3D Human Tissues Modeling In Clinical Applications

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INTRODUCTION

There are many situations in human medicine when it is very complicated to understand condition of patient's body. In these cases it is useful to have 3D computer tissues models. Such models help us to have better idea of patient body condition and help us to plan or simulate surgical procedures. It is also possible to made real copy of the tissues by using some Rapid Prototyping technology. The real models can be also used for surgery planning and simulations. The aim of this poster is to present the 3D tissues models creation methods. Some examples of the models applications in clinical practice of Orthopedic Surgery, Stomatology and Plastic Surgery are also presented.

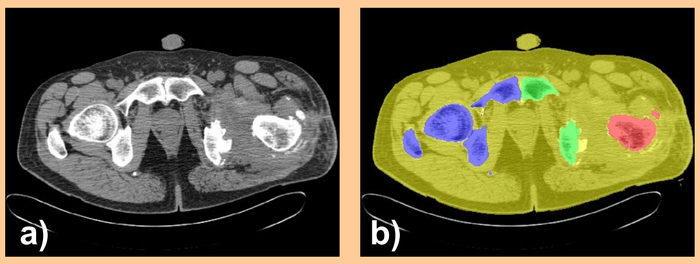

Fig. 1: CT image segmentation: a) source structure image, b) tissues segmented image

SUBJECTS AND METHODS

Some data describing human tissues geometry and structure are needed to create computer 3D geometrical models. As the source data we have used Computer Tomography (CT) and Magnetic Resonance (MR) image diagnostic data (Fig.1a). The source data are 3D, discrete and describe internal structure of patient body. But for our applications we need vector based 3D geometrical tissues models. Therefore, creation process of the 3D tissues models based on the source CT/MR data consist of several steps:

- Tissues segmentation of the source CT/MR data (Fig. 1)
- Vectorization of the segmented CT/MR data by "Marching cubes" method (Fig. 2a)
- Smoothing of created polygonal models by "Geometric signal processing method" method (Fig. 2b)
- Reduction of polygonal models by "Surface simplification quadric error" method (Fig.2c)

Many times we need real tissues models. It is possible to make them effectively by application of Rapid Prototyping (RP) technology. We have used RP machine ZCorporation Z310. The RP machine is able to made accurate (~0,1mm) models in couple of hours, fully automatically and directly from computer data.

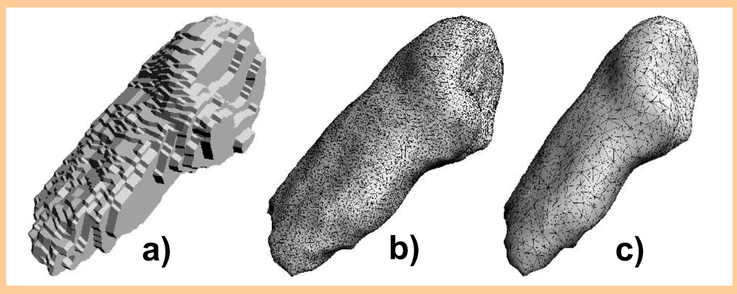

Fig. 2: Tooth model: a) model created by Marching cubes, b) same model smoothed, c) same model after triangles reduction

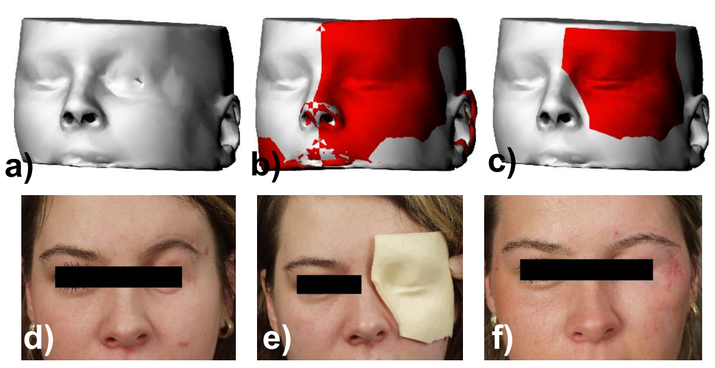

Fig. 3: Plastic surgery application: a) deformed face geometry model, b) face geometry corrected by mirroring, c) face geometry model with designed supplement, d) original face photo, e) face with realized supplement, f) face 6 weeks after correction plastic surgery

RESULTS

Plastic Surgery:

Patient has deformed face because of retino-blastoma (Fig. 3d). We have created 3D geo-metrical model of the face (Fig. 3a). By mirroring we have design face correction supplement (Fig.3b,c). By RP we have made real correction supplement (Fig. 3e). The real supplement was used for planning and in time of correction plastic surgery (Fig. 3f). Three of such surgeries were realized actually.

Orthopedic Surgery:

Patient after complicated hip join fracture and inflammation which has deformed acetabulum (Fig. 4a). From CT data we have created 3D model of pelvis bone. By RP we have made a real copy of the bone (Fig. 4c). The real copy was used for planning of orthopedic surgery, especially choice of implant type, implant position and application procedure (Fig.4d). Five of such surgeries were realized actually.

Stomatology:

Sometimes happens, that some teeth are ectopic (Fig. 5a). The problems can be repaired by repositioning of the teeth into correct position (Fig. 5f). From CT data we have created 3D models of ectopic teeth (Fig. 2). By RP we have made their real copies (Fig. 5e). In time of surgery the copies were used to help prepare recipient alveolus (Fig. 5c,d). Ten of such surgeries were realized actually.

