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# The Future of Dental Implants Robotics Vs. Navigation

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**Abstract**

Since the invention of the first robot for industrial use in the late 1960s, robotics has seen tremendous development. Technological advancement has meant that surgery assisted by robots demonstrates several advantages, like greater precision, efficiency, less invasiveness, and safety, when compared with conventional approaches. The article states the precision of implant placement in dentistry in robot-assisted cases in comparison with static computer-assisted implant surgery (SCAIS), dynamic computer-assisted implant surgery (DCAIS), as well as freehand operations.

**Keywords:** Dental implants, Dynamic Navigation, Static computer assisted implant surgery, Robotic dental implants.

## INTRODUCTION

Three-dimensional positioning of implants in dentistry is of importance for both the stability of the implant and the aesthetic outcomes of the prosthetic restoration. A poor implant position can result in complications such as inadequate bone integration, increased risk of infection, or compromised aesthetics due to improper alignment with adjacent teeth [1].

A prominent robot in dentistry is the archwire-bending robot developed by Suresmile Orthodontic System and first described in 2001. A commercially available robot for the practice of general dentistry is YOMI, which was conceptualized in 2017 with FDA approval. Being a semi-active robot system, it has the ability to perform drilling in an autonomous fashion towards placement of implants. Further development introduced a fully automatic robot system that, in addition, can aid in presurgical treatment planning along with autonomous drilling and placing the implant with a tracking or guiding mechanism. These help decrease human error, including fatigue and variability in technique, which can lead to more consistent outcomes. There is a decreased chance of human error factors while placing, drilling, calibrating, and registering. Further, it also helps to reduce deviations caused by surgeon factors, as a result improving accuracy in surgery, safety, rate of success, and making it more efficient by decreasing trauma to the patient [3].

Freehand (FH) surgery relying on traditional 2D radiographs or even 3D CT scans alone can sometimes lead to less precise implant placements. Excellent surgical view during treatment without the use of any device will hinder the direct vision at the implant site. Good bone temperature control allows cooling fluids to reach the drill site. FH has bare minimum accuracy for prosthetics as well as presurgical treatment plans for patients. Mispositioning with FH is frequent. There is more risk for patient morbidity, postoperative pain, swelling, and longer chair time associated with freehand-guided implant surgery [4]. The advancement of digital technologies, such as static (sCAIS) and dynamic (dCAIS) computer-assisted implant surgery, shows dramatically improved precision [1].

Static CAS makes use of a template fabricated using computer-aided manufacturing technology with regard to preoperative treatment planning. This template can be tooth-supported or mucosa- or bone-supported at the time of operation. This will guide you mechanically to the site. The depth and angulation at the time of insertion of the implant are coordinated through a surgical kit. During bone drilling & placement of the implant, the CT-generated guide provides accurate implant placement with the use of the flapless approach and less invasive surgery, helping to lessen patient morbidity [4]. They have various disadvantages, which include a broken intraoperative static guide, decreased water cooling, grafting procedures occurring simultaneously that cannot be indicated, feedback obtained in real time not appearing, and placement in the posterior region not being able to be planned by using a static guide because it is difficult [2].

Dynamic navigation systems are definitely revolutionizing implant surgeries. The real-time visualization of anatomical structures is crucial for avoiding critical areas, improving both safety and accuracy. The integration of real-time tracking with a pre-acquired CBCT scan really enhances precision, especially when it comes to placing implants in the optimal position. It involves 3D planning with exploration with CBCT and analysis of prosthetic factors prior to surgery. This improves the precision of implant placement, helps in accurate implant angulation & proper placement of the implant, and takes care of parallelism. Since the system is associated with high cost, it is limited to in-vitro studies associated with dynamic navigation research [3,4].

A derivative of freehand surgery, s-CAIS was used in placing implants around the late 1990s. Nevertheless, s-CAIS is constrained by the longer treatment time brought on by the guide manufacture, higher implant deviation brought on by displacement of the guide, as well as inadequate cooling of the surgical site as a result of guide insertion [5][8,9].

Based on studies, d-CAIS and r-CAIS help to enhance implant surgical precision by accelerating the digital application for dental implants. r-CAIS exhibits fewer axial, coronal, and apical deviations in comparison with d-CAIS due to several reasons [5][10].

