Original Research Article

Adoption and Barriers of Digital Dentistry in Clinical Practice: A Survey-Based Study

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Abstract:

Background: Digital dentistry has significantly enhanced diagnostic precision, treatment workflows, and patient communication. However, its adoption varies widely among clinicians due to financial, educational, and practical limitations. Understanding these adoption patterns is essential for promoting effective digital integration in dental practice. With the aim to assess the level of adoption of digital dentistry tools among dental practitioners and to identify the key barriers hindering their widespread use in clinical practice. **Materials and Methods:** A cross-sectional survey was conducted using a structured digital questionnaire distributed to general dentists and specialists. The survey evaluated the use of digital tools (digital radiography, CBCT, intraoral scanners, CAD/CAM, digital smile design), perceived benefits, barriers, and practitioner readiness. Responses were collected anonymously and analyzed descriptively. Graphs and tables were generated to visualize adoption trends and obstacles. **Results:** Digital X-rays (85%) and CBCT (60%) were the most widely adopted technologies. Advanced tools such as intraoral scanners (45%), CAD/CAM systems (35%), and digital smile design software (30%) showed lower adoption rates. Cost emerged as the most significant barrier, particularly for intraoral scanners (60%) and CAD/CAM systems (70%). Training deficiencies and steep learning curves were also prominent challenges affecting digital workflow integration. **Conclusion:** Although digital dentistry is increasingly recognized for its clinical advantages, its adoption is still limited by financial constraints, inadequate training, and operational challenges. Targeted educational programs, cost-effective digital solutions, and improved practitioner support are essential to accelerating digital transformation in dental practice.

Keywords: Adoption barriers, CBCT, clinical practice, Digital dentistry, intraoral scanner

Introduction: Digital dentistry encompasses advanced tools such as digital radiography, cone-beam computed tomography (CBCT), intraoral scanners, CAD/CAM systems, and digital smile design software. These technologies enhance diagnostic accuracy, precision in restorative treatments, and patient engagement.[1-3] Despite clear advantages, digital adoption varies significantly between practices based on clinician experience, financial considerations, and educational exposure. Understanding these adoption patterns and identifying barriers is essential to fostering a smooth transition toward adigitally empowered clinical environment.[4] This study aims to evaluate the adoption levels and obstacles in integrating digital dentistry through a structured practitioner-based survey.

Materials and Methods:

A descriptive, cross-sectional digital survey was distributed to general dentists and specialists across private practices and institutional setups. The questionnaire included items related to demographics, digital tool adoption, perceived benefits, challenges, and willingness to incorporate new technologies. Responses were collected anonymously over four weeks. Data were analyzed descriptively, and visualized using tables and graphs generated through Python to present adoption trends and barrier distribution.

Results:

A total of survey responses was analyzed to understand the current adoption patterns of digital dentistry tools and the barriers encountered during their implementation in clinical practice. The distribution of usage across different digital technologies demonstrated significant variability.

Adoption of Digital Tools: Digital X-rays emerged as the most widely adopted technology, with 85% of respondents using them routinely in daily practice. This high uptake reflects the long-standing availability, ease of use, and cost-effectiveness of digital radiography compared to conventional film-based imaging. CBCT usage was also prominent, reported by 60% of practitioners, indicating growing reliance on three-dimensional imaging for implant planning, endodontic assessment, and maxillofacial diagnosis. Adoption of more advanced digital workflow technologies was comparatively lower. Intraoral scanners were utilized by 45% of respondents, CAD/CAM systems by 35%, and Digital Smile Design (DSD) by only 30%. The lower adoption rates of these tools suggest that despite their clinical advantages, practical and financial challenges hinder widespread implementation. (Graph 1)
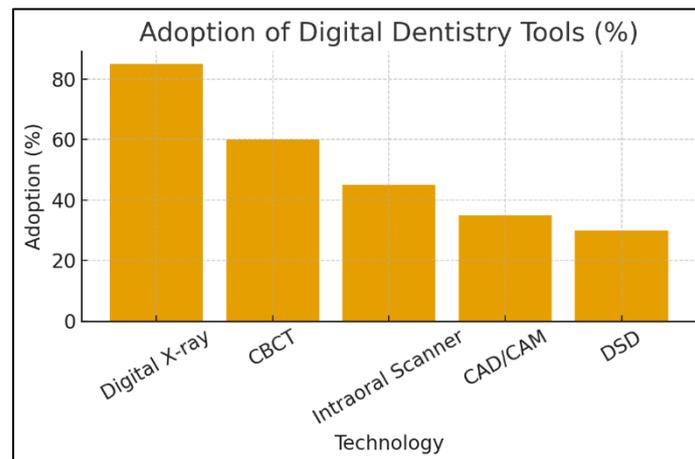
Graph 1: Shows details of adoption of digital dentistry tools

