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**WORK INSTRUCTION IMAGE PROTOCOL AND SEGMENTATION**

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## 1. INTRODUCTION

Mimics is a software developed by Materialise specifically for the processing of medical images. This software is used for the segmentation of 3D medical images (from CT, MRI, microCT, CBCT, Ultrasound) and the result is high-precision 3D models of the patient's anatomy. In this protocol, the process of segmentation of medical images will be described in detail to obtain the 3D reconstruction of the anatomical parts analyzed.

## 2. OBJECTIVE

The objective of this work instruction is to give a detailed overview of all steps that are to be performed in the image quality check and the segmentation by company Planning Assistant using Mimics Medical Materialise software, to ensure high quality, standardized, and production process.

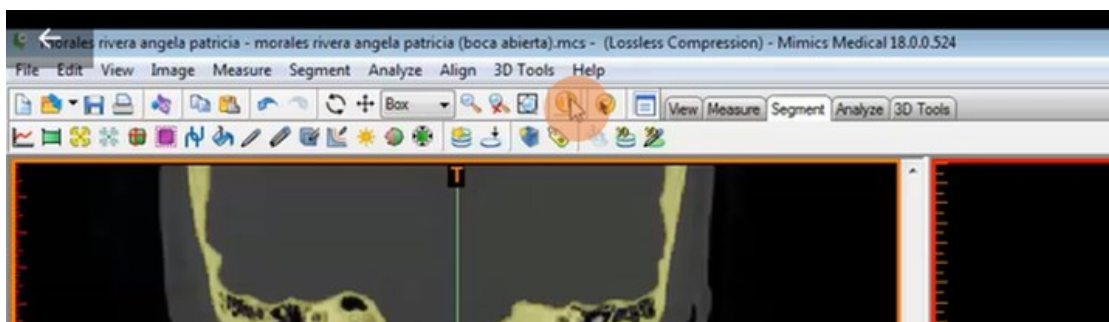
## 3. IMAGE PROTOCOL

The files must be only in DICOM format. You cannot receive other formats (JPG, PNG, OBJ, IGES, etc.) because the Mimics Medical Materialise software cannot read these files.

Generally, in cases that require a separate jaw, it is recommended to send us open-mouth and closed-mouth CT scans. If the open-mouth CT is not available, manual segmentation must be performed.

DICOM scan must comply with the parameters of the company protocol (see table 1). Open the DICOM file in Mimics and click on the “project information” icon to validate this data.

In addition to the information from the company protocol, validate that the files contain the patient's information to verify that the images correspond to the case under study.



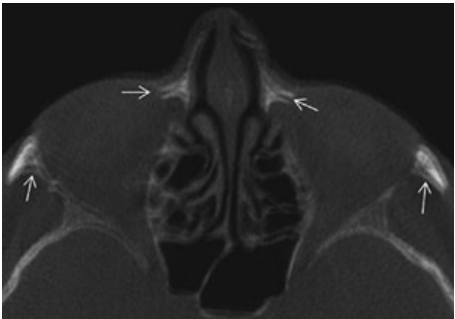
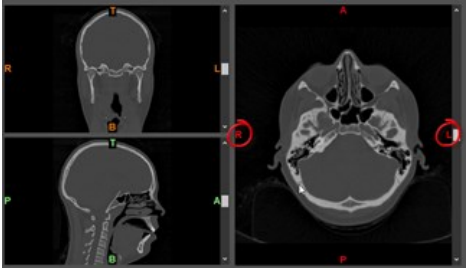
*Figure 1. Mimics Medical interface.*

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*Table 1. CT scans satisfy company protocol*

