Exploration of BioMat-X

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Biomaterials in dentistry: the analogue/digital transition

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The amalgamation of technology and dentistry has catalyzed a paradigm shift in oral healthcare, propelling the field toward unprecedented advancements. The advent of digitalization has reshaped the traditional approaches, fostering precision, efficiency, and patient-centric care. This editorial aims to elucidate the transformative impact of digitalization in dentistry and delve into the progressive integration of biomaterials, particularly in 3D printing, revolutionizing treatment modalities and patient outcomes [1]. The digital revolution in dentistry has fostered a spectrum of innovations, permeating diagnostic, treatment, and prosthetic realms. Imaging technologies such as cone beam computed tomography (CBCT) and intraoral scanners have augmented diagnostic accuracy, enabling precise three-dimensional reconstructions of oral structures with minimal invasiveness. This shift towards non-invasive imaging has enhanced diagnostics and facilitated comprehensive treatment planning, leading to tailored interventions and improved patient outcomes [2, 3].

Moreover, the adoption of computer-aided design and computer-aided manufacturing (CAD/CAM) has revolutionized prosthetic dentistry. This technology empowers clinicians to fabricate restorations, crowns, bridges, and dental prostheses with unparalleled precision, optimizing fit and functionality. The digital workflow has streamlined the production process, reducing chairside time and enhancing overall patient experience [4]. Digital dentistry, despite its advancements, faces limitations in precision, costs, and rehabilitation types. While digital methods offer superior accuracy in specific applications, the precision in capturing complex anatomical details can sometimes be challenging, particularly in areas with limited access or visibility. The costs associated with digital dentistry, from initial investment in equipment and software to ongoing maintenance and updates, can be prohibitive for some practices. Additionally, although expanding, the types of rehabilitation achievable through digital means may not always match the versatility and adaptability of analog techniques, especially in highly customized or complex cases.

In orthodontics, digital techniques provide clear advantages in treatment planning and appliance customization, outpacing analog methods in efficiency and patient comfort. In prosthodontics, digital

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workflows enhance precision and reduce turnaround times for prostheses like crowns and dentures. However, the tactile feedback and material familiarity of analog methods still hold value for some practitioners. Surgical applications see digital technology offering unparalleled planning accuracy and the possibility for minimally invasive procedures; however, the reliance on technology requires a steep learning curve and significant investment, which can be seen as limitations compared to traditional surgical techniques.

3D printing and biomaterials: a nexus of advancement

Integrating 3D printing with biomaterials is a pinnacle of innovation within this digital transformation landscape. The convergence of biocompatible materials and additive manufacturing technologies has transcended traditional fabrication constraints, presenting many possibilities in dental applications [5].

3D printing facilitates the fabrication of patient-specific dental implants, prostheses, and anatomically precise models, transcending the limitations of conventional manufacturing. The ability to tailor designs to individual patient anatomy ensures optimal fit and function, mitigating complications and enhancing treatment efficacy. Moreover, the versatility of biomaterials in 3D printing offers a spectrum of choices, from polymers to ceramics, enabling the creation of structures with varying mechanical properties to meet diverse clinical demands [5–7].

Accelerated innovation and research

The heterogeneity in methodologies applied across different research and clinical practices in the realm of 3D printing and biomaterials use in dentistry poses a significant challenge. Establishing uniform procedures and standards is imperative to ensure the reproducibility and reliability of research outcomes. Collaborative efforts among international dental research communities and standardization bodies are crucial to developing consensus-based guidelines encompassing the entire digital dentistry workflow—from material selection, design, and printing processes to post-processing and clinical application. Such standards would bolster the consistency and dependability of research results and facilitate the regulatory approval process and adoption in clinical settings [8, 9].

The longevity and clinical performance of patient-specific dental implants and prostheses fabricated using 3D printing technologies require extensive longitudinal research. Studies focusing on wear, degradation, and biocompatibility over time are essential to ascertain these innovations' long-term efficacy and safety. This research is vital for refining material compositions, printing techniques, and post-processing methods to enhance the durability and functional outcomes of 3D-printed dental applications [10]. The rapid prototyping capabilities of 3D printing underscore the need for stringent regulatory measures to ensure the safety and biocompatibility of newly introduced biomaterials. Regulatory bodies, alongside research institutions, play a pivotal role in setting comprehensive evaluation frameworks that encompass material characterization, in vitro and in vivo biocompatibility assessments, and clinical trials. Such regulatory oversight is fundamental in safeguarding patient health while encouraging the exploration of innovative materials that could further enrich the arsenal of digital dentistry. The extensive adoption of digital workflows, including 3D printing in dentistry, has potential economic implications for oral healthcare delivery. While these technologies offer significant benefits in terms of precision and efficiency, their impact on the overall cost of dental care and the economic accessibility for patients warrants critical examination. Initiatives aimed at reducing the cost of digital dentistry through technological advancements, economies of scale, or subsidy models could mitigate potential economic disparities, ensuring broader access to high-quality dental care. The symbiotic relationship between materials science, bioengineering, and dental practice is a cornerstone in advancing new biomaterials and enhancing 3D printing technologies in dentistry. Interdisciplinary collaboration fosters the exchange of knowledge and expertise, driving innovation that addresses the complex needs of dental care. Such partnerships are instrumental in accelerating the development of biomaterials that combine biocompatibility, mechanical robustness, and aesthetic appeal, thereby elevating the standard of patient care. Evaluating patient experiences and

