International Poster Journal IPJ of Dentistry and Oral Medicine

Int Poster J Dent Oral Med 2000, Vol 2 No 4, Poster 50

Multi-modal volume registration of the Temporo-mandibular joint by using MRI- and CT-imagery

Language: English

Author(s): Wolf-Dieter Grimm, Jochen Jackowski, Axel Zöllner
Department of Periodontology, Department of Oral Surgery, Department of Prosthodontics
Dental School, University of Witten/Herdecke, Germany

Date/Event/Venue:
13.05.99-14.05.99
International Symposion on Craniofacial Morphology
Witten

Introduction

The diagnosis as well as the treatment planning concerning TMJ disorders is mainly based on information interpreted from the clinical assesment, the axiography and different radiological methods. All conventional radiological techniques are limited in their ability to measure accurately both the soft and hard tissues in three dimensions. 3D-imaging permits an accurate topographical evaluation of the temporomandibular joint (TMJ). Based on the resulting static images a rapid sequence created a dynamic presentation of the mouth opening, comparable with the incremental movement visualised by the axiography (see series of photographs). The data can also be used for the computer-aided manufacture of TMJ models. A more realistic simulation of structural changes can be achieved with the transfer of the CT and MR images to individual lifesized 3D-TMJ models by means of a computer-aided milling machine or stereolithography and the integration of replaceable disks. We have attempted to overcome the technical limitations in 3D-imaging of the TMJ. The development in MR imaging and computer graphics during the past two decades made it possible to obtain images independent of overlying structures. With no doubt the position of the articular disk is of great importance. The disk, made of fibrocartilage, has a low-signal (black) appearance. It can therefore be differentiated from the adjacent superior and inferior joint space showing a brighter shade caused by the Synovia.

Anatomical situs

Laser technology has opened a new way to produce 3D-models. These replicas are produced not by grinding a solid block, as with MMM, but by selectively irradiating a photocurable resin with an ultraviolet laser beam to harden it (laser lithographic modelling). The system requires three components:

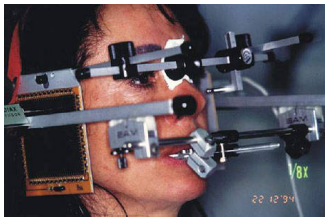
- A container for the UV-sensitive material in the form of liquid polymer and photo-initiators.
- A platform carring the TMJ model which is dipped into the liquid polymer in 0,5 mm steps, depending on the thickness of the layer.
- A laser-based light system for photopolymerisation to harden each layer of the TMJ model.We have used it to reconstruct the TMJ disk space for diagnostic purposes. Although soft tissues replicas based on the MRI data seem sufficiently precise, the models are far from even limited clinical use.

Material and Methods

TMJ-disorders

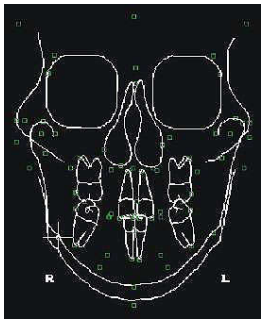
Axiography
(computer based, Slavicek)

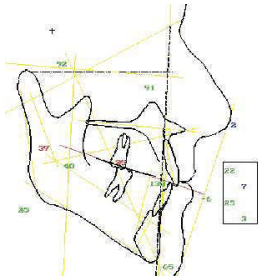
- 3-dimensional recording of condyle movements in dynamic occlusion with/without manipulation (active/passive) by the investigator
- Measurement of the 3-dimensional translation of the hinge axis between centric relation and intercuspal position
- Time/Speed correlated presentation

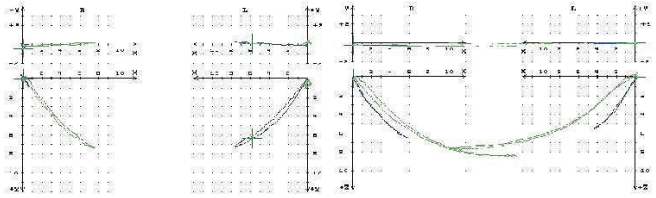


Lateral X-Ray
(Planmeca, 68 kV, 12 mAs, 0,5 s)