CT SCAN PARAMETERS						
PARAMETERS	Orthognathic - Reconstruction	Cranial	Facial Implant	Leg Region (fibula)	Hip Region	Orthopedic
Imaging scan time	≤ 3 months.		≤ 6 months.	≤ 3 months.	≤ 3 months.	≤ 3 months.
mAs	≤ 200.milisegundos			Automatic	NA.	??
Slice Thickness	≤ 1.0mm.			≤ 1.0mm.	≤ 1.25mm	
Slice increment	≤ 1.0mm.			≤ 1.0mm.	≤ 1.25mm	
Reconstruction algorithm	Bone or high resolution.			Moderate-Soft tissue -NO bone -Detail	Standard or Soft tissue	??
Axial tomography	True axial slices are recommended.					
helical tomography	A negative PITCH is required.					
Matrix	512 x 512					
Orientation	RAB					
Pixel size	≤ 1.0mm.					
Gantry Tilt	0°.					

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No presence of Motion (Not in the region of interest)	
R/L indication (If you need to indicate the right and left side, the images needs to be rejected)	

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3.1. File of view per case for segmentation.

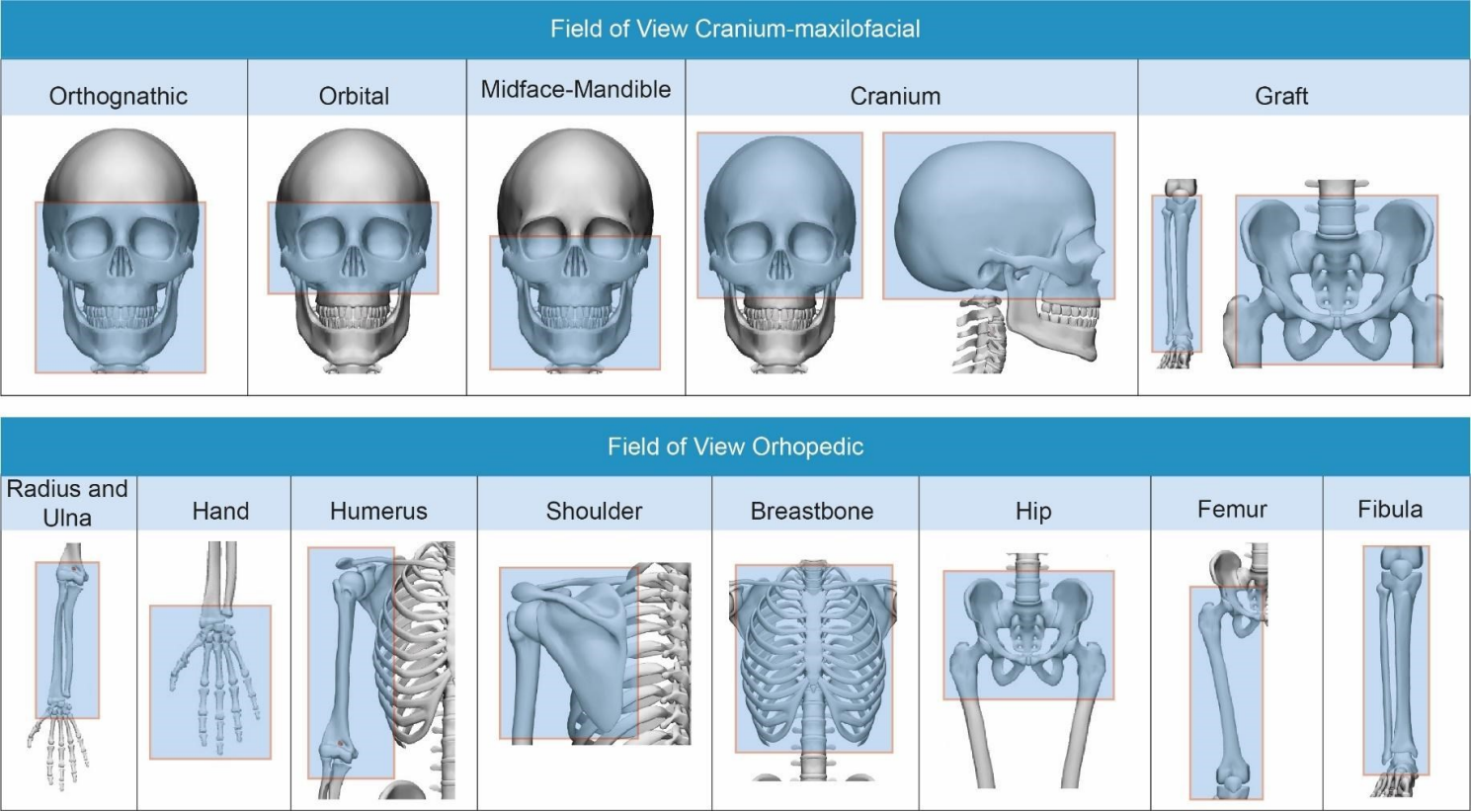


Figure 2. Field of view per case.

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#### 4. TYPE OF IMAGES.

##### 4.1. X-rays:

X-rays are a type of radiation called electromagnetic waves. X-ray imaging creates pictures of the inside of your body. The images show the parts of your body in different shades of black and white. The most familiar use of x-rays is checking for fractures. ***X-rays aren't valid to start the company process. It could be used as an additional file.***



Figure 3. X-ray image.

