ISSN 1 746-7233, England, UK
World Journal of Modelling and Simulation
Vol. 3 (2007) No. 3, pp. 235-240

Comparison study on the 3D reconstruction of mandible according to Virtul Chinese Human slice data and CT data *

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(*Received January 10 2007, Accepted May 2 2007*)

Abstract. Objective: To resonstruct 3D model of mandible on the basis of Virtual Chinese Human data and normal CT pectures,and to compare their resonstruction results with each other. Methods: To select mandible data from Virtual Chinese Human slices and normal CT pictures, and reconstruct 3D model of mandible respectively by using a modified MC algorithm. Rusults: A 3D model of mandible was reconstructed accurately by adopting virtual human slice data. Conclusions: To reconstruct 3D digital model of human bone by specific software is a beneficial way for our research. The 3D mandible model reconstructed by adopting virtual human slices is more accurate than that by adopting CT pectures.

Keywords: mandible, three-dimensions reconstruction, Chinese Digital Human(CDH), CT

1 Introduction

To obtain the three-dimensional image of human histological structures using the computer aided three-dimensional reconstruction is a method for morphological study of human body, which involves processing serial images of the organisms. In the field of mandibular three dimensional reconstruction, there are many ways to obtain the three dimensional models of human mandible[1, 4, 7–9], such as MRI images processing, CT images processing, et al. In this article, we report three-dimensional reconstruction of human mandible with Chinese Digitital Human (CDH) section images and CT data respectively[2, 3, 5, 10] and the accuracy differences of the two three-dimensional models.

2 Materials and methods

The primary data for mandibular three-dimensional reconstruction was from the head data base of CDH, including the sectional data from the mental region to the mandibular condyle process. The CT sectional data of the same region was also used for mandibular three-dimensional reconstruction. The software packages of Adobe Photoshop and 3D Doctor by Able were used to reconstruct the three-dimensional models of mandible with the respective data.

* Particular thanks to Tang Lei for his collaboration in the research on the CDH.
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2.1 Specimen

The CDH specimen was a 24-year-old Chinese male who died from car accident. His family members voluntarily donated his body for medical research. After medical inspection, the specimen was adopted to construct the organ data base of Chinese digitized virtual human.

2.2 Procedures of data collection

2.2.1 Specimen fixation

The blowing agent was used to blow up in a symphylium container, followed by setting the cadaver into the conventional anatomic posture. While the blowing agent gradually hardened, the cadaver was effectively fixed.

2.2.2 Collection of CT data

The cadaveric head was scanned with SIEMENS PLUS4 CT machine to harvest the tomograms in intervals of 1mm. Totally 257 images were obtained in size of 512512 pixels and in format of Dicom, which amounts up to 133m. We show No.192 image by CT scanning as an example in Fig. 1.

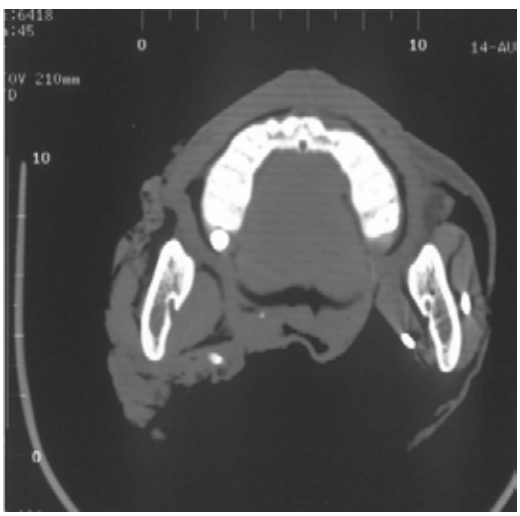

Fig. 1. The No.192 CT picture

2.2.3 Intra-arterial infusion and fixation of the specimen

The specimen was immersed into $20°C$ clear water for rewarming and defrosting[2]. The well-prepared infusion solution was infused from the femoral artery in dose of 1200ml, followed by sealing up the cadaver in posture of standing position. The cadaver was then put into $-10°C$ hypertonic saline for 72h till its total freezing with subsequent embedding.

2.2.4 Specimen embedding

The embedding box specially used for human head specimen was prepared based on the size of the human head for specimen fixation, followed by the addition of 3% gelatin till the neck. The embedding box was then put into the frige till the embedding solution was totally frozen. After that, the embedding box was taken out for addition of embedding solution till lips for frozen. The same procedure was repeated as above to add the embedding solution till respective nose, eyes and forehead until the specimen embedding was completed.

