



**Karolinska  
Institutet**

From the Section for Image and Functional Odontology, Department of  
Dental Medicine

## **Accuracy of Virtually Planned and CAD/CAM- guided Dental Implant Surgery**

**AKADEMISK AVHANDLING**

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## ABSTRACT

**Aims:** The aim of this thesis was to compare the deviation between the position of virtually planned implants, and the position of implants placed with a CAD/CAM-guided surgical template, between the mandible and maxilla in human cadavers and in patients. Furthermore, to compare the deviation between implants placed by different surgeons in plastic jaw models. To perform virtual variation simulations on virtually planned implant placements and to compare them with corresponding results from actual surgeries performed on human cadavers in a previous study.

**Material & Methods:** In Study I, 145 CAD/CAM-guided implants were placed in 17 human cadaver jaws. In Study II, 1.450.000 virtual surgeries were performed in software based on 3D data, obtained from Study I and results calculated. In Study III, 139 implants were placed in 25 patients with a CAD/CAM guided surgical template. In Study IV, 150 CAD/CAM-guided implants were placed in 25 duplicate plastic maxilla jaws by five surgeons. In Study I, III and IV, the preoperative and postoperative CT/CBCT scans were aligned, and actually placed implant positions were compared with the virtually planned implant positions.

**Results:** Study I and III, demonstrated a statistical significant difference between the virtually planned implant positions and the clinically placed implant positions after surgery. Study I demonstrated a statistically significant difference between mandibles and maxillae for the outcome variables, hex, apex and depth measurements, with smaller deviations for the maxilla. In Study III it was found that the patients moved during the preoperative and postoperative CBCT scans. When combining the movement factor between the virtually planned implants and actually placed implants positions, a statistical significant difference was observed for the hex and apex. If the movement factor was included, a statistical significant difference was found between the maxilla and mandible for the outcome variable angle. In Study II, the implant distributions were neither static nor normally distributed. Thus, within the limitations of this study, the definitive geometrical variations of the implants were not static, as they depend on the individual anatomy of the jaws and the ability to place the CAD/CAM-guided surgical template in the proper position. The Mann-Whitney U test showed that the definitive implant distributions in this study could not be assumed to be normally distributed. In Study IV a statistically significant difference was observed between all five surgeons for the outcome variables, apex, depth and angle. A statistically significant difference was also found between the virtually planned implant positions and the actually placed implant positions for the outcome variables, apex, hex and depth.

**Conclusions:** Statistically significant differences were observed between the virtually planned and clinically placed implants, between mandibles and maxillae and between surgeons. Further studies have to be performed to evaluate the contributing factors of all steps involved in CAD/CAM guided surgery. In order to further improve knowledge about guided surgery accuracy, it is important to perform accuracy studies on conventional surgery in order to compare the results and, thus, provide a more secure treatment to the patients. In other words, the most important goal is to provide the most secure treatment available for the patients.

**Keywords:** dental implant, computer-guided surgery, CAD/CAM-guided surgery, surgical template, flapless surgery, virtual planning, CT, CBCT, stereolithography, accuracy

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