosis, assessment, and cure.
- Some technical notes, editorial letters, and even mini-reviews, including details on technical advancements in dental care, were also included.

Key Points of Literature Search

The researcher has included only those reviews published between 2015 and 2024 that pertain to the research question of this present study.

- Publications relevant to the subject of this targeted systematic overview were identified using digital databases, such as PubMed, Web of Science, and Scopus.

The researcher generated a preformatted list of keywords prepared under the guidance of academic and medical experts. Some of the essential keywords were "advanced technology," "modern technology," "artificial intelligence/ machine learning/ robotic dentistry," and "3D technology" in dental healthcare professions and its "applications" in "dental practice."

The total number of studies and reviews included in the study was 129. However, after a closer analysis, it was found that only 97 of the studies passed the selection criteria and had the set keywords. Hence, further evaluation was conducted on these 97 studies only.

Technological Advances in Dentistry

In particular, the field of Dentistry saw a range of technological innovations during the study period, i.e., 2015 to 2024. These new technologies have targeted the accuracy level during treatment, accuracy in diagnosis, & above everything, Patient health, and safety. Lo Russo et al. (2023). Such technologies have vastly enhanced patients' dental health care by making dental processes integrated, easier, and more cost-effective. Here are some of the mentioned modern-day technologies in detail:

Intraoral imaging devices

As an instance of this transition toward digital impressions, intraoral scanners capture accurate and efficient geometric images of the oral cavity. Optical scanning technology in portable devices that replace traditional imprint trays and materials helps accelerate the treatment process and significantly improve the patient's comfort. Accuracy in treatment planning with intraoral scanners has improved, Dentists and dental labs have better communication, and Intraoral scanners have increased the standard of care in restorative dentistry. Ohara et al (2022)

3D printing

Additive manufacturing, a new technology in dentistry, provides unlimited possibilities for the precise production of surgical guides, dental appliances, and anatomical models on demand. In dentistry, examples of applications for CNT are surgical guides and custom trays. These instructions utilize computerized images of the patient's mouth and jaw to ensure precise placement of implants, orthodontic appliances, including braces and clear aligners, and temporary restorations. Liu YX et al. (2022)

Dental lasers

Dental Treatments– laser technology is a revolutionary aspect. It can achieve accurate tissue contact, hemostasis, and sterilization with minimal thermal damage and much quicker tissue healing. Lasers can be used for soft tissue surgery, periodontal therapy, endodontic procedures, and minimally invasive cavity preparation. The focused tissue ablation capacity of lasers encourages conservative treatment modalities, enhanced patient outcomes, and faster recuperation after surgery. Al-Halabi et al (2022)

Using digital imaging

Digital radiography and Cone Beam Computed Tomography (CBCT) are the central components of modern dental imaging that reveal unparalleled information about tooth anatomy and disease. By replacing conventional film-based X-rays with digital sensors, where images are obtained instantly with better definition and less radiation exposure, digital radiography has emerged as a revolutionary imaging technology. (4,5) However, attention to three-dimensional reconstruction of oral structures by CBCT evaluation enables accurate diagnosis and management in complex cases like orthodontic treatment plans and implant placement. Gupta (2021); El-Ghafour et al. (2020) AI models trained on large datasets of dental X-rays, CBCT, and panoramic images can detect: Caries : AI algorithms can highlight early demineralization areas. Periodontal Disease: AI detects bone loss and periodontal pockets from radiographs. Endodontic Lesions: AI identifies periapical lesions, root fractures, and resorption. Oral Cancer: AI-based image recognition can detect early signs of oral malignancies. Jung, S.K., et al. (2023)

CAD/CAM setups

CAD/CAM: Revolutionizing Dental Restorations Production CAD/CAM or computer-aided design and manufacturing solutions have changed the game of dental restoration production. These systems can be based on digital impressions, virtual restoration design, and manufacturing restorations using various materials with automated milling. The solutions transform treatment protocols and increase patient satisfaction through swift delivery at the chairside, superior aesthetics, and precise restoration fit. CAD/CAM technology is bringing a peak in digital dentistry, making using digital data to produce dental work easier. Herpel et al. (2023);