##### 4.2. CBCT:

Cone Beam Computed Tomography is a radiographic imaging method that allows accurate, three-dimensional (3D) imaging of hard tissue structures. ***They are valid to start the company process.***



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Figure 4. CBCT image.

#### 4.3. CT:

A computed Tomographic or TAC scan combines a series of X-ray images taken from different angles around your body and uses computer processing to create cross-sectional images (slices) of the bones, blood vessels, and soft tissues inside your body. ***They are valid to start the company process.***

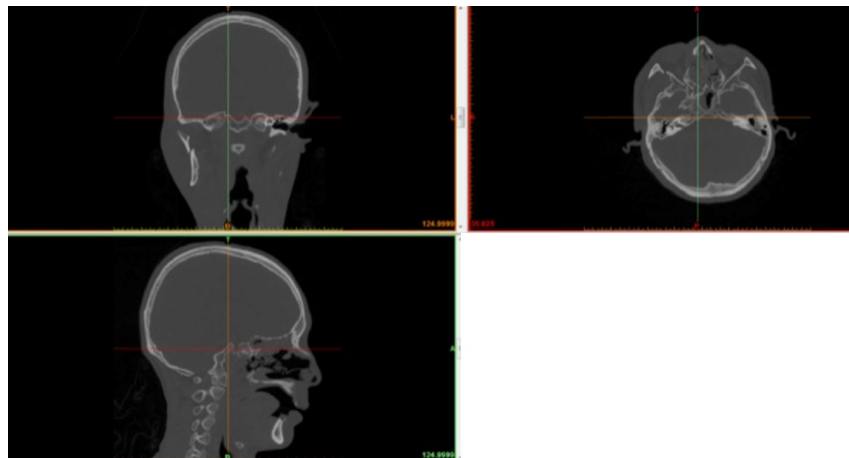


Figure 5. CBCT image.

#### 4.4. MRI:

Magnetic Resonance Imaging is a medical imaging technique that uses a magnetic field and computer-generated radio waves to create detailed images of the organs and tissues in your body. ***MRIs aren't valid to start the company process. It could be used as an additional file.***



Figure 6. MRI image.

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## 5. SEGMENT WITH SCRIPT (MIMICS TRAINING).

Open Mimics Medical software

### 5.1. Scripting library:

The first step for the segmentation process selects the automatic segmentation created by company.



Figure 7. Select the scripting library.

Mark each item as soft tissue, metals, save rejects, and shell reduction. After that browse the DICOM or DICOMDIX archive, which is on the “Local Disk C”. Click “ok” to continue. Next, select the type of procedure you need.