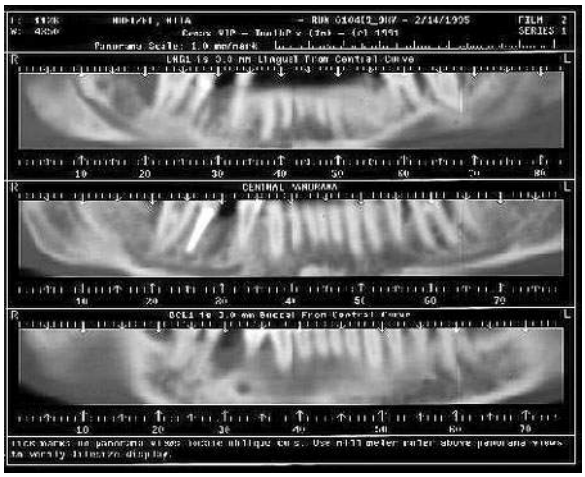
- marked hinge axis (HA), marked infraorbital Point (IO)
- Hinge Axis (HA) with inserted protrusive movement (PR) of the condyles, copied from the axiography
- Occlusal Plane (OP)

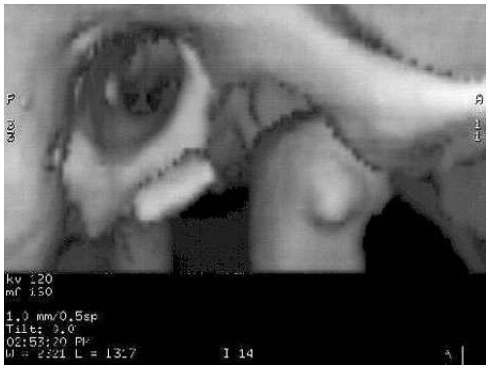


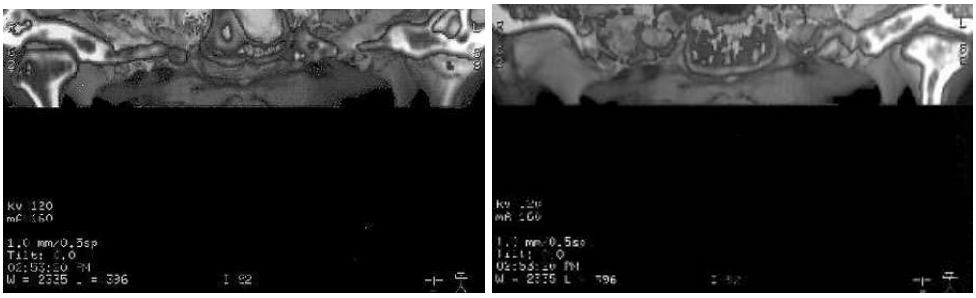




Computertomography:

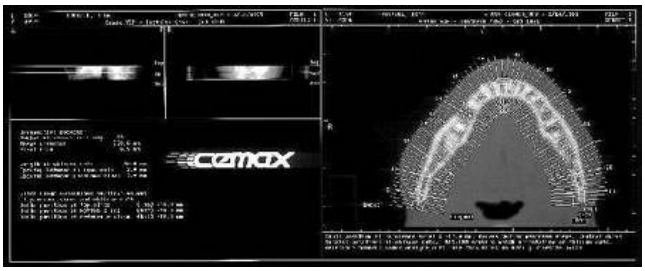


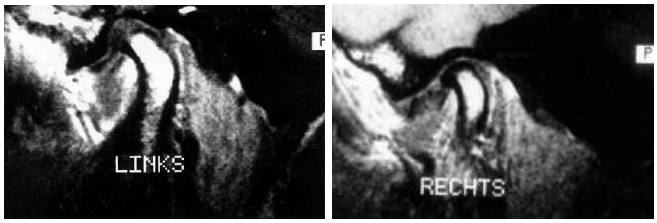




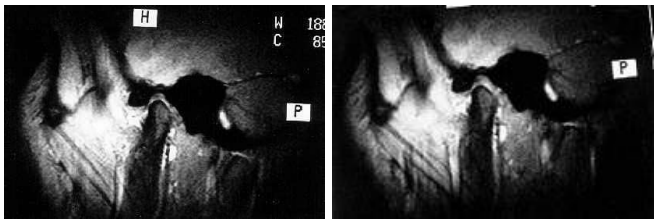
NMR:

