

Intraoperative Efficiency of Dental Robotics



Bruce A. Smoler, DDS »

New technologies often decrease the overall efficiency of procedural workflows. The purpose of this study was to document the efficiency of using haptic robotics for partial- and full-arch patients compared to freehand implant placement.

Eighty-three patients with 171 implants comprising 4 groups were included in a multi-site, prospective multi-arm clinical study: partial implant and full-arch cases placed with the traditional freehand technique, and partial implant and full-arch cases placed robotically. To evaluate and compare the efficiency of this robotic workflow, time durations for setup, total OR time, and time required for each osteotomy and implant placement were

recorded.

Digital workflows have improved dental implant placement accuracy and precision in both partial and full-arch dental implant cases, with the goal of predictable restorations. Despite the introduction of CBCT-based planning software and fabricated surgical guides, challenges remain in efficiently and accurately transferring and executing the plans at surgery. Limitations inherent in the static guide workflow include treatment delays related to guide fabrication, the risk of poorly fitting guides, and the physical bulk of the guide impeding surgical site access and visualization. Robotic guidance using haptic boundaries has been well-documented to enhance accuracy, precision, and flexibility across many surgical fields. Recently, haptic guidance with a novel robotics platform (Yomi [Neocis Inc]) has shown rapid adoption in both the partial- and full-arch dental implant space (Figure 1).¹⁻⁵ However, the introduction of new technology in surgery often reduces efficiency and may be associated with a learning curve to reach time neutrality.

While many studies have documented the accuracy of various technologies used to place dental implants, few have focused on the timing and efficiency of these new workflows. The study with the most granular examination of surgical workflow was performed by Schneider et al,⁶ n = 26 in single-implant, partially edentulous patients. In this study, 73 patients were treated with either standard freehand placement, stereolithography static surgical guide placement, or 3D-printed static surgical guide placement. In this study, the authors stratified the overall surgical time into increments representing flap elevation, implant placement (osteotomy and implant seating), guided bone regeneration, and wound closure with median total surgery times of 45 minutes, 51 minutes, and 54

minutes, respectively. Timing is important as prolonged oral surgical exposure has been correlated with increases in postoperative discomfort and morbidity.

Before surgery, the robotics workflow is very similar to all 3D-guided procedures, either guided by dynamic optical navigation or by preprinted static guides. A preoperative CBCT is used to create a 3D virtual plan. (Figure 2). However, on the day of surgery, the robotic workflow deviates from these other 3D-guided procedures. With robotic guidance, a single-patient use, disposable splint (YomiLink) is used, which is tooth mounted (for partially edentulous cases) or bone mounted (for fully edentulous cases) to the anterior maxilla or mandible. A CBCT scan is then taken with a splint-mounted fiducial array and merged with the previously created virtual plan. The fiducial array is then replaced with a patient tracker arm attached to the robot to track the patient's motion relative to the tool attached to the end effector of the robot. Intraoperatively, the surgeons maneuver a handpiece attached to the robotic guidance arm, which provides haptic (physical), audio, and visual feedback to constrain the drill or implant to the planned location, orientation, and depth (Figure 3). The aim of this study was to document the timing and efficiency of using haptic robotics for partial- and full-arch dental implant patients compared to freehand implant placement.

MATERIALS AND METHODS

Study Design

This manuscript describes a multi-site, prospective multi-arm clinical study which included 83 patients with 171 implants comprising 4 groups; partial implant patients with implants placed freehand (27 patients, 37 implants) and robotically (39 patients, 58 implants) and full-arch patients with implants placed freehand (3 patients, 20 implants) and robotically (14 patients, 56 implants) (Table 1). Four surgeons from 3 different sites contributed data. To evaluate and compare the workflow efficiency between groups, procedural timing data was collected for all patients. For robotic cases, the patient preparation steps specific to robotic surgery include placement of the YomiLink, placement of the fiducial array, and collection of the pre-op CBCT to match the pre-op plan to the intraoperative coordinate system. The time required for each osteotomy and the time required to place each implant were measured.

RESULTS

The average setup time for the Yomi robot was 4.7 minutes (range: 2 to 10 minutes) and was completed outside of OR time for all robotic cases. Thus, the time to set up the robotic system did not interfere with the surgeon's or patient's workflow and is identical for both partial and fully edentulous cases. For osteotomies in the partial implant patients, freehand preparation was 2.0 times longer than using robotics (3.9 vs 1.9 minutes), and freehand placement of implants was 1.5 times longer compared to robotic implantation (1.6 vs 1.1 minutes). For osteotomies in the full-arch patients, freehand preparation was



Figure 1. The Yomi robotic system (Neocis Inc). »

3.2 times longer than using robotics (4.2 vs 1.3 minutes), and freehand implantation was 4.5 times longer than robotic implantation (5.0 vs 1.1 minutes). These data are graphically represented in Figure 4.