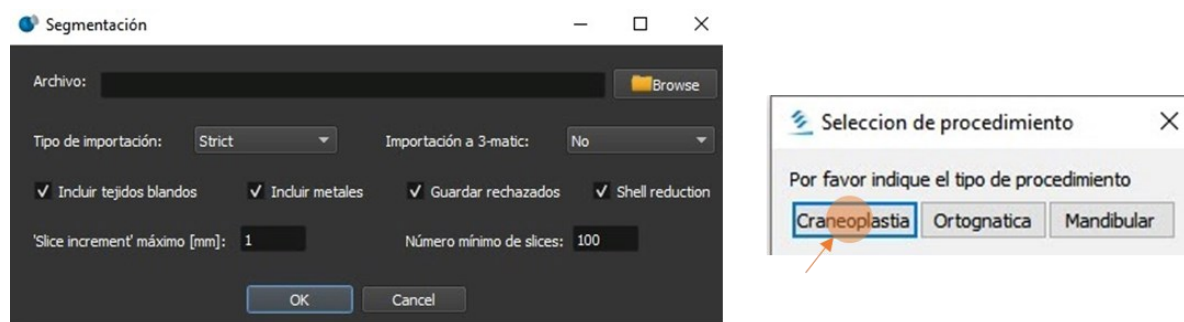


Figure 8. Browse the DICOM file and procedures type.

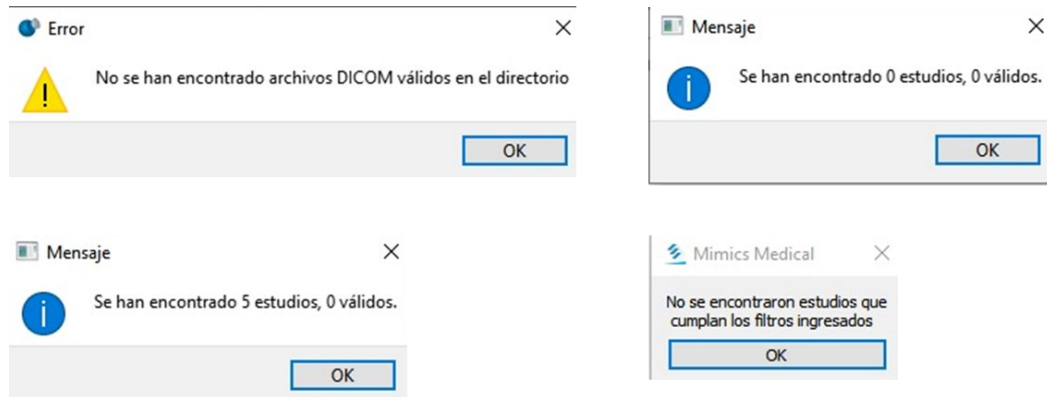
### 5.2. Incorrect files:

If the DICOM files are incorrect, these are the possible messages you may see. The messages may say that the files aren't found, there aren't studies in the file, the



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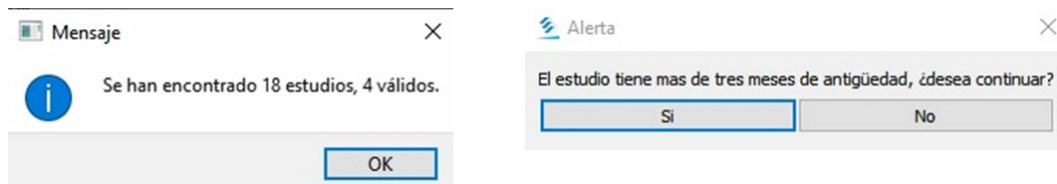
program found some studies, but they aren't valid, and the studies don't meet the company filters.



**Figure 9. Messages for wrong files.**

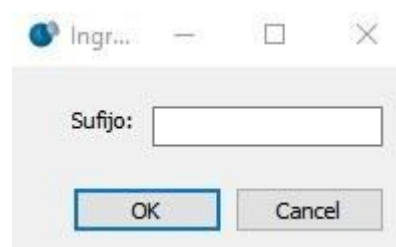
### 5.3. Correct files:

When the DICOM files are correct, you will see these messages. Click "ok" to continue with the study. Later, if the time in which the DICOMs were taken doesn't affect the design process, you can accept and obtain the segmentation proposed by the scripting.