2.2.5 Specimen sectioning and image collection

A sectioning machine tool was set 0.2mm progressing in Z axis for equal interval sectioning. Each cross-section was labeled with Section No., standard color and length proportion. The camera of Fuji FinePix S2 Pro with the camera lens of Nikkor AF 24/2.8D was used to taken the sectional images in 1.5 times focal distance. The image resolution ratio was 3024×2016 pixels.

2.3 Image data

Totally 1277 section images in equal interval of 0.2mm were harvested and the data amounted up to 22.35GB in 3024×2016 pixels and in format of TIF. We show the No. 1020 section image in Fig. 2. Considering the computing capability of personal computer, 280 serial section images in equal interval of 0.6mm from the mental region to the mandibular condyle process were collected for three-dimensional reconstruction and the TIF format was transformed into JPG format for personal computer processing.

Additionally, 1720 CT scanning images were obtained in section thickness of 1mm. All the images were stored in format of Dicom.

Fig. 2. The No.1020 slice

2.4 Software package processing of 2-dimensional images

Compression :With the software package of Adobe Photoshop, the primary JPG images were compressed in equal resolution ratio and equal size.

Image segmentation and registration :Based on the 4 standardized points in the primary images, the images registration was performed. With software package of Adobe Photoshop, the images were segmented into section data in 3000×1200 pixels for three-dimensional reconstruction.

2.5 Three-dimensional reconstruction

The 280 section data after segmentation and registration were introduced as a file folder into the software package of Mimics 8.1 by Materialise. And 170 CT images from the mental region to the mandibular condyle process were introduced into Mimics in the format of Dicom.

Structures and outlines including mandible and teeth were differentiated in each image. The outlines of mandibular cortical bone on each section and the outlines of the tooth socket fossa on each section were traced for teeth biting after reconstruction. The outlines of each section were closed curves. With the software package, the surface and body of the mandible were reconstructed and a three-dimensional line-frame model

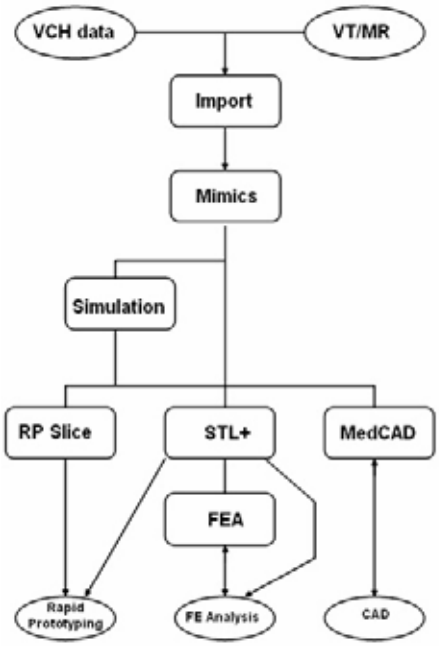

Fig. 3. 3D reconstruction procedure

as well as an entity model of the mandible was established. After surface smoothing to the models, texture and material substance were assigned to make them look real. Subsequently, the three-dimensional mandible models based respectively on the CDVH section database and CT image database were output.

Fig. 4. Mimics programe

3 Results

The mandible model based on CDH section database had 536 points and 962 triangular plane, while that based on CT image database had 9444 points and 19106 triangular plane. Using CDH section database, more

accurate three-dimensional model of mandible was established to precisely present the anatomic morphology of human mandible. Overview of the three-dimensional models from each direction was shown in Fig. 3 and Fig. 4.