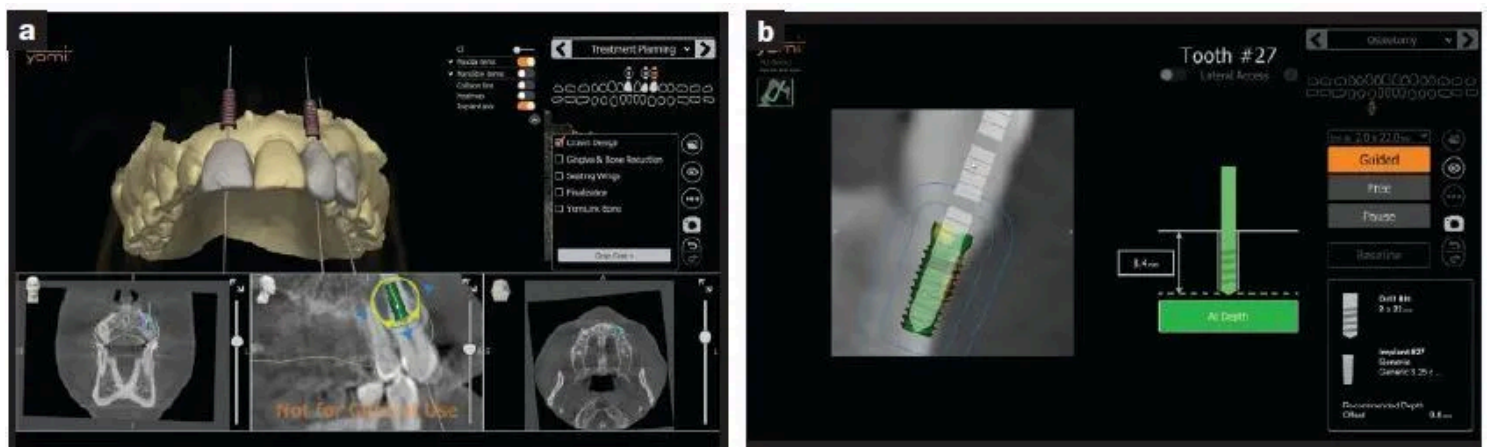


Figure 2. (a) Screenshot of preoperative plan for multiple implants and (b) screenshot of visual feedback given during osteotomy. »

DISCUSSION

This comparison of haptic robotic guidance vs freehand placement in both partial implant and full-arch patients showed significantly more efficient osteotomy and implantation

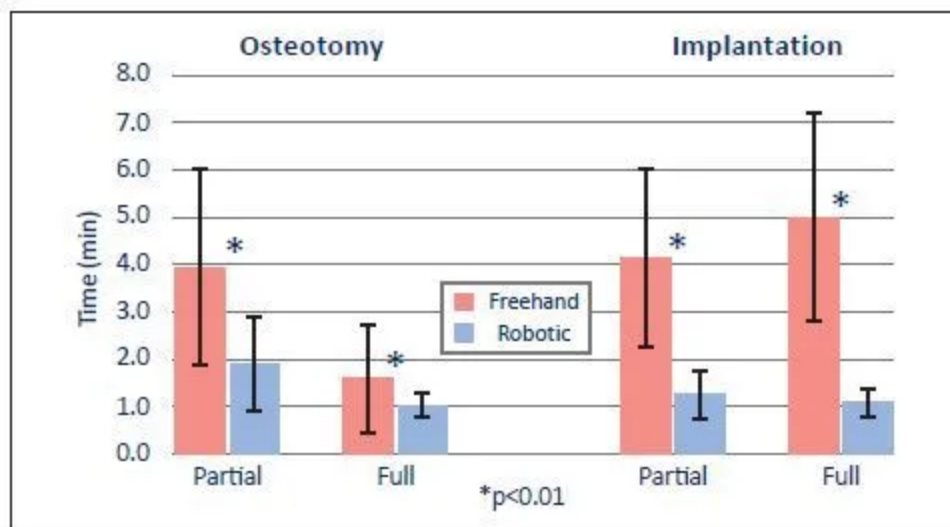
times when utilizing robotics. The setup of the robotic system requires approximately 5 minutes and can be performed ahead of time without affecting the patients' care pathway or active surgeon time. Furthermore, haptic robotics is compatible with minimally invasive soft tissue management and access to immediate loading of restorations for candidate subjects. The data from this study show that utilizing robotics resulted in an average osteotomy time of 1.9 minutes per implant and an implantation time of 1.1 minutes per implant for partial implant patients. For full-arch patients, the average osteotomy time per implant was 1.3 minutes, and the implantation time was 1.1 minutes per implant. Comparing the freehand controls in this study showed that for osteotomies in the partial implant patients, freehand preparation was 2.0 times longer than using robotics, and freehand placement of implants was 1.5 times longer compared to robotic implantation. For osteotomies in the fullarch patients, freehand preparation was 3.2 times longer than using robotics, and freehand implantation was 4.5 times longer than robotic implantation.