**Figure 10. Messages for correct files.**

Finally, add a suffix for found files and save.



**Figure 11. Messages for correct files.**

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### 5.4. Export STL:

On the right of your window, you will see all masks. You must save the STL files of the study (*Soft tissue, Bone, and teeth*) with the company code and the patient's initials.

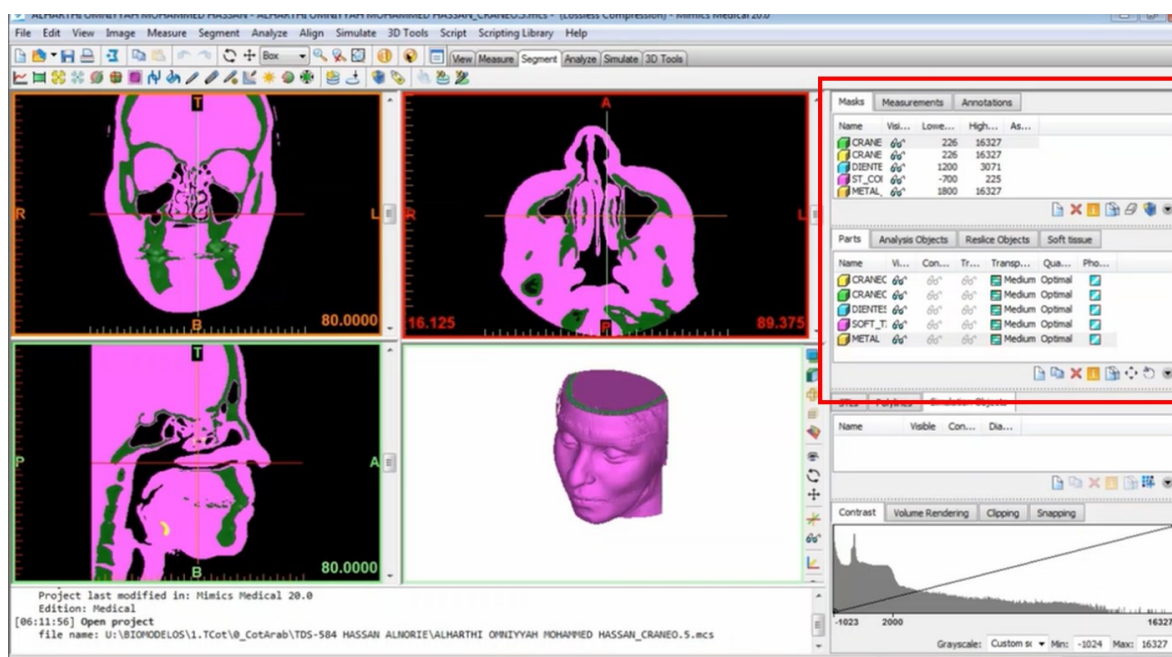


Figure 12. The final 3D reconstruction.

## 6. MANUAL SEGMENTATION (MIMICS TRAINING).

Open Mimics Medical software

### 6.1. New project:

The initial step for the segmentation process is to create a new project from "File" – "New Project Wizard" as shown in the image below.

