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Short Communication

Future Perspectives in Implantology: Robotics, AI, and Dynamic Navigation

Sarra Nasri[1*], Ranym Jebali[1], Yosra Gassara[1], Boutheina Mahjoubi[1], Moncef Omezzine[1]
[1]University of Monastir, Faculty of Dental Medicine of Monastir, Research Laboratory of Occlusodontics and Ceramic Prostheses, LR16ES15, 5000, Monastir, Tunisia

***Corresponding Author**
Sarra Nasri
University of Monastir, Faculty of Dental Medicine of Monastir, Research Laboratory of Occlusodontics and Ceramic Prostheses, LR16ES15, 5000, Monastir, Tunisia

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The field of dental implantology is rapidly evolving, with digital tools already reshaping how clinicians plan and execute treatments. Yet, what we're seeing today may only be the beginning. The future promises an even deeper integration of robotics, artificial intelligence (AI), and real-time navigation systems, technologies that could transform implant surgery into an even more predictable, efficient, and patient-centered discipline [1].

Robotic Assistance: Toward Surgical Precision on Autopilot

Robotic systems represent one of the most exciting developments in implant placement. Unlike static guides or manual navigation, robots are capable of physically guiding or even performing the drilling sequence with high mechanical precision. Chen *et al.*, highlighted how robotic guidance can significantly reduce both angular and apical deviation, often achieving results that are difficult to match through manual methods—even with the help of static or dynamic guides [2].

These systems don't just enhance accuracy; they also introduce a level of consistency that can help mitigate human error. This is particularly relevant for young clinicians still developing their tactile skills or for complex cases where minute deviations can lead to esthetic or functional compromise [3].

Artificial Intelligence in Planning and Decision-Making

Beyond mechanical guidance, AI has the potential to reshape the diagnostic and planning stages of implantology. By analyzing thousands of clinical cases, AI algorithms can help identify optimal implant positions, anticipate potential complications, and even suggest prosthetically favorable outcomes based on individual patient anatomy. This kind of predictive planning could become especially valuable in multi-disciplinary cases where orthodontic, periodontal, and prosthetic considerations intersect.

Moreover, as more digital records become available, machine learning models could begin to personalize implant planning—recommending workflows based not just on anatomy but also on patient habits, systemic conditions, and esthetic preferences.

Real-Time Navigation and the Rise of Mixed Reality

Dynamic navigation systems, already a step forward from static guides, are also progressing. The next generation may involve augmented reality (AR) or mixed reality interfaces, where the surgeon can visualize the implant plan directly overlaid on the patient's anatomy through specialized glasses or screens. This immersive environment can provide live feedback, improving hand–eye coordination and reducing reliance on external monitors [4].

Democratizing Digital Surgery

While these technologies are often associated with high-end clinics or academic centers, their continued development may lead to cost reductions and wider accessibility. Portable navigation units, AI-assisted mobile applications, and simplified planning software are already emerging, suggesting a future where precision-guided implantology could be available in most dental practices, not just a select few.

That said, the human factor will remain indispensable. As sophisticated as these tools may become, they are most powerful when used to support, rather than replace, the clinician's judgment, experience, and intuition [5].

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