Title:
Modelling of Temporomandibular Joint

Authors:
Ishfaq A. Ahmed, 20mmed07@iiitdmj.ac.in, PDPM IIITDM-Jabalpur, India
Vijay K. Gupta, vkgupta@iiitdmj.ac.in, PDPM IIITDM-Jabalpur, India
Anubhav Tiwari, 1713605@iiitdmj.ac.in, PDPM IIITDM-Jabalpur, India

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Introduction:
The body is a remarkable structure and joint is one of them. One of the fascinating parts of the human body is the Temporomandibular joint (TMJ) for its movement, complexity, and degree of freedom. The most distinguishing part is the movement of the mandible and its sliding action over the articular disc in a forward and downward direction causing the motion of protrusion and retrusion in the face, giving the jaw 6 degrees of freedom. [8]

So as to understand and simulate the work we need to model the mandibular bone and other parts in the related area so as to study the load in the TMJ and understand the pattern of loading in the area. Formulating the co-relation of geometry and stress on the mandible. Also, change in the muscular coordination and or transfer of load in TMJ in various activities.

TMJ is the joint in the face that connects the mandible with the skull. It plays the important role in various activities like drinking, screaming, biting, mastication, yawning, speaking, and swallowing food [7]. Mastication or chewing is one of the essential functions of the human body controlled by TMJ and various studies have helped to study the model and simulation of the same. [10]

Temporomandibular disorder (TMD) is a generic term used to describe the disease or issues related to the Joint [3]. Various reason for the having problem in TMJ is due to injury, grinding issue, dislocation of Jaw, or osteoarthritis in TMJ. Various surgeries for correcting the mandibular bone and other parts in the related area have led to studying the load in the TMJ and understanding the pattern of loading in the area. Formulation of the co-relation of geometry and stress on the mandible. Also, change in the muscular coordination and or transfer of load in TMJ.

In this paper we will see the procedure of modelling the TMJ joint using the DICOM file from the CT scan data.

Main Idea:
The main idea is to create a 3D model of the mandible and other parts related to TMJ that could be used to generate the implant. This would benefit to design of a more suitable implant for the patient that would enhance the stability, implant life, and compatibility of the mandible implant to the patient's body. Moreover, it gives the future use of the model generated for the stress analysis and customized implant printing that could be used for patient-specific conditions.

For achieving the goal, we need to follow a systematic procedure and in the paper we create a flow chart in which a person can work so as to achieve the goal of modelling the TMJ and use it for further process. This steps majorly consists of Collecting the data, followed by Modelling of the parts, and finally the Assembly of all the parts. This can be understood from the below figure.

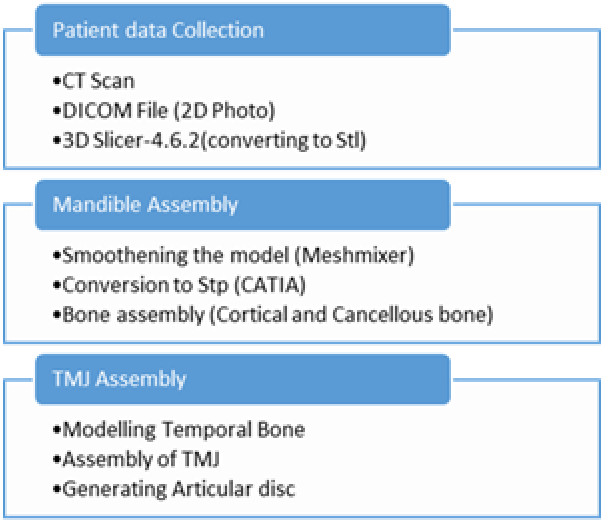

Fig. 1: Proposed Work Methodology.

Discussions:

This article gives a step wise procedure in which how the data is collected from the patient by carrying out the CT scan on the Patient, in our case it was a Asian Male of age 29.

Fig. 2: CT Scan Image: (a) Axial Plane, (b) Sagittal Plane, and (c) Coronal Plane (referred to from left to right).

The collected DICOM (Digital Image and communication in medicine) file is imported into the 3D Slicer [6]. From the imported data, the 3 View is seen i.e., Axial, Sagittal, Coronial Plane. Axial Plane scanning is done in the offset of 5 mm and 53 slices are formed, then the Coronial and the Sagittal plane is scanned in the offset of 1 mm, and 231 Slices are formed on each plane.

Based on the threshold values of Hounsfield the Bone region is separated out from the Muscle and skin region. Followed by which the segmentation and generation of part is carried out. Once the model is formed in the 3D slicer we carry out the smoothening process on the part body to achieve more smoothened surface in the Meshmixer [2].

