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3D VIRTUAL PRESURGICAL PLANNING FOR THE PLACEMENT OF DENTAL IMPLANTS.

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ABSTRACT

In case of loss of one or multiple teeth dental implants are first choice but there are certain challenges in the placement of dental implants like accuracy of placement and chances of collision of drill with the nerve. Therefore, planning becomes the crucial part of procedure for placement of implant in bone at suitable location. In this work our focus is to do the optimum position of implants virtually by addressing the above mentioned issues and to achieve precise drilling and implant placement.

Keywords: Dental implants, Implant placement, Bone.

INTRODUCTION

A number of options exist for the replacement of missing teeth. The most recent of these is dental implant. Modern dental implants are the treatment of choice for the replacement of missing teeth. Dental implants offer an excellent alternative to the limitations of conventional dentures, bridges and missing teeth. Dental implants are changing the way people live, they are rediscovering the comfort and confidence to eat, speak, laugh and enjoy life. [5]

While dental implants are expensive in the short term, they are long lasting and more tooth saving than traditional bridgework since they do not rely on neighbouring teeth for support. It is impossible to put a price tag on some of the aesthetic and health benefits of dental implants. Dental implants integrate with the jawbone to help prevent the loss of bone that accompanies conventional dentures or bridges. The level of pain or discomfort that the majority of patients experience in the process of getting implants is very little to none. Not everyone is a candidate for dental implants. Adequate bone in the jaw is needed to support the implant, and the best candidates have healthy gum tissues that are free of periodontal disease. [13].

Steps involved in dental implant surgery are incision, pilot drilling with the twist drill, incremental drilling, conical reaming, implant placement, healing time, placement of abutment and placement of tooth crown. From the accuracy point of view the most important step is drilling which involve both pilot drill and incremental drilling. The technique of using surgical guides for the placement of implants is known as pre surgical planning in which surgeon can ensure placement of implant at the location where there is sufficient bone, no chances of collision of drill with the nerve and the drilled

hole is of exact size as desired which further results in less chances of implant failure and less healing time.

In the 3D virtual presurgical planning for dental drilling software named mimics innovation suite was used and below said objectives were kept in consideration:

1. How deep drill /implant can go inside the jaw bone without touching the nerve and there must be at least some gap between the two as a safety measure.
2. To ensure sufficient bone around the implant.
3. To get the measurements: How deep to drill in the jaw bone and what should be the angle of drilling.

The final decision regarding all the three points would vary case to case and on the decision of the dental surgeon.

The basic requirements for virtual pre surgical planning for the placement of implant using image processing software are:

- CT scan in dicom format for the studying the jaw and determining the coordinates for performing the drilling operation.
- Mimics Innovation suite, it is a software with complete set of tools developed for biomedical professionals that allow them to perform a multitude of engineering operations starting from medical imaging data. The suite consists of three modules which include: Mimics, 3-matic and Magics.

  Mimics: This software is for Medical Image Segmentation and 3D model creation. The Mimics can be used for the segmentations of 3D medical images (coming from CT, MRI, micro-CT, CBCT, 3D Ultrasound, Confocal Microscopy). Results obtained are highly accurate 3D models of patient's anatomy.

  3-matic: It is truly unique software to combine CAD tools with pre-processing (meshing) capabilities and is a perfect complement to CAD package.

  Magics: It is the most powerful STL editor. It is a user-friendly data preparation software package.

METHODS AND TECHNIQUES

A. Segmentation of mandible from the full face CT scan

First of all it is necessary to segment area of interest i.e. the portion at which we are going to work and in this case it was mandible. Whole dicom folder was imported in mimics. The moment data set was imported, the basic information regarding dataset including the number of slices, slice thickness and other machine parameters appears on the screen. Data set can be visualized in the three different views coronal, sagittal and axial views.

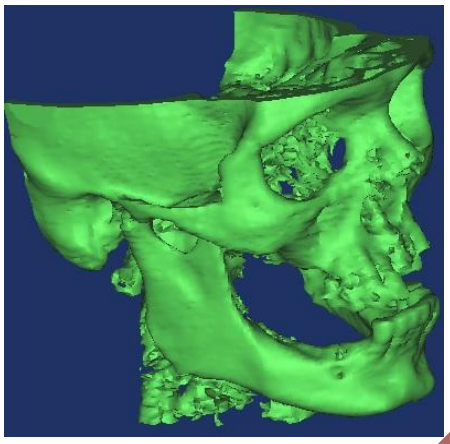

Figure 1. 3D model of a mask created in mimics from CT scan.

The sequence of commands used for the segmentation of mandible and creating its 3D model:

- Creation of new mask by choosing specific threshold value which is only for the tooth.
- Calculate 3D (Transform data from the 2D images into a 3D model).
- Region growing in order to separate out floating pixels and remove unwanted areas.
- Edit mask in 3D (Editing can be done on a mask in the 3D view).
- However, a new 3D model must be calculated after editing is done in order to view the changes: Box was resized including all the region of interest. Region was marked that we want to get rid off and in this case this is the points at which mandible is attached to other bones or portion of face and hit remove.
- Further refinements were done on 2D images by using other commands like edit mask by removing unwanted portion layer by layer, Wrapping and smoothing by using suitable parameters.