MR-imaging: For MR data acquisition, continuous coronal MR scans were taken of the region of interest using a Magnetom SP 63 (SIEMENS, Erlangen, Germany). MR scanning was performed with a TR of 600 to 800 and a TE up up to 20. Images were obtained in the closed-mouth position. The 3D-sequences were performed using FLASH 3 D changing the angulation between 30° to 50°. The TE varied between 13 to 20 ms. This CINE-technique (FAST MOVIE) with fast gradient echo MR sequences was applied using an incremental mouth opener.

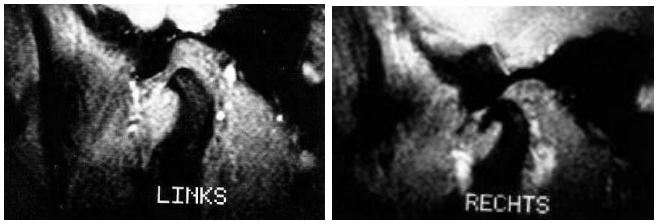




Closed-mouth position, the disk and the bilaminar zone appear to be compressed.

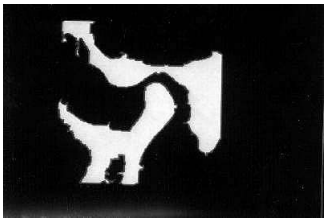
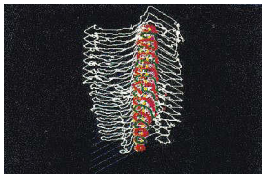
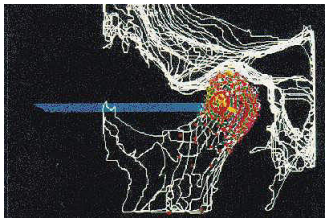


Gradient echo images have been obtained during incremental mouth opening (protrusivemovement) using a modified Burnett device.

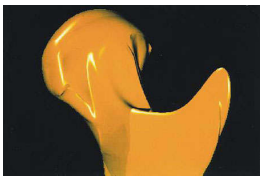
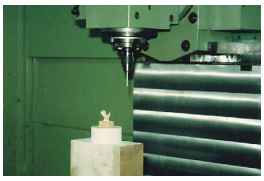


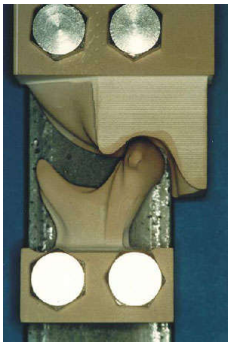
Gradient echo images obtained during incremental mouth opening.