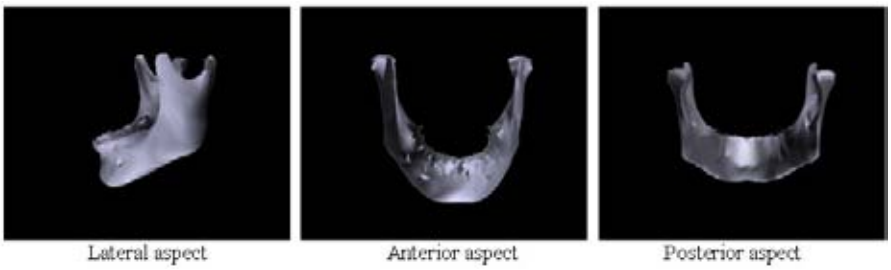

Fig. 5. 3D model reconstructed with date from CDH dataset

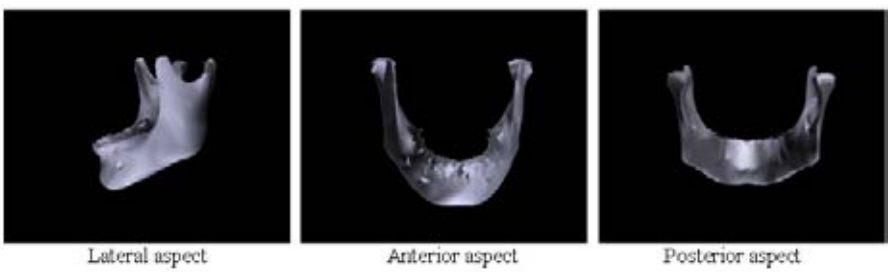

Fig. 6. 3D model reconstructed with CT picture

4 Discussion

4.1 Accuracy difference of reconstructed models

Human mandible has been reconstructed using Chinese Digital Human (CDH), whose accuracy is far beyond that using CT images. Through reconstruction with software package, the anatomic morphology of human mandible was actually presented and the model based on CDH database is far more accurate than that based on CT image database. Therefore, study on the presentation of anatomic morphology has been stepped further.

4.2 Features of human mandible model based on CDH

Part or whole human mandible can be three-dimensionally presented from arbitrary direction. And arbitrary segmentation, duplication and storage can be easily realized. Besides, various personalized and multi-functional data formats can be output, such as STL format for fast shaping equipment to manufacture replacement repair wares of bio-medical engineering, IGES format for limited meta-analysis of bio-mechanics, et al.

4.3 Establishment of digital anatomic model

In the same way, other three-dimensional anatomic structures, such as teeth, et al can be established. It will facilitate full appreciation and understanding of human body for medical researches and studies of other fields. Digital anatomy represents the orientation of our further studies.

5 Conclusion

Through respective reconstruction of human mandible with CDH section database and CT image database, two three-dimensional human mandible models have been established. Compared to the model based on CT image database, the model based on CDH section database more accurately presents human mandible, which can be used for replacement repair in the field of bio-medical engineering, limited meta-analysis in the field of bio-mechanics and establishment of digitized anatomic models.

References

[1] B. Gao, J. Zhou, Y. Mao, et al. Fabrication dental prosthesis with laser engineered net shaping method. part 1:measurement of dentognathic gypsum models with a 3d digitizer by cutting and scanning layer-by-layer. *Journal of Practical Stomatology*, 2000, **16**(1): 4–6.

[2] X. Huang, Q. Fu, C. Liu, et al. Research on artery perfusion in virtual chinese human modeling. *Chin J Clin Anat*, 2002, **20**(5): 327–329.

[3] X. Huang, L. Yuan, L. Tang, et al. Preparation of the cadaveric specimen of Virtual Chinese Human I before cryomacrotoming it. *Chin J Clin Anat*, 2002, **20**(5): 336–337.

[4] L. Li, R. Zhang, L. Yu, et al. 3D geometric simulation of mandible with dental arch from CT data. *Shanghai Kouqiang Yixue*, 2000, **9**(4): 235–236.

[5] L. Tang, L. Yuan, W. Huang, et al. Data collecting technology on virtual chinese human. *Chin J Clin Anat*, 2002, **20**(5): 324–326.

[6] J. Willer, A. Rossbach, H. Weber. Computer-assisted milling of dental restorations using a new CAD/CAM data acquisition system. *J Prosthet Dent*, 1998, **80**(3): 346–353.

[7] H. Yang, H. Liu, L. Cheng. Three-dimensional finite element analysis of the TMJ and the mandible under orthopedic chincup forces. *Journal of Modern Stomatology*, 2000, **14**(2): 107–108.

[8] B. Zhao, N. Li, Y. Zhou, et al. A study of a three-dimensional anatomic model of mandibles. *West China Journal of Stomatology*, 2002, **20**(1): 21–23.

[9] Y. Zheng, F. Zhang, L. Chen. Establishement of dimensiona finite element model of the dentulous mandible with CT scanning. *Journal of Practical Stomatology*, 2000, **16**(2): 31–33.

[10] S. Zhong, L. Yuan, W. Huang. Suppositional digital human being expand new study area for clinical anatomy. *Chin J Clin Anat*, 2002, **20**(1): 3–4.