International Poster Journal IPJ of Dentistry and Oral Medicine

Int Poster J Dent Oral Med 2002, Vol 4 No 1, Poster 110

Computer assisted insertion of dental implants

Language: English

Authors: Jakob Brief[1], Stefan Haßfeld[1], U. Sonnenfeld [2], N. Persky[2], Robert Krempien[3], Martina Treiber[3], Joachim Mühling[1]
[1]Department of Oral and Maxillofacial Surgery, University of Heidelberg, D-69120 Heidelberg, Germany
[2]DenX, Moshav Ora 106, Jerusalem 90880, Israel
[3]Department of Radiology, University of Heidelberg, D-69120 Heidelberg, Germany

Date/Event/Venue:
09.06.01 - 10.06.01
2. Assistentenkongreß in der ZMK und an der 2. Jahrestagung des Arbeitskreises für Angewandte Informatik in der DGZMK
Berlin, Germany

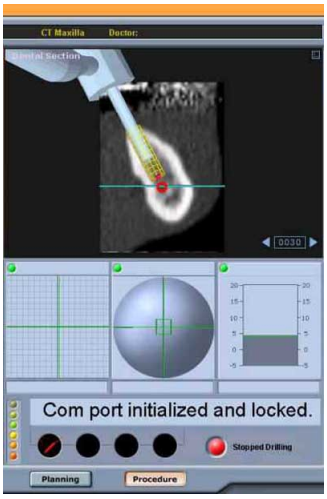
Introduction

We are introducing a method that combines a pre-operative 3D plan for inserting dental implants with a dental navigation system. The method is based on the visualization of the CT data of the patient's maxilla and mandible. The position and orientation of each implant is clinically planned using the CT data set as well as the size and type of the implant.
The treatment plan supplies the location of the implants in the patient's coordinates and is transferred to the patient using a dental navigation system (DenX's, IGI System).
The system "assists" the dentist during the pre-operative planning and also during the intra-operative procedure, while the optimal treatment plan is applied directly to the patient. A PC based software, IGI allows for simulation, visualization, and planning the surgical intervention.
The system was tested in Israel at the company site as a prototype and will be installed at the University Hospital of Heidelberg for further evaluation and experience until it will be used for clinical application during the middle of 2002.

Material and Method

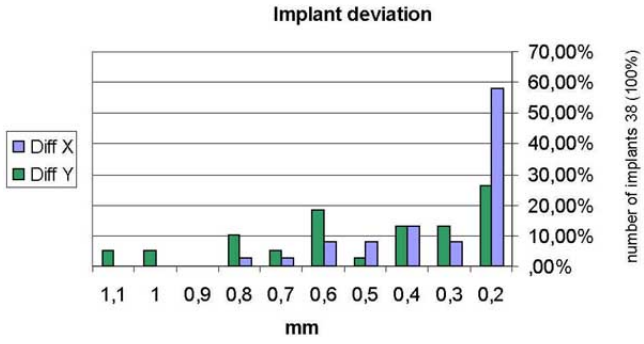
For evaluation, we used the prototype planning and navigation - System called IGI (DenX, Israel), which tracks the actual position of the handpiece in real-time. The type, size, position and orientation of the implants are planned based on CT data with IGI Software from DenX Ltd.
KaVO^{TM} phantom jaws were used for the tests. Different methods of fiducial locations were used for the different kinds of jaw models. For the EWL surgery model an acrylic splint was prepared and eleven Ceramic spheres, 3 mm in diameter were cemented to the splint's occlusal surface. For the implant model, the above-mentioned spheres were cemented to the jaw itself. The jaws were CT scanned with the artificial landmarks and the digital data were transferred onto the IGI station. The 3D planning of the implantation and the drilling was then performed in the following order:
Virtual implants of 3.75 mm diameter, 10 mm length were used for the tests. 38 drill holes were prepared in 2 model implant jaws, 23 in one jaw and 15 in the other, located at distances of about 5 -10 mm between the centers of each implant and vertical to the occlusion plane as was determined in the CT scan. Eight more implant sockets were prepared in two surgery model jaws, four on each jaw, drilled in the missing teeth area vertical to the occlusion plane as was determined in the CT scan.
It is necessary to brace the patient's maxilla and mandible during treatment so that the patient remains in a fixed position during surgery. The position of the patient was referenced by registering the landmarks. The spheres on the splint and on the jaw implant are used as landmarks for the registration procedure. All the pre-operative determined implant sites were drilled carefully while the IGI system's visual and audio indicators made sure that during the entire procedure there was no deviation from the original plan.
The jaws were sent to post operative CT. The digital postoperative CT data were transferred to the IGI station and the saved virtual implants are fused to the CT data using the fiducial location.
In the postoperative CT, the drill holes could be easily seen and defined. The drill hole center top position and end position were defined with the software ruler tool and the 3D coordinates of the top and end center were registered. The same procedure was done with the virtual implants and the deviation between the virtual implant and actual hole was calculated.