During pre-operative preparation, r-CAIS calibration and its registration operation will be carried out using a robotic arm, which is shown to be far more stable in comparison to d-CAIS. In addition, this robotic system is recognized by itself all throughout the procedures [5][11].

Any deviations regarding the robotic system are mitigated by understanding how outstandingly stable the robotic arm is and how highly precise the automated recognition works. Implant robots react to variations in milliseconds. Implant efficiency is enhanced by the surgical robot's sensitivity to deviations and the promptness of reorganizing the implant path [5][12].

When utilizing a dynamic navigation system, dentists have to alternate between the computer screen and the surgical area. They might overlook crucial data as a result, which might result in deviations. Robots superior accuracy, efficacy, and stability make it easier to transfer 3D implant location from pre-operative treatment planning to the implant site of the patient. Presently, implant robotics are unable to display the implant site bone density during surgery, rendering it virtually difficult for the operator to ascertain

whether the implant surgical procedure needs to be modified or not during r-CAIS [5].
A study by Ye & Wang et al. showed dynamic navigation systems coronal, apical, and axial deviations at single tooth sites that were healed were, respectively, 0.70 ± 0.30 mm, 0.85 ± 0.25 mm, and 1.80 ± 0.70. The implant robot's axial, coronal, and apical deviations for treated regions are 1.36 ± 0.54 mm, 0.46 ± 0.29 mm, and 0.56 ± 0.30 mm, respectively [5][13].
Chen et al. evaluated precision between d-CAIS and r-CAIS. Coronal deviations of d-CAIS and r-CAIS are 0.73 ± 0.20 mm and 0.58 ± 0.31 mm in that order. Apical deviations for d-CAIS and r-CAIS were 0.86 ± 0.33 mm and 0.69 ± 0.28 mm in that order, whereas axial deviations were 2.32 ± 0.71 and 1.08 ± 0.66 [5][14].
These outcomes revealed that r-CAIS had much lower maximum deviations in coronal, apical, and axial directions than d-CAIS. Therefore, the excellent steadiness of the robotic arm lowers the variety of surgical deviation. R-CAIS offers feedback in real time with d-CAIS in addition to physical direction, unlike s-CAIS. This promises to be an area of attention in dental implant surgery in the coming years [5].
Jia et al. evaluated static and robot-assisted navigation-assisted implants in a clinical investigation. The robot-assisted dental implants had significantly higher accuracy (angular deviation of 1.48 ± 0.59 degrees, coronal deviation of 0.43 ± 0.18mm, and apical deviation of 0.56 ± 0.18 mm) than the static navigation-assisted dental implant (angular deviation of 2.42 ± 1.55 degrees, coronal deviation of 1.31 ± 0.62 mm, and apical deviation of 1.47 ± 0.65 mm) [2][10].
In their case study, Mozer et al. revealed angular deviations ranging from 0 to 1 degree (0.3-0.5mm for coronal, 0.5mm for apical, and 0.4mm for vertical deviations, respectively). It was thereby inferred that aberrations with regard to robot-assisted implant procedures are equivalent to static navigation-aided surgeries [2][15].
Surgical robots therefore decrease error that may occur due to surgeon tiredness, tremor (if any), poor postures, and presence of blind spots at the time of preparation of the surgical site. In addition, by virtue of robots having a stiff and stable mechanical surgical arm controlled by software for the purpose of tracking, it is seen to be much more accurate [2][16].
However, robots and their use in implant dentistry are currently restricted since their intelligence is known to be limited, machinery and software production incur high costs, and structure and workflow are complex when combined with enormous machine volume as well.It is predicted that robots will be much more economical as technology advances. Enhanced software and robot cost-effectiveness may result in their widespread clinical application in dental technology [2].

## Conclusion

Robotic intelligence in dentistry is seen to be limited, with the operation being assisted primarily by surgeons. Though functionally simple, it is structurally complex at most times, and so is the volume very large. It is believed, however, that there will be widespread application of robotic technology in clinical dentistry in the near future owing to the maturation of hardware and software of dental robotic systems. With ongoing advancement and the optimization of digital technologies, r-CAIS is a promising potential surgical method. More study is needed to confirm the clinical utility of robotic dental implantology.

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