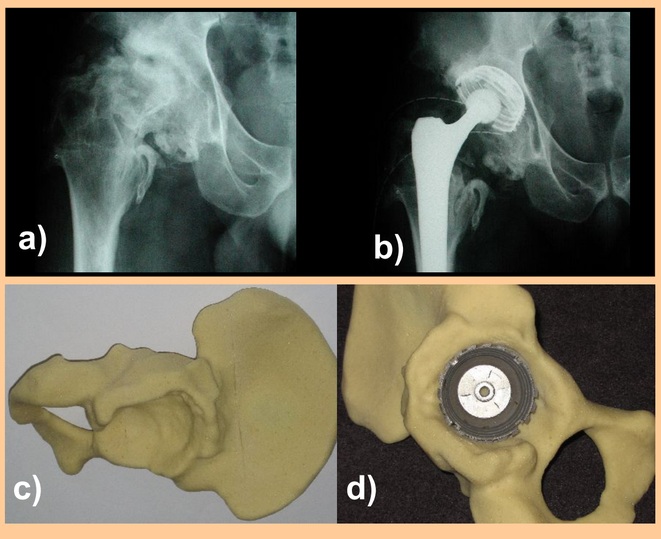

Fig. 4: Orthopedic surgery application: a) RTG of deformed hip join, b) RTG of corrected hip join, c) real model of pelvis bone, d) simulated implan-tation of artificial acetabulum

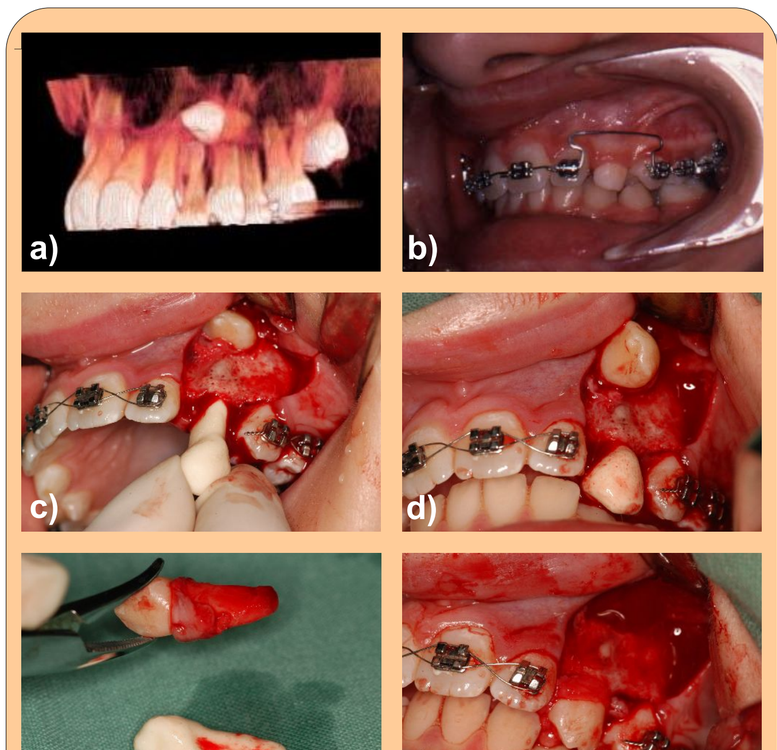

Fig. 5: Stomatology application: a) 3D volume view on teeth situation with ectopic canine, b) before surgery, c) canine real copy used for probing of prepared recipient alveolus size, d) canine copy inserted in prepared recipient alveolus allow to check articulation, e) extracted impacted perma-nent canine and its real copy, f) permanent canine transplanted to its correct position

CONCLUSIONS

The applications of the 3D tissue models or their real models are very useful in case of complicated situation inside of patient body. The tissue models can be used for surgery planning, surgery procedure simulation and as a supports helping in time of surgery. Also it is possible to use them for surgeons training and real surgery simulators.

Surgeries supported by the models could be more accurate, with lover risk of possible complications and shorter. Generally it helps to made health care better and cheaper.

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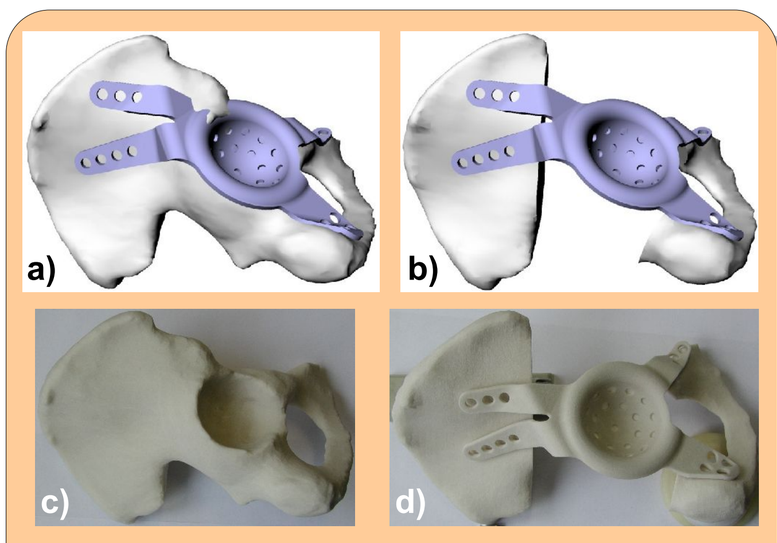

Fig. 6: Custom made implants design: a) virtual design of custom made acetabulum implant based on pelvis bone 3D computer model, b) virtual application of the custom made implant, c) real model of pelvis bone, d) real simulation of implantation surgery procedure with real model of designed implant.
The application was realized in cooperation and for Czech company Beznoska a.s., Czech producer of orthopedic implants and instruments.