Results

Isodentisy curve and hypothetical 3D-model

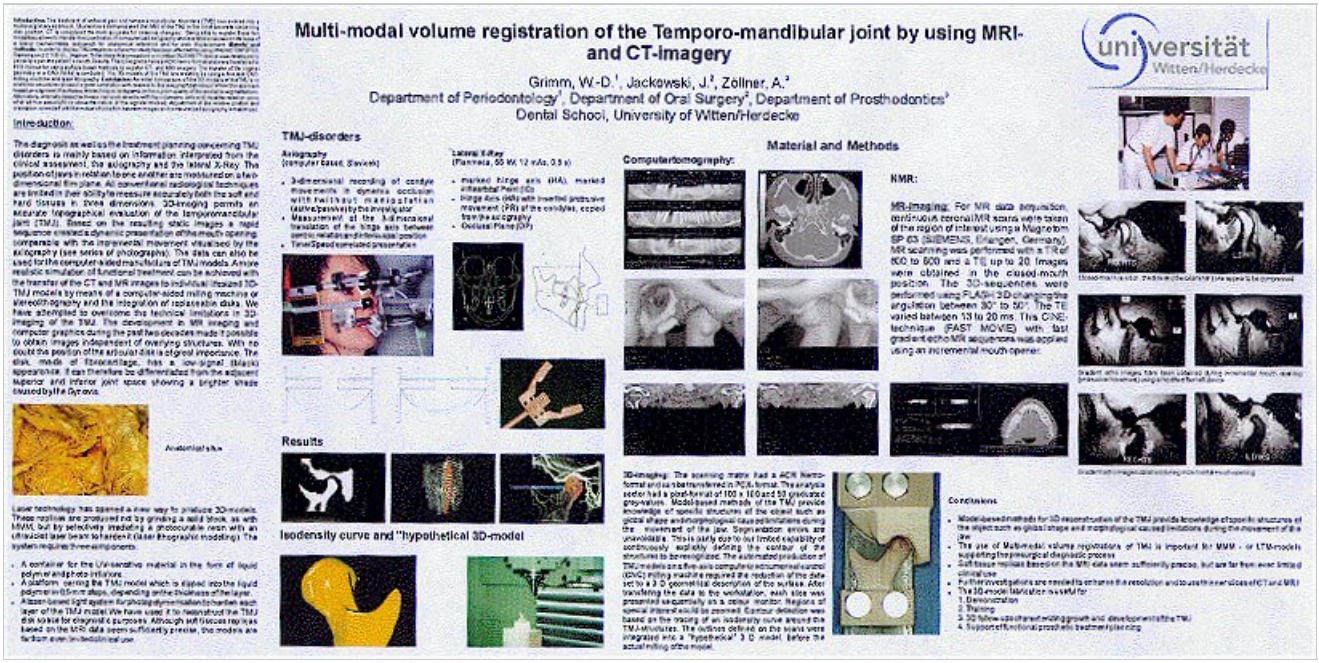


3D-imaging: The scanning matrix had a ACR Nemo-format and can be transferred in PCX-format. The analysis sector had a pixel-format of 100 x 100 and 50 graduated grey-values. Model-based methods of the TMJ provide knowledge of specific structures of the object such as global shape and morphological caused limitations during the movement of the jaw. Segmentation errors are unavoidable. This is partly due to our limited capability of continuously explicitly defining the contour of the structures to be recognized. The automated production of TMJ models on a five-axio computerized numerical control (CNC) milling machine required the reduction of the data set to a 3 D geometrical description of the surface. After transfering the data to the workstation, each slice was presented sequentially on a colour monitor. Regions of special interest could be zoomed. Contour detection was based on the tracing of an isodensity curve around the TMJ-structures. The outlines defined on the scans were integrated into a "hypothetical" 3 D model, before the actual milling of the model.

This Poster was submitted on 15.11.00 by Professor Wolf-Dieter Grimm.

Correspondence address:
Professor Wolf-Dieter Grimm
Universität Witten/Herdecke
Alfred Herrhausen Straße 50
58448 Witten
Tel.: (02302) 926-666

Poster Faksimile:



Multi-modal volume registration of the Temporo-mandibular joint by using MRI- and CT-imagery

Grimm, W.-D.[1], Jackowski, J.[2], Zöllner, A.[2]
Department of Periodontology[1], Department of Oral Surgery[2], Department of Prosthodontics[3]
Dental School, University of Witten/Herdecke

universität Witten/Herdecke

Introduction:

The diagnosis as well as the treatment planning concerning TMJ disorders is mainly based on information interpreted from the clinical assessment, the autography and the lateral X-Ray. The position of bars in relation to one another are mostly not on a two-dimensional film plane. All conventional radiological techniques are limited in their ability to measure accurately both the soft and hard tissues in three dimensions. 3D-imaging permits an accurate topographical evaluation of the temporomandibular joint (TMJ). Based on the resulting static images a rapid sequence created a dynamic presentation of the mouth opening, comparable with the incremental movement visualized by the autography (see series of photographs). The data can also be used for the computer-aided manufacture of TMJ models. A more realistic simulation of functional treatment can be achieved with the transfer of the CT and MR images to individual titanium 3D-TMJ models by means of a computer-aided milling machine or stereolithography and the integration of replaceable disks. We have attempted to overcome the technical limitations in 3D-imaging of the TMJ. The development in MR imaging and computer graphics during the past two decades made it possible to obtain images independent of overlying structures. With no doubt the position of the articular disk is of great importance. The disk, made of fibrecartilage, has a low-signal (black) appearance. It can therefore be differentiated from the adjacent superior and inferior joint space showing a brighter shade caused by the synovia.