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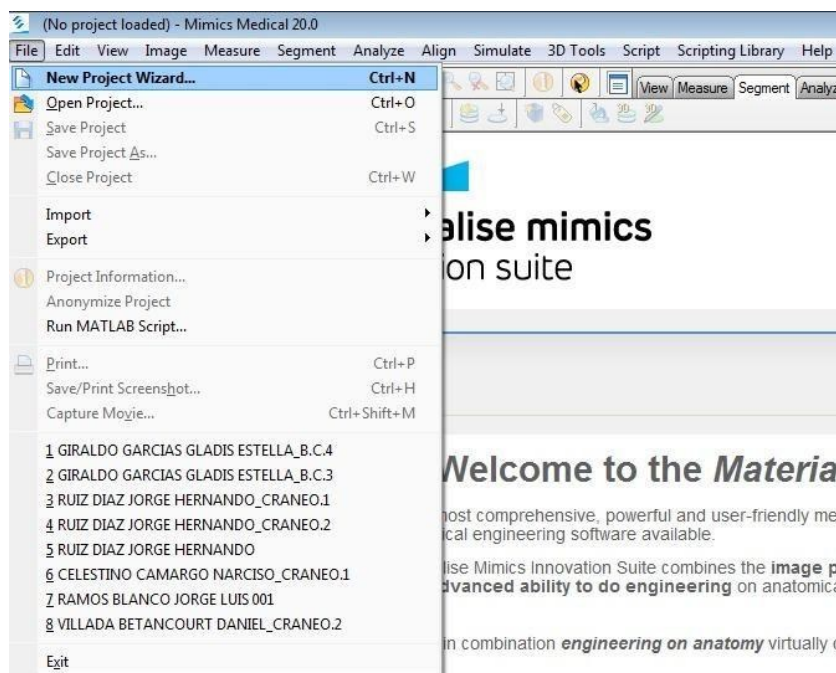


Figure 13. Mimics Medical interface.

- Select DICOM file: Then you must select the folder that has the DICOM or DICOMDIX archive, which is on the *Local Disk C*, select "Next" to continue.