2. DISCUSSION

The systematic review specifically found pertinent research and findings regarding the extensive use of cutting-edge technology, which is now necessary for higher patient satisfaction levels with diagnosis, treatment plans, and treatment results in the medical and dental fields. Peters et al. (2021) and Aksakalli et al. (2023) Recognizing and summarizing the extensive use of cutting-edge technology in dentistry at different patient management levels is preferable. The outcome of this analysis indicates that many dentists are highly knowledgeable in promoting cutting-edge technologies in patient care. Ye RR et al. (2022) The systematic review will help spread knowledge about modern technologies to broader populations, ensuring that every dental clinician and patient can access improved dental treatment. New technology has significantly enhanced dental treatment by making it more accessible, safe, and effective. Chevalier et al. (2022); Schneider et al. (2019). A small number of extra outcomes will also be addressed in the evaluation to address the secondary objectives. The secondary outcomes covered in this review include advances in artificial intelligence, machine learning, and more invasive scenarios such as autonomous implant implantation, which have finally been combined with intricate 3D navigation or tooth preparation procedures that have been documented in the literature. Digital X-rays and 3D printing are two examples. For underserved populations, this shift opens the door for dentists to offer more affordable dental care and improve patient results. Ding et al (2022); Gupta et al (2021)

According to several researchers, using advanced technology in dental care is to give patients more effective and efficient treatments; in other words, sophisticated technology has significantly altered the dental profession. They added that improvements in technology have completely changed how dental care is provided, improving accuracy, security, and patient comfort. Digital X-rays and 3D printing are two notable examples. Qi W et al. (2022) This study demonstrates the overwhelmingly favorable effects of modern technology on dental care. From the standpoint of public health, this trend will likely continue. The results of this study show that newer, more sophisticated technologies will impact all facets of dental patient care. Bae et al (2022)

Table 1: Summary of Technological Advancements in Dentistry

S.No	Areas Focused	Thrust area
1	Every intr-aoral scanner shows the capacity to create a digital complete implant imprint in vitro, based on the average misfit value (150 µm) documented in the literature. The Primescan and iTero were the only devices with insignificant systematic error sources, according to the 3D distance study.	Implantology
2	Both 3D-printed multilayer mouthguards gained patient approval and displayed a fit that was clinically acceptable.	Orthodontics
3	According to the results, it may be possible to use the produced 3D-printed teeth to practice caries eradication in preclinical dentistry education.	Conservative dentistry
4	20% of patients preferred and utilised digital dentures on a daily basis, despite the fact that patient satisfaction or quality of life may be slightly lower with DDs than with CDs. DDs created through 3D printing may, therefore be as useful and effective as CDs.	Prosthodontics
5	Before having their lips repaired surgically, newborns with unilateral complete cleft lip and palate (UCLP) can have their maxillary arch dimensions (MADs) improved with the newly invented 3D-printed nasoalveolarmoulding (D-NAM) appliance.	Pedodontics
6	Overdentures made using 3D printing could be an alternative to those made using more traditional methods. This study serves as a first step and proof of concept for the prospective use of 3D-printed dentures in the future.	Prosthodontics
7	In the context of this study, utilising a 3D-printed model to practice obturation did not significantly enhance dentistry students' obturation abilities.	Endodontics
8	Removable dentures made using 3D printing have some benefits that increase their accuracy and patient comfort.	Prosthodontics
9	The prospect for educational development in the crucial pulp treatment and cariology fields is provided by the benefit of integrating new technology in terms of boosting student confidence and decreasing stress.	Endodontics
10	With the test guide and the control, implants were inserted precisely for single posterior edentulous spaces. It is necessary to conduct additional research in scenarios with numerous missing teeth that are more complex.	Periodontics and implantology
11	Although dentists have a favourable opinion of robotics and artificial intelligence, there will be a pressing need to raise knowledge of this idea in the near future.	Dental education
12	Participants expressed optimism and believed that AI would have a beneficial effect on dentistry practice in the future.	Clinical practice
13	Understanding the importance of haptic virtual reality simulators in dental education is made possible thanks to the work, which is a critical first step.	Dental education
14	The findings of this study suggest that a skill can be transferred from one level of force feedback (FFB) to another, provided students practice it for a long enough period of time.	Dental education
15	When trained on two-dimensional panoramic condyle pictures, the artificial intelligence model enhanced the ability to diagnose TMJ-OA and can be successfully used by dentists as a screening diagnostic tool for the condition.	Diagnosis
16	Despite being in its early stages, artificial intelligence is expanding the potential of cutting-edge dental models. To evaluate the clinical effectiveness of AI approaches in dentistry, more research is necessary.	Clinical practice
17	A machine learning-based automated system performs quite well. They can even outperform dental specialists in terms of performance and accuracy, mimicking the precision and accuracy of experienced specialists.	Treatment outcome
18	AI models have the potential to be an effective tool for detecting the margin of the tooth preparation, forecasting the failure of a restoration, and helping to diagnose caries and vertical tooth fracture.	Diagnosis