Figure 3. Surgeon interacting with haptic device during implantation. »

It is important to note that many patient preparation steps specific to robotic surgery, including placement of the tooth-mounted Yomi- Link, placement of the fiducial array, and collection of the pre-op CBCT to match the pre-op 3D plan to the intraoperative coordinate system, do not require the surgeon. This means the surgeon can efficiently perform other tasks, in or outside of the OR, during the preparation time until either the time of extraction or the first osteotomy. A recent study by Neugarten⁵ showed that the use of haptic robotic guidance resulted in minimal placement errors, demonstrating high accuracy and high precision compared to all other technologies reported in the existing literature (including freehand placement, static computer-guided placement, and dynamic

computer-guided placement). Ensuring precision in implant placement is crucial, as errors can lead to intraoperative complications involving critical anatomical structures and post-op challenges related to prosthetic reconstruction, patient satisfaction, and implant longevity. With both partial- and full-arch patients, robotic guidance efficiently provides both the added accuracy and precision, with all the associated clinical benefits.



...notable efficiency improvements during osteotomy and implantation....

Figure 4. Comparison of osteotomy and implantation times for the 4 groups. »

Table 1. Number of patients and implants in each group		
	FREEHAND	ROBOTIC
Partial Implant	27 patients, 37 implants	39 patients, 58 implants
Full Arch	3 patients, 20 implants	14 patients, 56 implants

Table 1. Number of patients and implants in each group »

CONCLUSIONS

The surgical times reported in this study of haptic robotic guidance for both the partial implant and fullarch patient show specific workflow

efficiency benefits during osteotomy and implantation. While robotics is disruptive in terms of its advanced technology, it does not significantly disrupt the workflow and efficiency of a standard dental implant practice. Instead, it shows notable efficiency improvements during osteotomy and implantation in all patients, with a particularly significant overall workflow efficiency for full-arch patients. These results may attest to the quick integration of the haptic robotic protocol into the digital practitioner's clinical workflow and the ease of employing robotic guidance to enhance patient treatment. Additionally, there was no wait for surgical guide fabrication, and no physical guide impeding access or visualization. Robotic haptic guidance securely constrained the handpiece to the virtual restorative plan. Given the accuracy, precision, and intraoperative flexibility of robotic surgical platforms, this data on surgical efficiency supports the growing interest in haptic robotic guidance to augment dental implant surgery.



Bruce A. Smoler, DDS, will present a FREE LIVE



WEBINAR on November 18, expanding on this article's topic. Scan QR code or visit dentistrytoday.com/webinar to register

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Dr. Smoler is a general dentist with an implant-based practice located in Westland, Mich. He received his DDS from Northwestern University in Chicago. He has been involved in over 10,000 implant procedures including more than 1,000 robotically placed implants and has attained over 6,000 hours of CE. Innovations and advances in fullarch dental implant reconstruction drive Dr. Smoler. He is committed to expand the knowledge base of the profession with his in-office Over The Shoulder Training Programs. He can be reached at drbruce@smolersmiles.com.

Dr. Marina is a restorative and surgical dentist with a focus on full-mouth rehabilitation, prosthodontics, and patient-centered care in private practice in Lawrence, Kansas. He is known for his empathetic approach, particularly in treating patients with complex oral health needs or previous negative dental experiences. Dr. Marina has a special interest in digital dentistry, including the integration of AI, telehealth, robotics and 3D printing in clinical workflows. He is committed to advancing the patient experience through personalized, evidence-based care. Outside of dentistry, he is an avid traveler and adventurer, having visited over 60 countries. He can be reached at adammarina@gmail.com.

Dr. Pinker is a board-certified oral and maxillofacial surgeon practicing in Daytona Beach, Fla. He earned his doctor of dental surgery degree from Columbia University College of Dental Medicine in New York City, trained in oral and maxillofacial surgery at the University of North Carolina at Chapel Hill, and earned his doctor of medicine degree from the University of North Carolina at Chapel Hill. His professional interests include orthognathic surgery, robot-assisted dental implant surgery, dentoalveolar surgery, maxillofacial pathology, and maxillofacial trauma. Outside of the profession, he enjoys running and watching all sports, in particular, Miami Hurricanes football. He can be reached at bmp2125@gmail.com.

Dr. Thayer is a Fellow with the American College of Surgeons (FACS) practicing in Daytona Beach, Fla. He obtained his DMD and his Oral and Maxillofacial Surgery Residency at Nova Southeastern University, College of Dental Medicine. Dr. Thayer served 3 years in the United States Navy, 2nd Dental Battalion, as a general dentist for the Marine Corps Air Wing. He did a GPR at National Naval Medical Center in Bethesda, Md. Dr. Thayer is committed to providing his patients with the utmost care and latest technology. He enjoys doing humanitarian work, flying, and aerial photography. He can be reached at retepegs@yahoo.com.

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Bruce A. Smoler, DDS

Adam Marina, DMD

Bradley M. Pinker, DDS, MD

Roger S. Thayer DMD