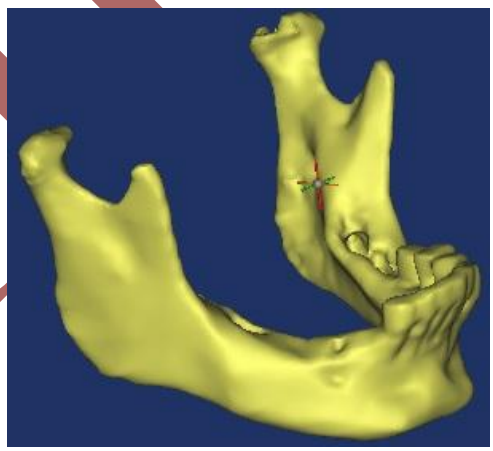

Figure 2. 3D model of segmented mandible.

B. *Segmentation of nerve*

To minimize the potential risk of damaging the nerve while drilling and placement of implant, it is necessary that it must be clearly visible at its exact location while planning the surgery and for this segmentation of nerve is required and the sequence of command used are:

- Dynamic region growing (It allows to grow a mask from a selected point without having to threshold first. It is extremely useful for vessels, nerves, and arteries.): Firstly it's needed to restrict to specific area and then click on specific point that needs to segmented out. A click on point shows value of threshold at a particular point and then select minimum and maximum deviation and select multiple layer because then we look at whole data set which falls under the box for the selected threshold value (within range of deviation). It was required to delete the connections of nerve from outside portion so that we just get nerve.
- Calculate 3D was used to create 3D model of nerve
- Extra portion which is not part of nerve was removed by using command edit mask in 3D.
- Nerve can be wrapped and smoothened.

This nerve provides us a reference to place implant inside. Figure 3 shows the 3D model of segmented nerve inside mandible while keeping the transparency of the mandible on.

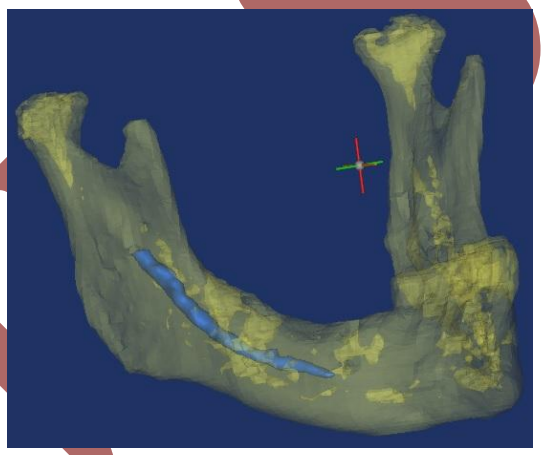

Figure 3. 3D model of segemnted nerve visible inside mandible.

C. *Determination of Drill / Implnat position*

To determine the position for drilling and placement of implant both nerve and mandible were transferred from mimics to 3-matic module of mimics suite, to do this we just need to copy 3D objects from mimics and paste them in 3-matic and a new primitive (cylinder of required length and diameter) was created in 3-matic which acts as an implant. Then it was required to place the cylinder at the position of implant, it was done by using commands interactive translate and rotate by dragging cylinder in any direction XYZ and rotating it and while doing this transparency of mandible was kept on to see how deep implant can go without hitting the nerve and keeping a safe distance from nerve and one more point need to be kept in mind while placement of implant in the jaw is that there must be sufficient bone around the bone to support it. To perform optimum placement of implant dental surgeon needs to be consulted.

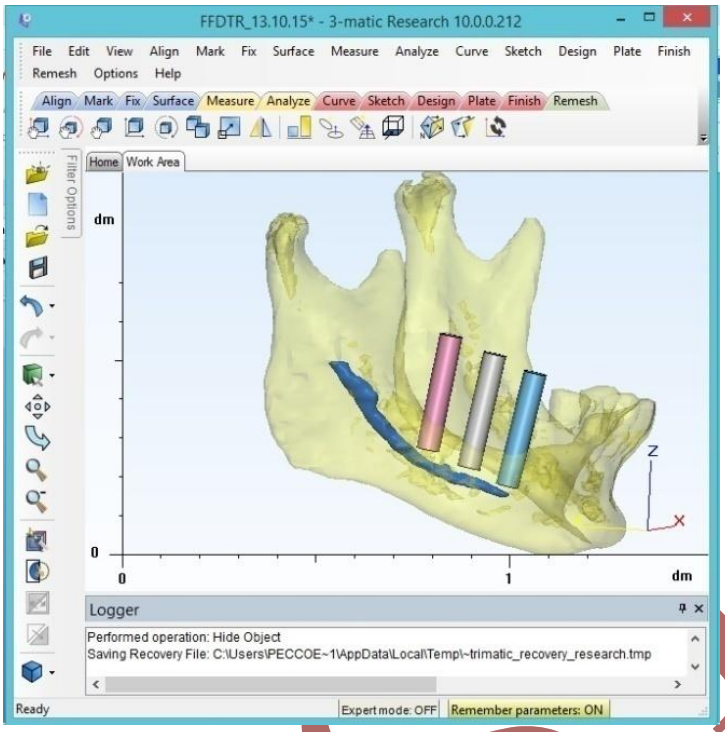

Figure 4. 3-matic window for planning the implant position.

