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Editorial

Bridging the gap between bench and chairside in dental science

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Abstract

The field of dental science has witnessed remarkable advances in molecular biology, biomaterials, regenerative medicine, and digital technologies. Despite this progress, a significant gap remains between benchside discoveries and their translation into clinical dental practice. This editorial addresses the urgent need to bridge this divide, emphasizing that scientific innovation alone is insufficient without effective clinical integration. In periodontology, host-modulation therapies and microbiome research have redefined disease understanding, yet practical applications remain limited. In prosthodontics, although novel biomimetic materials and digital workflows are emerging, their clinical uptake faces barriers such as cost, training, and long-term validation. Regenerative dentistry, with advances in stem cell applications and tissue engineering, promises to restore dental structures biologically, but complex translational challenges delay their routine use. Similarly, artificial intelligence shows potential for diagnostics and treatment planning, but concerns about reliability, standardization, and ethical implementation remain. The editorial also explores the role of personalized dentistry, behavioral sciences, and implementation research as essential components for effective translation. It advocates for interdisciplinary collaboration, integration of systemic health considerations, and global equity in oral healthcare delivery. Bridging the gap between research and practice is not merely a scientific task but a multidisciplinary challenge requiring alignment of clinical, educational, economic, and policy efforts. A comprehensive approach to translational dentistry can ensure that innovations lead to measurable improvements in patient outcomes and public oral health, making advanced care more accessible, efficient, and personalized across diverse populations and healthcare systems.

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The 21st century has brought about unprecedented advancements in the biological, material, and digital sciences. These developments have profoundly shaped the field of dentistry, especially in areas such as periodontology, prosthodontics, implantology, oral microbiology, and regenerative therapies (Gawali *et al.*, 2024; Nasiri *et al.*, 2023). Despite this progress, a significant divide persists between what is discovered in research laboratories and what is implemented in clinical dental practice (Zych *et al.*, 2025). Bridging this gap remains one of the most critical and urgent challenges in modern dental science. The path from scientific discovery to clinical application is often long and fragmented. Laboratory findings in tissue engineering, stem cell research, or biomaterial development frequently remain confined to preclinical phases due to limited clinical translation (Wei *et al.*, 2024; Salthouse *et al.*, 2023). Conversely, many clinical decisions are still based on traditional practices that lack robust evidence derived from mechanistic or translational research (Bauer and Chiappelli, 2010). The result is a disconnect that slows the adoption of innovation and limits improvements in patient outcomes.

In periodontology, for instance, recent discoveries related to host-modulatory therapies, the role of the oral microbiome, and systemic inflammatory responses have redefined our understanding of periodontal disease as a complex, multifactorial condition. Basic science has identified pathways involving interleukin signaling, matrix metalloproteinases, and immune cell dysfunction as key contributors to tissue destruction and disease progression (Ursu *et al.*, 2022; Hajishengallis *et al.*, 2020). However, translating these findings into safe, affordable, and effective therapies remains limited by the complexity of human biology and variability in patient responses. While concepts such as personalized periodontics and salivary diagnostics have emerged, they are not yet integrated into routine clinical workflows (Li *et al.*, 2024). Similarly, the development of bioactive and biomimetic materials has revolutionized prosthodontic research. The evolution from conventional metal-based prostheses to high-strength ceramics, hybrid resins, and nanostructured composites has provided new opportunities for durable, aesthetic, and biocompatible restorations (Thirumalaivasan *et al.*, 2025; Melo *et al.*, 2023). Yet many of these materials are introduced without long-term clinical trials or are underutilized due to lack of clinician familiarity or concerns about cost-effectiveness. The translational process is further challenged by variability in patient-specific factors, such as occlusal load, parafunctional habits, and anatomical constraints, which often complicate material performance in real-world settings (Hajaj *et al.*, 2025).

