Chapter 12
Accuracy of the First Integrated Cone-Beam System for Computer Aided Implantology

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ABSTRACT
The aim of the chapter is to give a complete survey of Computer Aided Surgery (CAS) systems in dental implantology from the different 3D visualization technologies to the different available approaches for implant planning data transfer to the corresponding anatomical patient’s sites. Focus will be on the illumination of advantages and disadvantages for the different systems components. Further on, the diagnostic value, radiation dosages to the patient, availability and costs as well as the transfer accuracy results for the investigated system will be discussed.

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ACCURACY OF THE FIRST INTEGRATED CONE-BEAM SYSTEM FOR COMPUTER AIDED IMPLANTOLOGY

Since 1997 different approaches for computer-assisted surgery (CAS) and computer aided dental implantology (CAI) are available. These systems comprise different technologies for three-dimensional (3D) visualization of the patient’s anatomy and visualization software capable of virtual dental implant position planning. The artifice of registration is the key for transferring the virtually planned implant positions to the corresponding patient’s anatomical sites on basis of different navigation technology approaches.

Visualization

Since the introduction of the cone-beam (CBCT) technology (Mozzo, Procacci, Tacconi, Martini, & Andreis, 1998), 3D visualization in dental medicine mainly was available by computer-tomography (medical CT) and magnetic resonance imaging (MRI). Nowadays, mainly 3D CBCT and medical CT data sets are utilized for visualization of the patient’s anatomy, making diagnosis and virtual dental implant position planning. Both image modalities have their distinct advantages and disadvantages. Beside the operational availability and the device costs, the main impact for evaluating these technologies in terms of dental implant planning are diagnostic value of the achieved data sets, as well as the radiation dosages to the patient.

High diagnostic values of the achieved data sets result from highly accurate visualization of all important anatomical structures of the facial skull. Concerning the geometric accuracy of 3D medical CT and CBCT data sets our investigations proved highly effective linear and volumetric measurement opportunities (Mischkowski, Pulsfort et al., 2007). For comparison purposes linear and volumetric phantoms as well as dried human skulls equipped with gutta-percha-points in prefabricated drill holes were exactly measured and scanned with a CBCT scanner (GALILEOS, Sirona Dental Systems, Bensheim, Germany) as well as a 6-detector row medical CT scanner (SOMATOM Sensation 6, Siemens Medical Solutions, Erlangen, Germany). On basis of 100 linear as well as 25 volumetric measurements the accuracy for both investigated technology in contrast to the real distances and volume could be described. We could prove that there was no significant difference in the measurement accuracy between the two investigated visualization technologies. The investigated linear deviations ranged in the area of 1%, the volumetric deviations turned out to range around 5% from the real values. Similar errors also were reported for different CBCT systems by other investigators.

Besides the geometric accuracy also the visualization quality for the important anatomical structures in pre-surgical dental implant planning play an extremely important role. To establish a basis for weighing the potential diagnostic and therapeutic benefits of 3D CBCT data sets in contrast to digital orthopantomography (PT) and medical CT, we performed an investigation comparing the visualization quality of different anatomical structures important for pre-surgical dental implant planning (Dreiseidler, Mischkowski, Neugebauer, Ritter, & Zöller, 2009). This study compared the visualization properties of the general image quality, the mandibular canal, incisive foramen, mental foramen, temporo-mandibular joint (TMJ), the bony nasal floor, maxillary sinus floor, the implant region its bone borders and adjacent teeth. Analysis was performed on an implant group and a control group. The implant group consisted of twenty-seven patients receiving a single pre-implantologic CBCT scan as well as a post-OP follow-up digital PT. In the control group 29 patients received both medical CT and CBCT diagnosis. Significant superior imaging quality in contrast to PT imaging could be approved for
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