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Perspective

Robotic Assistance in Dental Procedures: Hype or Hope

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A B S T R A C T

Robotic technology has revolutionized various fields of medicine, offering enhanced precision, reduced invasiveness, and improved outcomes. In dentistry, robotic assistance is an emerging innovation with potential applications in implantology, endodontics, orthodontics, maxillofacial surgery, and dental education. However, the integration of robotics in dental practice raises important questions about clinical efficacy, cost-effectiveness, accessibility, and the readiness of current infrastructure.

Keywords: Robotic Dentistry, Dental Robotics, Robotic-Assisted Procedures

Introduction

The integration of robotics into medical fields has been transformative, and dentistry is no exception. Robot-assisted dental procedures are emerging as a significant innovation, offering precision, efficiency, and patient-centered benefits. However, as with any technological advancement, this area is often surrounded by both hype and genuine potential.[1]

The use of robotics in dentistry has evolved from rudimentary tools to sophisticated systems capable of performing complex tasks. Early applications focused on enhancing imaging and diagnostics, but recent advancements have introduced robots that actively assist or even independently perform certain dental procedures. Notable examples include robotic systems like Yomi®, which is FDA-cleared for dental implant surgeries, and other experimental models aimed at endodontics and orthodontics.[2]

Key Technology

The Yomi Robotic Dental System is a prominent example of robotic innovation in dentistry. Developed by Neocis, Yomi is the first FDA-cleared robotic system for dental implant surgery. It combines haptic feedback, dynamic navigation, and 3D imaging to assist dentists in planning and executing implant procedures with exceptional accuracy. Yomi enhances safety by providing real-time adjustments to the drill's position and depth, ensuring implants are placed precisely as per the treatment plan. Unlike fully autonomous robots, Yomi works collaboratively with the dentist, preserving their control while enhancing their precision and confidence. Its minimally invasive approach reduces patient discomfort and recovery time, making it a game-changer in modern dental care.[3,4]

Current Applications of Robotics in Dentistry[5,6]

Dental Implantology

Robots like Yomi assist in implant placement with unparalleled accuracy. By using real-time feedback and pre-surgical planning, they ensure precise alignment and positioning, reducing risks and enhancing outcomes.

Endodontics

Robotic systems are being explored for use in root canal procedures, where precision is critical. They can navigate intricate root canal systems with minimal damage to surrounding tissues.

Orthodontics

In orthodontics, robotics is employed in the design and placement of braces and aligners. Systems that automate wire bending and bracket positioning are improving treatment accuracy and reducing procedure time.

Surgical Applications

Robotics is gaining traction in oral and maxillofacial surgery, particularly for complex procedures like bone grafting and tumor resection. Robots enhance surgical precision, reduce operating time, and improve recovery outcomes.

Advantages of Robot-Assisted Dental Procedures[6,7]

- Robotic systems ensure accurate placement of implants and precise execution of procedures, reducing the margin for error.
- Technologies like Yomi provide real-time adjustments based on anatomical conditions.
- Robots enable smaller incisions and targeted interventions, leading to reduced pain, swelling, and faster recovery for patients.
- Force and torque sensors, along with haptic feedback, prevent excessive pressure or accidental tissue damage.
- Robotic systems maintain high accuracy throughout procedures, reducing variability between dentists and improving treatment predictability.
- 3D imaging, augmented reality, and dynamic navigation help create detailed treatment plans and visualize complex anatomy during procedures.
- Automated processes streamline workflows, reducing the time patients spend undergoing treatment.
- Robotic systems assist in educating dental professionals by providing controlled, real-world simulations of dental procedures.

Shortcomings of Robot-Assisted Dental Procedures[4,8]

- Robotic systems and their associated technologies are expensive, making them inaccessible for smaller clinics and practices.
- Current systems like Yomi are not fully autonomous; they still rely heavily on human operators, limiting their independence.
- Robotic systems require regular maintenance, updates, and calibration, adding to operational costs and potential downtime.
- Equipment failures or software glitches during procedures could pose risks to patient safety and treatment outcomes.
- Robotic systems are primarily used in implantology and some surgical procedures, with limited functionality in routine dental care.
- The adoption of robotics in dentistry involves stringent regulations, and ethical concerns may arise regarding patient consent and data security.

Future of Robotic Dentistry[9,10]

The future of robotic dentistry is poised for transformative growth as advancements in technology continue to shape the field.

- Current systems like Yomi are assistive, but future robots may achieve higher levels of autonomy, performing routine and complex tasks with minimal human intervention.
- Artificial intelligence will play a significant role in diagnosing conditions, planning treatments, and even managing workflow in dental clinics.
- The development of smaller, more portable robotic systems will make advanced dental care accessible in remote or underserved areas.
- AR and VR integration will provide real-time overlays of 3D anatomical models, enabling dentists to visualize internal structures during procedures with unmatched clarity.

Conclusion

In conclusion, robotic dentistry is revolutionizing the landscape of dental care, delivering unprecedented advancements in precision, efficiency, and patient outcomes. As technology continues to evolve, robotics will play an increasingly integral role in dental practices, offering innovative solutions and enhancing the quality of care. The future promises even greater benefits, fostering a collaborative synergy between cutting-edge technology and skilled dental professionals to redefine patient experiences and outcomes.

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