CLINICAL ORAL IMPLANTS RESEARCH

Accuracy of a novel prototype dynamic computer-assisted surgery system

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Abstract

Objectives: To implement and evaluate the accuracy of a prototype dynamic computer-assisted surgery (CAS) system for implant osteotomy preparation and compare its accuracy vs. three commercial static CAS systems and the use of an acrylic stent.

Material and methods: Eight osteotomies were prepared in radiopaque partially edentulous mandible and maxilla typodonts. After cone-beam CT acquisition, DICOM files were imported into a prototype dynamic, and three static CAS systems (NobelClinician, Simplant, and CoDiagnostiX). Implant placements were planned to replicate the existing osteotomies and respective guides were requisitioned, along with one laboratory-made acrylic guide. The eight osteotomies per jaw were transferred to one typodont pair mounted in a manikin in a clinical setting and the process was repeated for four additional pairs. The 80 (two jaws × eight holes × five pairs) osteotomies were filled with radiopaque cement in-between the testing series. Three clinicians experienced with the use of the static CAS softwares used in this study prepared each 400 (80 holes × five modalities) osteotomies. One clinician repeated the experiment twice, resulting in a total of 2000 (five clinicians × 400) osteotomies. The lateral, vertical, total, and angular deviations of the actual vs. the original osteotomies in the master typodonts were measured using stereo optical tracking cameras. Linear regression statistics using generalized estimating equations were used for comparisons between the five modalities and omnibus chi-square tests applied to assess statistical significance of differences.

Results: The prototype dynamic CAS system was as accurate as other implant surgery planning and transfer modalities. The dynamic and static CAS systems provide superior accuracy vs. a laboratory-made acrylic guide, except vertically. Both dynamic and static CAS systems show on average <2 mm and 5 degrees error. Large deviations between planned and actual osteotomies were occasionally observed, which needs to be considered in clinical practice.

Conclusions: The prototype dynamic CAS system was comparably accurate to static CAS systems.

Implant-retained prostheses are today a treatment modality with a highly predictable outcome (Pjetursson et al. 2007). Poor implant positioning, however, compromises esthetics and function and increases the risk for biomechanical overload. An important premise for the long-term success of implant supported prosthetic restorations is proper implant position. Presurgical planning combined with use of a surgical guide during the placement of dental implants is therefore encouraged. Surgical guide techniques based on new computer technologies enable three-dimensional image reconstructions and interactive therapy planning; the latter leading to fabrication of surgical guides derived from computer tomography (CT) and computer-assisted surgery (CAS) (Fortin et al. 1995).

Static CAS modalities offer a reliable transfer of the planned implant locations. The intra-operative handling of surgical guides is uncomplicated and there is relatively easy co-ordination of procedures between guide planning, manufacturing and surgical application without the need for additional expensive equipment. However, there are also some limitations. The stability of the surgical guides, which are placed on a few remaining teeth, directly on the mucosa or the crest of the bone, is critical. Placement of implants in the posterior zone may also present a problem if the opposing dentition limits the space to insert and use the surgical guide. (Jung et al. 2009; Schneider et al. 2009; de Almeida et al. 2010; D'Haese et al. 2012; Hultin et al. 2012; Van Assche et al. 2012).

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