Regenerative dentistry is another area where translational challenges are particularly pronounced. Advances in stem cell research, scaffold engineering, and growth factor delivery have created the foundation for biological tooth repair and even whole-tooth engineering (Umapathy *et al.*, 2025). Preclinical studies demonstrate promising outcomes, including periodontal ligament regeneration and alveolar bone growth. However, the complexity of replicating periodontal structures in vivo, ensuring long-term integration, and navigating regulatory pathways poses significant hurdles (Fraser *et al.*, 2022; Galli *et al.*, 2021). The promise of true

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regeneration is visible, but its widespread clinical adoption requires multidisciplinary collaboration and carefully designed translational research protocols. Digital dentistry and artificial intelligence are rapidly transforming diagnostic and therapeutic strategies. Machine learning algorithms are now capable of identifying caries, periodontal bone loss, and even oral cancers from radiographic images with high accuracy (Gao *et al.*, 2025). Virtual articulators, intraoral scanners, and 3D printing technologies have made prosthodontic treatment planning and fabrication faster and more accurate. Despite these capabilities, the integration of such technologies into everyday dental practice is uneven. Barriers include cost, training, data standardization, and skepticism about algorithmic reliability (Lobo *et al.*, 2025; Zoabi *et al.*, 2022). Without a concerted effort to validate and implement these technologies in diverse clinical environments, their full potential will remain unrealized.

Beyond technological innovation, the interplay between oral health and systemic conditions continues to attract attention. The bidirectional relationship between periodontitis and diabetes, the potential link between periodontal pathogens and cardiovascular disease, and the impact of oral inflammation on pregnancy outcomes are now well-documented (Kim and Pang, 2025; Păunică *et al.*, 2023). These associations call for an integrated, interdisciplinary model of care that transcends the traditional boundaries of dental and medical practice. Translational research must not only examine biological mechanisms but also explore how interdisciplinary collaboration can be structured to benefit patients holistically (Kabbashi *et al.*, 2024). Behavioral and psychosocial factors are equally important in shaping treatment outcomes. Patient adherence to oral hygiene regimens, attitudes toward pain and esthetics, and perceptions of oral health often determine the success of therapeutic interventions (Jönsson *et al.*, 2012). Clinical trials frequently overlook these dimensions, which are essential for translating efficacy into real-world effectiveness. The science of behavioral change, patient communication, and decision-making psychology must be incorporated into translational efforts to ensure that dental innovations align with patient values and expectations (Onken *et al.*, 2014).

Another emerging focus is the development of precision dentistry—an approach that tailors treatment to individual biological profiles, lifestyles, and environmental exposures. Genomic studies have identified polymorphisms associated with periodontal susceptibility, drug metabolism, and inflammatory responses (Cho *et al.*, 2021). Metabolomic and proteomic technologies are being used to identify disease biomarkers in saliva, crevicular fluid, and blood. These advances open the door to predictive diagnostics, individualized risk assessment, and customized treatment plans. However, to translate this into clinical practice, large-scale validation, cost-effective testing platforms, and clinician training are essential (Amato *et al.*, 2025). Moreover, the need for implementation science is gaining recognition within the field of dentistry. Generating evidence is only the first step; understanding how to embed that evidence into daily practice is equally critical. Implementation science investigates the factors that facilitate or hinder the uptake of innovations, including workflow logistics, institutional culture, clinician attitudes, and policy frameworks. Identifying these variables and designing interventions to address them can drastically improve the translation of research into practice, especially in public health and community-based settings (Randall, 2023; Kao, 2006).

Global disparities in oral health care delivery highlight another layer of complexity in translational dentistry. While high-income countries may have access to advanced diagnostics and prosthodontic technologies, low- and middle-income regions often lack basic resources for preventive care or early diagnosis. Translational research must account for contextual factors such as infrastructure, cultural practices, and resource limitations. Developing scalable, low-cost interventions based on sound science can help bridge the gap in global oral health equity (Northridge *et al.*, 2020; Seminario *et al.*, 2020). The future of dental science depends not only on discovery but also on integration. Bridging the gap between bench and chairside requires a concerted effort across disciplines, institutions, and geographic regions. It demands an appreciation of both biological mechanisms and human behavior, of cutting-edge technology and real-world constraints. By cultivating an ecosystem where scientists, clinicians, engineers, educators, and patients work in tandem, we can accelerate the journey from innovation to impact (Polverini and Krebsbach, 2017; Slavkin, 2017).

Dentistry stands at a pivotal moment. The tools to transform patient care are already in our hands—what remains is to ensure they reach those who need them most, in ways that are safe, effective, and equitable. Bridging the bench-to-chairside divide is no longer a scientific challenge alone—it is a moral imperative for the future of oral health.

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Conflict of interest

The authors declare no competing interests.

Authors' contribution

Sadia Tahsin: conceptualization, research framework, literature synthesis, revised the editorial manuscript. The author has read and approved the final version of the published editorial.

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