Anatomical slice

Laser technology has opened a new way to produce 3D-models. These replicas are produced not by grinding a solid block, as with MMM, but by selectively irradiating a photocurable resin with an ultraviolet laser beam to harden it (laser lithographic modelling). The system requires three components:

- A container for the UV-sensitive material in the form of liquid polymer and photo initiators
- A platform carrying the TMJ model which is dipped into the liquid polymer in 0.5mm steps, depending on the thickness of the layer.
- A laser-based light system for photopolymerisation to harden each layer of the TMJ model. We have used it to reconstruct the TMJ disk solely for diagnostic purposes. Although soft tissues may vary as based on the MRI data seem sufficiently precise, the models are far from ever-lasting final use.

TMJ-disorders

Autography
(computer based, Siwiarb)

- 3-dimensional recording of condyle movements in dynamic occlusion with (without) manipulation (active/passive) by the investigator
- Measurement of the 3-dimensional translation of the hinge axis between centric relation and intercuspal position
- Time/Speed correlated presentation

Lateral X-Ray
(Planmeca, 66 kV, 12 mAs, 0.5 s)

- marked hinge axis (HA), marked orbitale/ Point (Or)
- Hinge Axis (HA) with inserted protrusive movement (PR) of the condyles, copied from the autography
- Occlusal Plane (OP)

Material and Methods

Computertomography:

MRI:

MR-Imaging: For MR data acquisition, continuous coronal MR scans were taken of the region of interest using a Magnetom SP 63 (SIEMENS, Erlangen, Germany). MR scanning was performed with a TR of 600 to 900 and a TE up to 30. Images were obtained in the closed-mouth position. The 3D-sequences were performed using FLASH 3D changing the angulation between 30° to 50°. The TE varied between 10 to 20 ms. This CINE-technique (FAST MOVIE) with fast gradient echo MR sequences was applied using an incremental mouth opener.

Results

Isodensity curve and "hypothetical 3D-model

3D-imaging: The scanning matrix had a 4CR Kentoformat and was transferred in TCS-format. The analysis sector had a pixel-format of 100 x 100 and 50 grayscale grey-values. Model-based methods of the TMJ provide knowledge of specific structures of the object such as global shape and morphological caused limitations during the movement of the jaw. Segmentation errors are unavoidable. This is partly due to but limited reliability of continuously explicitly defining the contour of the structures to be investigated. The automated production of TMJ-models are five-axis computer-controlled numerical control (CNC) milling machine required the reduction of the data set to a 3-D geometrical description of the surface. After transferring the data to the workstation, each slice was presented sequentially on a colour monitor. Regions of special interest could be zoomed. Contour detection was based on the tracing of an isodensity curve around the TMJ-structures. The outlines defined on the slices were integrated into a "hypothetical" 3-D model, before the actual milling of the model.

Conclusions

- Model-based methods for 3D reconstruction of the TMJ provide knowledge of specific structures of the object such as global shape and morphological caused limitations during the movement of the jaw.
- The use of Multi-modal volume registrations of TMJ is important for MMM - or LTM-models supporting the presurgical diagnostic process.
- Soft tissue replicas based on the MRI data seem sufficiently precise, but are far from ever-lasting clinical use.
- Further investigations are needed to enhance the resolution and to use the overdoses of CT and MRI.
- The 3D-model fabrication is useful for:
  1. Demonstration
  2. Training
  3. 3D follow-up of hard and soft tissue growth and development of the TMJ
  4. Support of functional prosthetic treatment planning