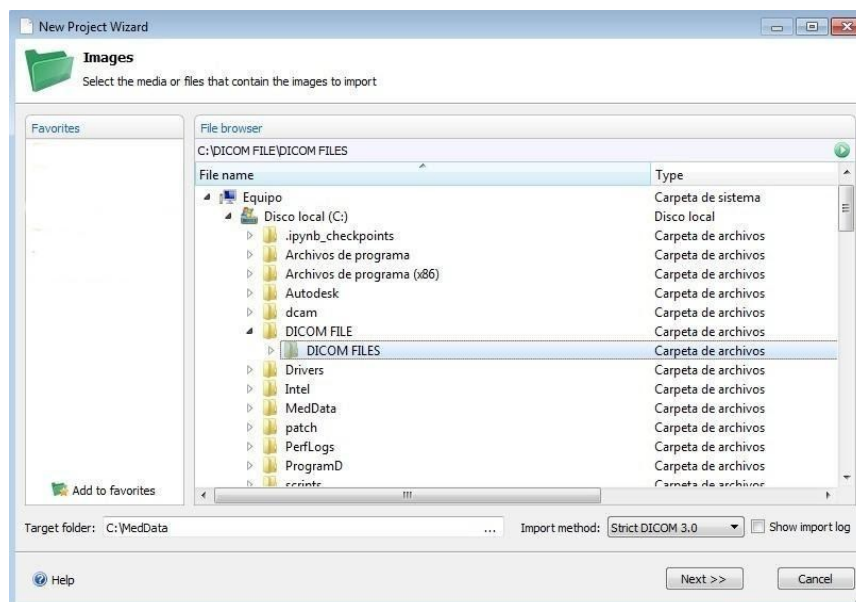


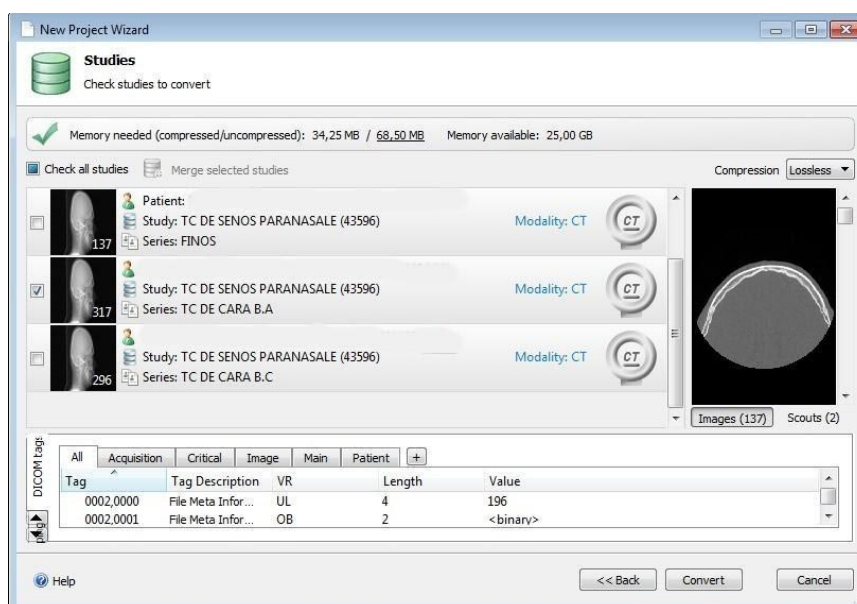
Figure 14. Selecting the DICOM file.

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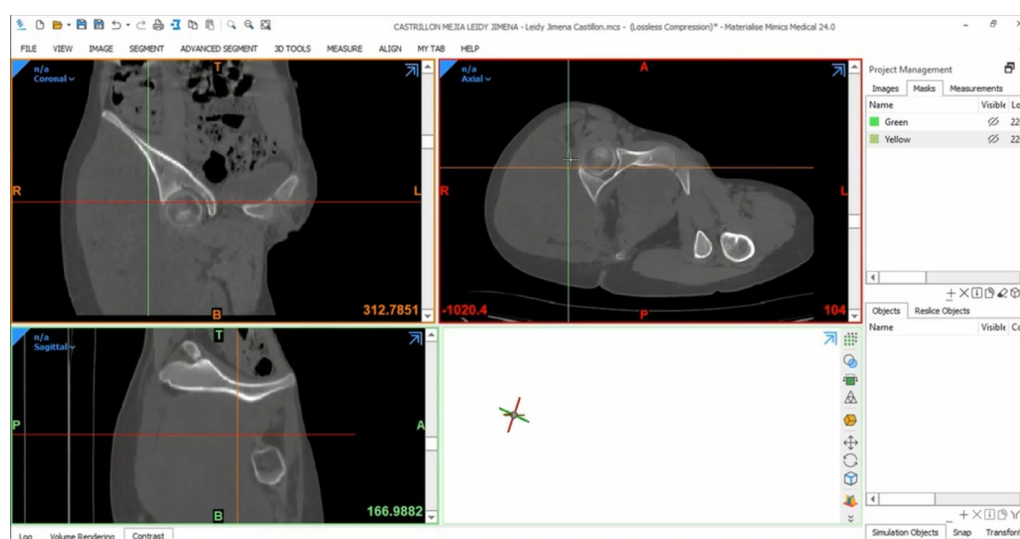
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- Convert Files: Choose the study with the most cuts (317 for this example), select the "Convert" option to continue.



**Figure 15. Conversion of the DICOM file.**

Below, you can see the images in the different planes: axial, coronal, and sagittal. With the mouse, you can move through the slice and change the contrast to the images.