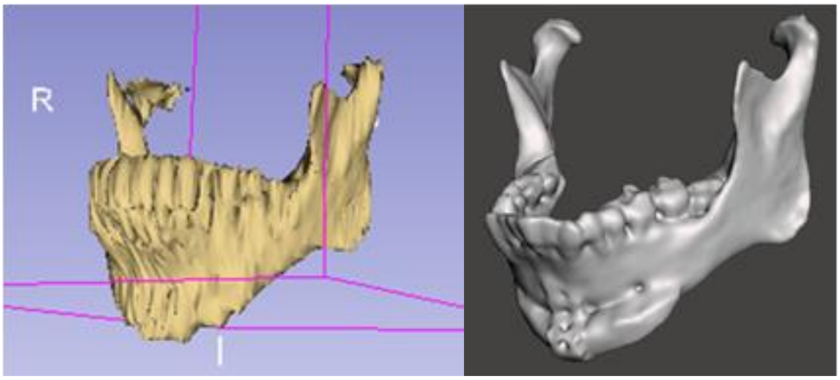

Fig. 3: Fig. on left a) Before Smoothening Mandible; Fig. on right b) After Smoothening Mandible.

After smoothening of a model, the STL file is imported in the CATIA [5] in the shape sculpture. The model is post repaired in CATIA for any loss of data during conversion, the mandible is converted into the solid model. After completing the solid model, the thickness analysis was carried out and the lower thickness section was corrected or eliminated based on the area of interest.

Similar segmentation procedure is carried out over the Skull region to segment out the temporal bone. In addition to earlier step a plane cut is performed after smoothening of the model (skull) to separate out the region of interest or the temporal bone, and repairing the model after the plane cut, and sectioning to have a proper model.

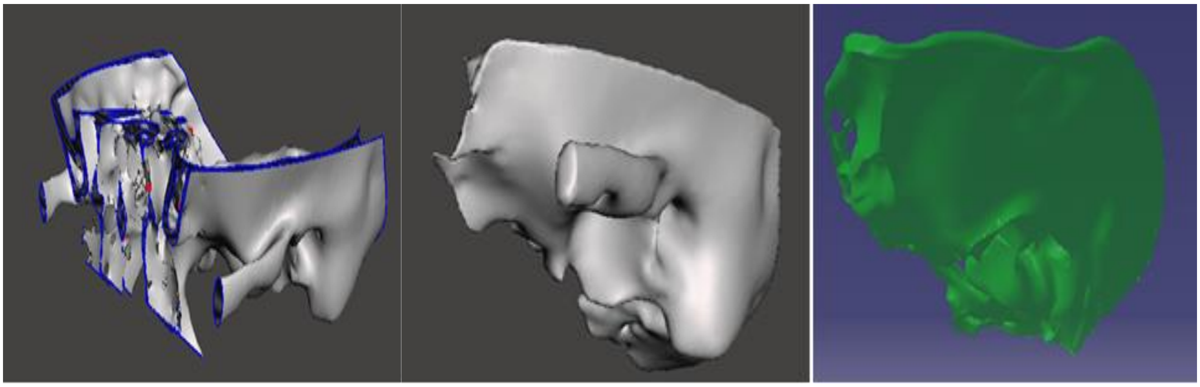

Fig. 4: Fig. from left to right, a) Cutting Plane of Skull, to form temporal bone; b) Post Repair of Temporal Bone; c) Correction for lower thickness.

Once both sides of the temporal bone are modelled, we move into the Assembly part and assemble the Mandible with both the temporal bone. The region in between the temporal and mandible region is modelled considering the Articular disc in the place in between.

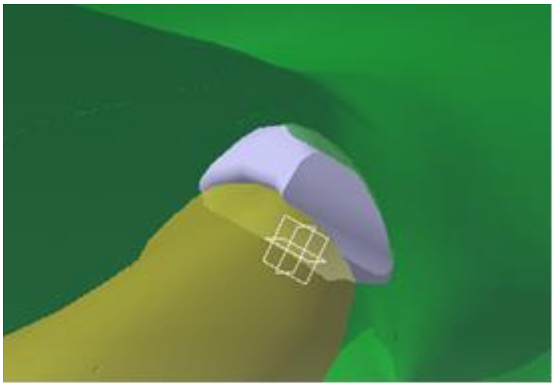

Fig. 5: Modelling the Articular Disc

Once all the three major parts are modelled, the assembly is carried out in such a fashion that it fits properly on the spatial plane and this can be used to simulate and analyze for stress simulation and implant design.

Conclusions:

This article gives a different approach on how to make a computer model of the temporomandibular joint that comprises the jaw (mandible), articular disc, and temporal bone. This model could be used for investigating the dynamic analysis of the jaw and the TMJ region. This will possibly be used to development of the implant and increase the life of the implant used.

This article also highlights on the future work that can be carried out considering the inputs from the 3D model generated from the DICOM file and its application like implant design and dynamic analysis and customization and motion study, which is open for study.

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