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Multi-Slice-Computertomographie und Genauigkeit navigationsassistierter Implantatbett-Bohrungen am Unterkiefermodell

Accuracy of multislice computed tomography-image guided surgical implant socket drilling using passive-marker tracking technology

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Purpose

Medical imaging, such as magnetic resonance and computed tomography is not only an important diagnostic tool, but also a necessary tool for therapeutic planning. Currently, systems for computer aided surgery usually consist of a computer workstation and a position measurement system used for determination of the position and 3D orientation of a surgical instrument. Position information is provided by radiological images in reformatted slices or 3-dimensional renderings that give the physician precise information on the anatomical situation. In craniomaxillofacial surgery, precision is needed when placing implants or screws for bone fixation. Many computer navigation systems have recently been developed for brain surgery, and the use of such systems in skull base and maxillofacial surgery is increasing. A potentially important application of image-guided navigation is the exact placement of dental implants in partially or completely edentulous patients. An accurate implant position is one of the main factors governing the phonetic, aesthetic and functional outcome. Computed tomography (CT) is currently the most powerful technique for visualization of anatomical structures. Particularly in atrophic edentulous jaws, the identification of critical exposed anatomical structures such as the inferior alveolar nerve and the maxillary sinus on the CT data is possible. This in turn

improves surgical performance and safety. The aim of this study was to evaluate the accuracy of navigation based drill sockets in an experimental setup.

Material and Methods

Laboratory accuracy measurements were performed on a synthetic mandible model. The model with prelabeled markers was scanned and registered with fiducial marker-based algorithms.

Computed tomography (CT) scans were carried out with a 16-line multisclice CT-scanner (Siemens Somatom Sensation 16). The position of multiple implant sockets was planned and sockets were drilled in the direction of a predefined target drill based on multislice CT-data. After drilling, the coordinates of all sockets were determined by a 3D-digitizer probe to evaluate the direction of misplacement of the drilled canal in relation to the target with a CAD-programme (Pro/Engineer).

Results

The results of 50 measurements using the mandible model showed a mean registration error of 0.22 mm (SD: 0.06 mm). With the refined multislice CT-scan technique, the accuracy of navigation-guided drilling was 0.87 mm (SD: 0.45 mm) and 1.71 degrees (SD: 0.44°).

Conclusion

From our experiments we conclude that both reliable registration and acceptable accuracy can be achieved for computer aided implant surgery. Advantages of the method compared to conventional splint methods include an improved reliability of the implant socket position in edentulous patients and the opportunity to use a smaller mucosal flap, thus resulting in an improved vascularization of the implant site. Image-guided surgical navigation using passive marker technology is a promising technique for minimal invasive procedures in oral and craniomaxillofacial surgery. The accuracy of navigation based drilling is sufficient and reproducible for a variety of clinical indications. Further research on parameters affecting the accuracy of surgical navigation is necessary.