Several top researchers gave the community creative ideas to advance dentistry and argued for a broader application of these new technologies called Plantronics. According to the study's findings, artificial intelligence (AI) and machine learning (ML)

are being used in dental research. Data-driven analysis algorithms examine large datasets to support dental diagnosis, prognosis, and treatment planning. These conclusive findings are consistent with some research showing that advances in robotics, machine learning, and artificial intelligence affect dental care results. Schneide et al (2019); Chen et al (2021)

Some of the cutting-edge researchers in dentistry studied artificial intelligence, machine learning, and "Dentronics." Murray et al. (2020), the study's authors, claim that prognosis, diagnosis, and treatment management in modern dentistry have all changed due to the incorporation of artificial intelligence. The current thorough investigation's findings suggest that future data management in this field may benefit from using artificial intelligence. Liu et al (2021); Mirghan et al (2018)

Several studies in Saudi Arabia evaluated dentists' understanding of the role that robotics (R) and artificial intelligence (AI) play in oral health and preventative dentistry. De Boer et al. (2019) Dental interns, graduates, and postgraduates were among the dentists who took part in the research. According to the studies above, dentists favored robotics and artificial intelligence (R/AI), but a lack of expertise and comprehension hampered its use and deployment. Shortly, increasing understanding of these ideas will be crucial to improving the effectiveness and efficiency of dental treatments. Jung et al (2023); Al-Sarem et al (2022)

Some researchers assessed trainee doctors' attitudes and perspectives to understand better their attitudes about artificial intelligence (AI) and its possible application in dentistry. Of the 1000 respondents, 11% claimed no information sources on artificial intelligence (AI), whereas 45% had at least a basic comprehension of the subject. 82% of respondents believe AI will transform dentistry and eventually displace dentists. In line with the findings of this systematic research, every participant expressed hope and thought AI might advance dentistry practice in the future. Abbasi et al (2021); Khanaga et al (2021)

Full-Arch Digital Implant Impression Accuracy of Contemporary Intra-oral Scanners (IOSs): A Systematic Review Mörch et al. (2021); Revilla et al. (2022). The computer application performed some 3D position and distance analysis to pinpoint the locations on each scanned body, where the two marking points creased to make contact with the static points of the body. The study found that all intra-oral scanners (IOSs) could deliver an in vitro fully digital implant impression, which is highly remarkable compared to an average misfit value reported in the literature (150 μm). 3D distance analysis confirms that only Primescan and iTero show significant sources of systematic error. These correspond to the applications of 3D technology addressed in this systematic research. Minervini et al (2023)

3. CONCLUSION

New technologies exemplifying modern dentistry stimulate innovation, efficiency, and patient-centric practice. Developments in dentistry, such as intraoral scanners, computer-aided design/computer-aided manufacturing (CAD/CAM) systems, laser dentistry, digital imaging modalities, and 3D printers, are broadening the possibilities of diagnosis and treatment. Let us continue to utilize these developments in our journey through the dynamic landscape of dental technology to better patient outcomes, expand knowledge in science, and shape the future of our industry in a way that centers around our patients and is supported by research. Digital transformation and approaches borrowed from the digital and e-commerce sectors can facilitate the transition to a sustainable oral healthcare model for the 21st century in which more patients can access high-quality, value-based care.

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