Barriers to digital adoption: Cost was identified as the most significant barrier across all major digital tools. Respondents reported high levels of financial burden, particularly with CAD/CAM systems (70%) and intraoral scanners (60%). Digital Smile Design software also scored high for cost-related concerns (55%). These findings indicate that while practitioners acknowledge the benefits, the substantial initial investment discourages many from adopting these technologies. Training barriers were also significant. Over 55% of respondents using

intraoral scanners and 65% using CAD/CAM systems reported insufficient training opportunities. Many practitioners indicated that despite the availability of short workshops, comprehensive, hands-on training modules are lacking. (Graph 2)
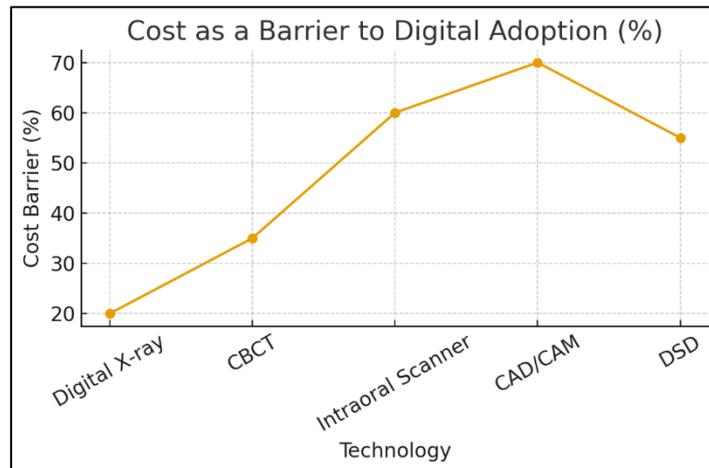
Graph 2: Shows cost as a barrier to digital adoption in dentistry

A steep learning curve was another prominent challenge. Technologies such as CAD/CAM and DSD software require digital literacy, understanding file formats, and familiarity with design principles. Between 40–50% of respondents reported difficulties adapting to these digital workflows. The learning curve was especially pronounced among practitioners with more than 10 years of experience, who often rely on established conventional techniques.

Demographic influence: Younger practitioners, especially those with less than 5 years of experience, showed higher adoption levels of advanced digital tools. Specialists—including prosthodontists, orthodontists, and implantologists—reported greater willingness to invest in digital technology due to higher clinical demand. Conversely, general practitioners in small private setups reported the highest levels of financial and training barriers.

Discussion

The findings of this study provide valuable insights into the current state of digital dentistry adoption and the barriers limiting its widespread integration in clinical settings. While certain digital technologies such as digital radiography and CBCT have achieved broad acceptance, more advanced systems—including intraoral scanners, CAD/CAM units, and digital smile design—remain underutilized. [6-8]

Interpretation of adoption trends:

The high adoption rate of digital radiography aligns with global trends, as digital X-rays offer superior image quality, reduced radiation exposure, and faster workflow compared to conventional methods. Similarly, the increasing uptake of CBCT reflects its growing importance in implantology and complex diagnostic cases.[9] However, the comparatively low adoption of intraoral scanners and CAD/CAM systems suggests that these technologies, while clinically beneficial, are still perceived as optional rather than essential by many

practitioners.[10] This discrepancy may be linked to differences in perceived value—while digital X-rays and CBCT provide immediate diagnostic benefits, CAD/CAM and DSD involve workflow changes that require time, training, and financial justification.

Financial constraints as the primary barrier:

The study reinforces that cost is the predominant barrier to digital adoption, consistent with findings from other global surveys. The high upfront investment for intraoral scanners, CAD/CAM milling machines, and advanced software poses a substantial challenge, especially for small and medium-sized private practices.[11] Many practitioners reported hesitation due to uncertainty about the return on investment, particularly in regions with cost-sensitive patient populations. Even when financing options are available, recurring expenses such as software updates, licensing fees, and maintenance further deter adoption. These results underscore the need for more affordable digital solutions and subscription-based models that reduce the financial burden on clinicians.[12]

Training and learning curve limitations:

Lack of training emerged as a critical barrier, especially for advanced digital tools. Many practitioners indicated that while digital courses exist, most are limited to short demonstrations rather than comprehensive, hands-on training. This results in poor confidence levels and inefficient workflow integration. [13] The steep learning curve is particularly evident in CAD/CAM and Digital Smile Design systems, which require proficiency in digital design principles and familiarity with software interfaces. Senior practitioners may struggle more due to limited exposure during dental school. This highlights the importance of restructuring dental curricula to embed digital dentistry as a core component rather than an elective skill.[13]

Influence of practitioner demographics:

Younger dentists demonstrated higher adoption rates of advanced digital technologies. This trend may be attributed to greater digital exposure during training, openness to technological change, and the desire to differentiate clinical services in competitive markets. Specialists, particularly prosthodontists and orthodontists, showed higher usage of CAD/CAM and digital planning tools due to the nature of their practice demands. Conversely, general practitioners and those working in resource-limited clinical environments reported the highest barriers, emphasizing disparities in access to digital infrastructure.[14]

Implications for future practice:

The findings highlight the need for coordinated efforts from dental institutions, technology manufacturers, and professional bodies. Recommendations include: Expanding hands-on digital dentistry training programs, introducing modular, subscription-based pricing for digital systems, supporting clinics with financing options and workflow training.[15] Increasing patient awareness to enhance acceptance of digital procedures with strategic support, digital dentistry has the potential to significantly elevate diagnostic accuracy, treatment outcomes, and patient satisfaction.[16]

Conclusion

Digital dentistry holds immense potential to optimize diagnostic precision, treatment planning, and patient satisfaction. Despite these benefits, adoption remains hindered by financial, educational, and perceptual challenges. Addressing these concerns through targeted training, affordable digital solutions, and increased practitioner awareness will accelerate the transition toward fully integrated digital dental practice.

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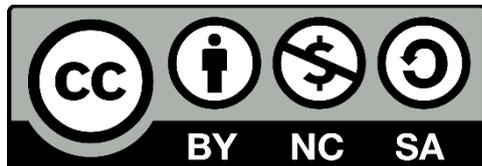
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