satisfaction with 3D-printed dental treatments necessitates methodical approaches and standardized instruments. Patient-reported outcome measures (PROMs) tailored to dental applications of 3D printing can provide valuable insights into aspects such as comfort, aesthetics, and overall satisfaction. Developing and validating these instruments are essential in ensuring that patient-centric perspectives are integral to assessing new dental technologies and treatments [11]. The rapid prototyping capabilities of 3D printing expedite the development and testing of novel biomaterials. This acceleration in research fosters the exploration of innovative materials, bioactive compounds, and composite constructs, paving the way for enhanced biocompatibility, durability, and regenerative properties. The synergy between materials science, bioengineering, and dentistry through 3D printing heralds a new era of biomaterial development, promising superior clinical outcomes and patient satisfaction [12, 13].

Conclusions

The rapid progression of 3D printing technologies in dentistry, especially for patient-specific applications, presents unique regulatory challenges. Adapting regulatory frameworks to accommodate the swift pace of technological advancements while ensuring patient safety and treatment efficacy requires a dynamic and forward-thinking approach. In collaboration with scientific communities, regulatory agencies must strive to create agile regulatory pathways that facilitate innovation without compromising safety standards. The amalgamation of digitalization and biomaterials, particularly within 3D printing, has engendered a transformative landscape in dentistry. This synergy promises personalized, efficient, and patient-centric oral healthcare delivery, transcending conventional limitations. As the field evolves, interdisciplinary collaboration and concerted research efforts will undoubtedly unravel further potentials, ensuring a continuum of innovation and advancements in pursuing optimal oral health outcomes.

Declarations

Author contributions

LF: Conceptualization, Writing—review & editing, Supervision. The author read and approved the submitted version.

Conflicts of interest

Luca Fiorillo who is the Guest Editor of *Exploration of BioMat-X* had no involvement in the decision-making or the review process of this manuscript.

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References

1. Pizzicannella J, Diomede F, Gugliandolo A, Chiricosta L, Bramanti P, Merciaro I, et al. 3D Printing PLA/ Gingival Stem Cells/ EVs Upregulate miR-2861 and -210 during Osteoangiogenesis Commitment. Int J Mol Sci. 2019;20:3256.
2. Runkel C, Güth JF, Erdelt K, Keul C. Digital impressions in dentistry—accuracy of impression digitalisation by desktop scanners. Clin Oral Investig. 2020;24:1249–57.
3. Roig E, Garza LC, Álvarez-Maldonado N, Maia P, Costa S, Roig M, et al. In vitro comparison of the accuracy of four intraoral scanners and three conventional impression methods for two neighboring implants. PLoS One. 2020;15:e0228266.
4. De Stefano R, Bruno A, Muscatello MR, Cedro C, Cervino G, Fiorillo L. Fear and anxiety managing methods during dental treatments: a systematic review of recent data. Minerva Stomatol. 2019;68: 317–31.
5. Baron J, Hazubski S, Otte A. 3D Multi-Material Printing of an Anthropomorphic, Personalized Replacement Hand for Use in Neuroprosthetics Using 3D Scanning and Computer-Aided Design: First Proof-of-Technical-Concept Study. Prosthesis. 2020;2:362–70.
6. Cervino G, Fiorillo L, Arzukanyan AV, Spagnuolo G, Cicciù M. Dental Restorative Digital Workflow: Digital Smile Design from Aesthetic to Function. Dent J (Basel). 2019;7:30.
7. Hodson R. Digital revolution. Nature. 2018;563:S131.
8. Schwendicke F, Samek W, Krois J. Artificial Intelligence in Dentistry: Chances and Challenges. J Dent Res. 2020;99:769–74.
9. van Noort R. Introduction to Dental Materials - E-Book: Introduction to Dental Materials - E-Book. Elsevier Health Sciences; 2014.
10. More R, Haubold A, Bokros J. Chapter: Biomaterials Science: An Introduction to Materials in Medicine. In: Biomaterials Science. Elsevier Inc; 1996. pp. 170–80.
11. Ventola CL. Medical Applications for 3D Printing: Current and Projected Uses. P T. 2014;39:704–11.
12. Fiorillo L, Cervino G, Galindo-Moreno P, Herford AS, Spagnuolo G, Cicciù M. Growth Factors in Oral Tissue Engineering: New Perspectives and Current Therapeutic Options. Biomed Res Int. 2021;2021: 8840598.
13. Tabrizian M. Exploration of biomaterials: a multidisciplinary venture. Explor BioMat-X. 2024;1:1–4.