IGI dental planning and navigation system for the positioning of implants / simulation

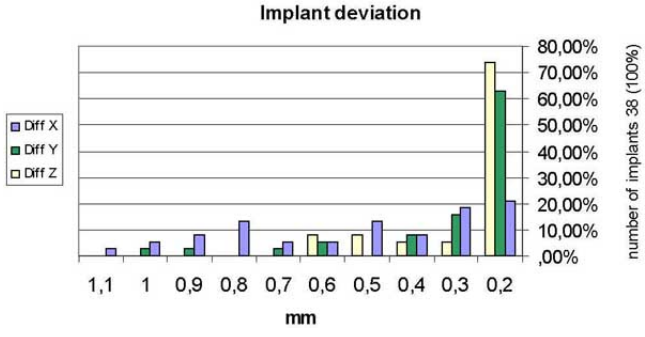


Controlling the plan while drilling

Executing the drilling, tracking the exact position of the handpiece and the patient (in fixed position).



deviation of implant top (bone entrance) position in edentulous phantom jaw



deviation of implant end (apex) positions in edentulous phantom jaws

Results

We tested 38 implants within edentulous phantom jaws and 8 implants in partially edentulous phantom jaws (Table 1a-b). We found an accuracy that has a deviation of 0 mm at best and a deviation of 1,2 mm at worst.
For both the edentulous and the partially edentulous it is shown that 95% of the deviations are below 1 mm, which coincides with the achievement of the 1 mm accuracy.

Conclusion

The IGI system will offer the dentist an easy to handle tool, which accurately transfers the preoperatively defined implant position directly to the patient during the surgical procedure. While evaluating the systems benefits and precision in a phantom study, we found the system's total accuracy equals 1.0 mm.

Acknowledgement

This research was performed by members of the Department of Oral and Maxillofacial Surgery, Prof. Dr. Dr. J. Muehling, University of Heidelberg, at DenX, Moshav Ora 106, Jerusalem 90880, Israel.
The work is being funded partially by the Sonderforschungsbereich 414 "Information Technology in Medicine - Computer and Sensor Supported Surgery" of the Deutsche Forschungsgemeinschaft.

This poster was submitted by Dr. Jakob Brief.

Correspondence address:
Dr. Jakob Brief
Department of Oral and Maxillofacial Surgery, University of Heidelberg
INF 400
D-69120 Heidelberg
Germany

Poster Faksimile:

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J. Brief *, S. Hassfeld *, U. Sonnenfeld **, N. Persky **, R. Krempien +, M. Treiber +, J. Mühling *

* Department of Oral and Maxillofacial Surgery, University of Heidelberg
D-69120 Heidelberg, Germany, Email: jbrief@mod.uni-heidelberg.de

* * DenX, Moshav Ora 106, Jerusalem 90880, Israel

+ Department of Radiology, University of Heidelberg, D-69120 Heidelberg, Germany

Universität Heidelberg

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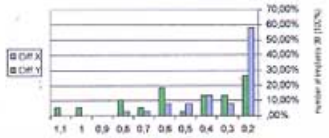

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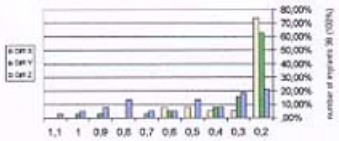

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