One Step Closer to Efficient Autonomous Dental Surgery

Advanced robotics could help improve the precision of tooth transplantation procedures, while reducing unnecessary bone removal

In vitro study examines autonomous robotic socket preparation for anatomically complex tooth transplantation procedures

CHINA, August 17, 2026 /EINPresswire.com/ -- Tooth autotransplantation offers a unique way to replace missing teeth using a patient's own tooth, but its success depends on accurate recipient socket preparation, which requires exceptional surgical precision. This study explores whether an autonomous multi-axis robotic system can overcome one of the procedure's greatest challenges by creating patient-specific recipient sockets with advanced surface-conforming milling. The research compares this innovative approach with a conventional guided technique, offering fresh insights into the future of precision dentistry.

Tooth autotransplantation is a recognized treatment option for replacing missing teeth, particularly in young patients, as it preserves natural tooth function, supports continued jaw development, and eliminates the need for dental implants. A key determinant of success is the precise preparation of the recipient socket, which must closely match the donor tooth while minimizing trauma to the surrounding bone and preserving the delicate periodontal ligament. However, conventional socket preparation relies heavily on surgical experience and manual refinement, making it difficult to consistently achieve the required level of precision. These limitations have driven interest in robotic-assisted surgical systems that can automate socket preparation and potentially improve accuracy, efficiency, and procedural consistency.

Against this backdrop, researchers from China developed an autonomous multi-axis robotic system capable of creating recipient sockets through nonlinear, surface-conforming osteotomy. The study was led by Dr. Shizhu Bai and Dr. Yimin Zhao from the School of Stomatology, The

Fourth Military Medical University, China. The study was published in International Journal of Oral Science on June 30, 2026.

“Our goal was to evaluate whether robotic-assisted socket preparation could achieve greater geometric accuracy and preserve more surrounding bone than a conventional static guide-assisted approach,” shares Dr. Bai.

The study was conducted using 40 three-dimensional printed mandibular models representing tooth autotransplantation scenarios. The models were divided equally between robot-assisted and static guide-assisted groups, with each group containing 10 single-rooted and 10 double-rooted tooth anatomies. Digital planning software was used to position donor teeth and design the ideal recipient sockets. To preserve periodontal ligament space, donor root surfaces were expanded by 0.5 mm, and undercuts were removed to allow easier insertion. In the robotic workflow, an autonomous multi-axis robotic system executed preplanned surface-conforming milling paths, while the conventional approach combined guided pilot drilling with freehand socket refinement. Following preparation, digital scans were used to evaluate positional accuracy, socket morphology, bone removal, and procedure time.

The robotic system demonstrated superior accuracy and geometric fidelity compared with the static guide-assisted approach. While both methods achieved similar accuracy at the socket entry point, robotic preparation significantly reduced deviations at the deepest part of the socket and produced more precise drilling angles. The robot-generated sockets also more closely matched the planned root morphology, showing higher volumetric agreement, lower surface deviation, and substantially less unnecessary bone removal. These advantages were particularly pronounced in double-rooted teeth, where complex anatomy poses greater surgical challenges. Despite these improvements, overall preparation times were comparable between the two techniques.

The findings highlight the potential of autonomous robotics to make tooth autotransplantation more predictable and less dependent on operator experience. “The technology enables the creation of recipient sockets that closely replicate donor root anatomy while minimizing unnecessary bone removal, potentially preserving surrounding bone, reducing repeated trial insertions, and creating more favorable conditions for periodontal ligament healing and primary stability,” notes Dr. Zhao. The greatest improvements were observed in double-rooted teeth, suggesting that robotic assistance may be particularly valuable for anatomically complex cases where conventional techniques are most challenging.

Although these findings were obtained using three-dimensional printed laboratory models, they provide an important proof of concept for integrating robotics into tooth autotransplantation. Future clinical studies will be needed to determine whether the improved geometric accuracy translates into shorter extra-alveolar time, enhanced healing, greater transplant stability, and better long-term outcomes in patients. Further research should also evaluate workflow efficiency, learning curves, and the performance of robotic systems under real surgical

conditions.

In conclusion, this study demonstrates that autonomous multi-axis robotic osteotomy can prepare recipient sockets with greater precision than conventional static guide-assisted techniques while maintaining comparable procedure times. By improving socket fidelity and reducing unnecessary bone removal, particularly in complex root anatomies, the technology represents a promising step toward more precise, reproducible, and patient-specific tooth autotransplantation procedures.

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Reference
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About The Fourth Military Medical University
The Fourth Military Medical University (FMMU), also known as the Air Force Medical University, is one of China's leading medical institutions, located in Xi'an, Shaanxi Province. Founded in 1941, the university is renowned for excellence in medical education, clinical care, and biomedical research. FMMU is home to several nationally recognized research platforms, including the State Key Laboratory of Oral & Maxillofacial Reconstruction and Regeneration and the National Clinical Research Center for Oral Diseases. The university has made significant contributions to regenerative medicine, stomatology, trauma care, neuroscience, and military medicine, while fostering innovation through interdisciplinary research and international scientific collaborations.
Website: https://www.fmmu.edu.cn/

About Professor Shizhu Bai from The Fourth Military Medical University
Dr. Shizhu Bai is working as a Professor at the School of Stomatology, The Fourth Military Medical University, China. Prof. Bai’s research focuses on integration of facial scanners, intraoral scanners, and computer-aided design in the field of dentistry. He has published more than 50 articles, with citations over 1,500.

About Dr. Yimin Zhao from The Fourth Military Medical University
Dr. Yimin Zhao is a Professor and Doctoral Supervisor of the School of Stomatology, The Fourth Military Medical University, China. His research interests include repair functional reconstruction of oral and maxillofacial defects. He has published 280 papers and authored three monographs. Dr. Zhao has established the intelligent simulation and restoration technology system for facial defects, created a systematic technology for masticatory function reconstruction following jaw defects, which significantly improved patients' quality of life and has become an internationally adopted technique.

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Yini Bao
Bone Research Editorial Office
+862885546461 ext.
br@scu.edu.cn
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