How to Make a Three Dimensional Realistic Model for Human Swallowing

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Abstract—The purpose of the study was to prepare a three dimensional model of human swallowing for further numerical simulation. CT of head and neck, video-fluorographic movies, and cine MRI of swallowing provided medical data for producing the realistic model. Those data were integrated on 3 dimensional computer graphics (3D-CG).

This study firstly proposed a way to make a 3D realistic model for numerical analysis of swallowing, and secondly indicated that 3D-CG software was useful to integrate incompatible data from different sources because of its having less limitation, as far as the results should thoroughly be verified from the viewpoint of medical science.

I. INTRODUCTION

The urgent clarification of the swallowing mechanism has been desired in order to take effective steps against aspiration pneumonia and food suffocation, which have rapidly increased in aging societies. Swallowing motion happens in almost a second involving consequently from the mouth, pharynx and to the esophagus. Each organ has so complex figure and moves so fast that the assembly is too complicated to be demonstrated by any medical images.

The purpose of this study was to demonstrate a 3D swallowing model matched to real structure and motion, which was produced from integration of the several medical images by mean of 3D computer graphics [1].

II. METHODS

CT images with slice thickness of 0.625mm of the head and neck region were done in the usual manner. The DICOM data were exported to 3D reconstruction software (Mimics, Materialize Inc.), Automatic depict was carried out for bone structures and manual trace was for soft tissues. The data formatted as stl were exported to 3D CG software (3ds Max, Autodesk Inc.), where the data were regularly rearranged in their figures and polygons. Thus the 3D model at the respiration was made.

The 3D model and the images from VF movies should be put together. At first, the jaw bones were superimposed by means of shifting and rotating the VF images. Then, the cervical vertebrae angle to the head of the 3D model was adjusted to the VF images. This was the first frame of the 3D swallowing model.

Next step was to make a 3D motion model in order to demonstrate the motion of swallowing organs. At first, each frame from the VF movies on the 3D software was appointed to shift to the next frame when the time on the 3D software advanced. With shift of VF images frame-by-frame, we changed positions and figures of the organs of the 3D model.

III. RESULTS AND DISCUSSION

The 3D realistic model was evaluated as to whether the model was suitable to the numerical analysis. The numerical analysis method we used was the moving particle simulation method (MPS method), which is one of non-mesh, particle simulation method. A commercially available software (Particleworks, Prometech software Inc.,) was used for the analysis.

The simulation images were clear without particle leakage or vent. The figure, speed and timing of the bolus flow were also well approximated.

The 3D realistic model presented clear solid figures of not only the bone structures but also all soft tissue organs. The 3D model demonstrated motions of all organs and bolus, in any view and at any time. The cross sectional images at any time were also visible (Fig.1).

The 3D realistic swallowing model might be useful not only for a simulator to clarify swallowing mechanism, but also as a teaching material for students and medical staffs.

Fig.1. The model matched to the real figure and motion. The mucosa, soft tissue, and bone were demonstrated.

REFERENCE