D. ***Measurements***

After the placement of the cylinder at the desired location linear and angular measurements were taken. Basically, these measurements were required: 1. Distance of cylinder from the nerve 2. How deep cylinder can go inside the jaw. 3. Angle of the axis of the cylinder with reference to any imaginary reference plane.

All the above said measurements were done in 3-matic. First two were Linear, which were taken by just selecting the points along which we want to measure the distance and for the last one i.e. for angular measurement firstly a reference plane was created and the then the angle was measured between the reference plane and the axis of the cylinder.

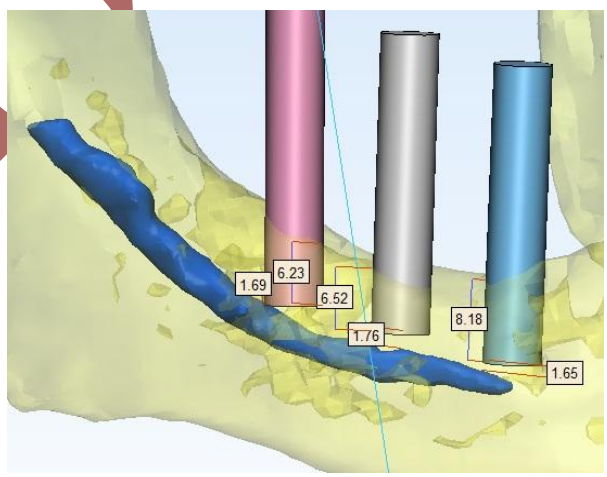

Figure 5. Measurenst done in 3-matic.

E. Implant Position Verification

Further a quick compression was done to check the fitment of implant in mimics. It was done by transferring mandible, nerve and the cylinder into mimics by just copying and pasting. Mandible, nerve and cylinder were at same location with reference to each other in mimics as they were in 3-matic.

Contours of the cylinder and mandible were turned on. In the coronal and sagittal views of figure 6 it can be seen that weather the implant hits any of the tooth & nerve and if there is sufficient bone around the implant to support it.

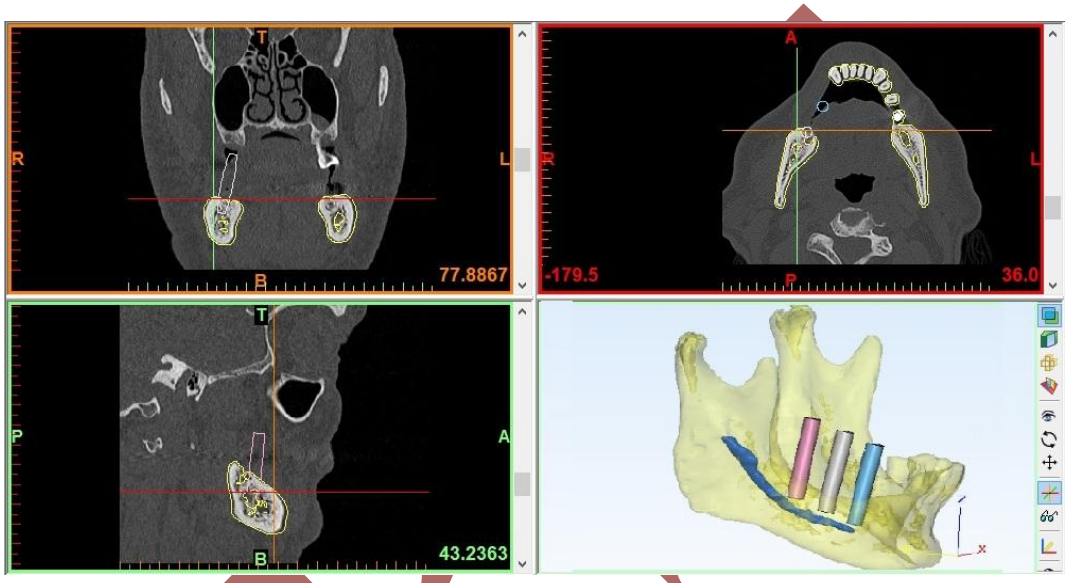

Figure 6. Implant position verification in mimics.

DISCUSSION

In this work, an attempt has been made to do the presurgical planning virtually by using mimics innovation suite. Firstly of all mandible and nerve were segmented from full face CT Scan and their 3D models were prepared and after that virtual implants were placed in the jaw while insuring sufficient bone around the implant and implant should not intersect with the nerve while maintaining sufficient gap between the nerve and implant. After the placement of implant/cylinder linear and angular measurements were taken which can help the surgeon to preplan the surgery virtually and he or she will get an idea how deep implant has to go inside the jaw and what has to be the angle of drilling, which further may improve the success rate of the implants.

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