**Figure 16. Visualization of the images in the axial, coronal and sagittal planes.**

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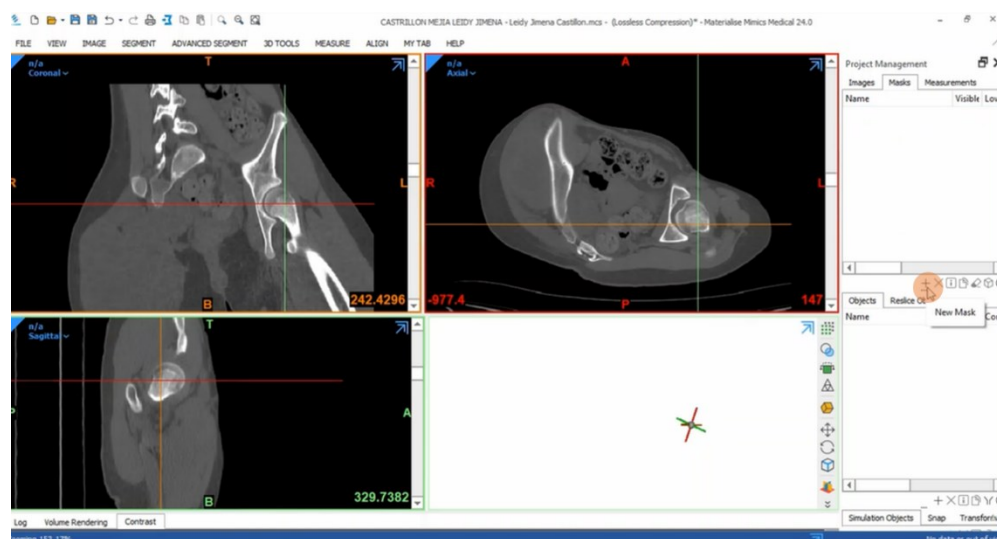
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### 6.2. Selection of parameters for segmentation:

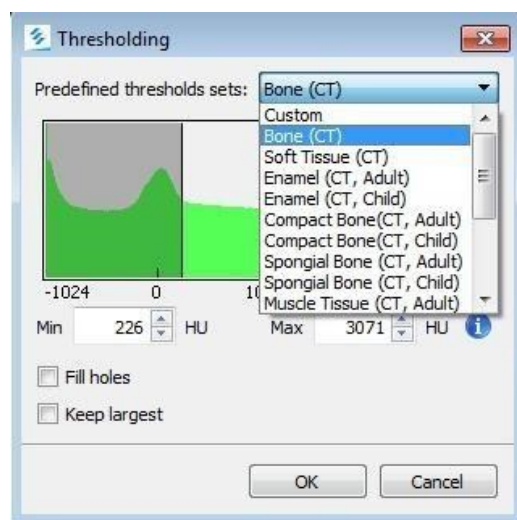
You can select the “New mask” or “thresholding” icon.

- **Thresholding:** The Thresholding technique is a type of image segmentation, in which areas of interest of an image are selected separating them from the rest:



*Figure 17. Selecting the Thresholding operation.*

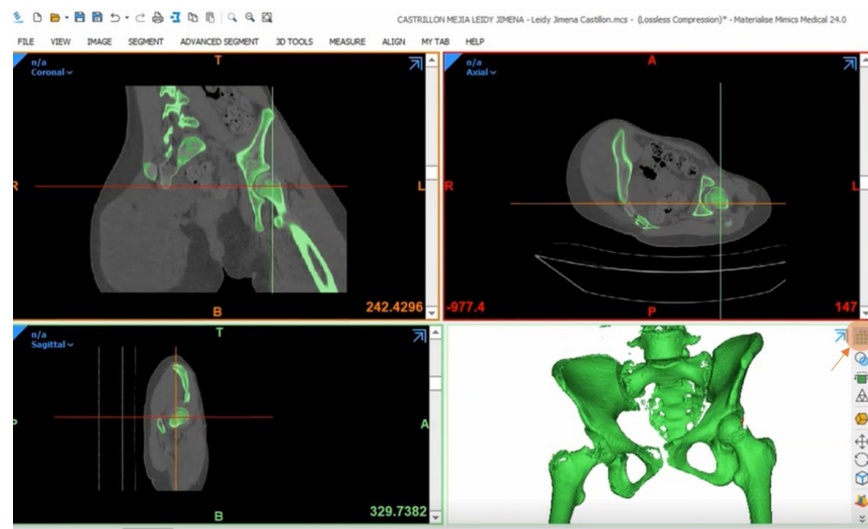
Some predefined filters can be selected. But it is possible to modify the threshold range to include/exclude different tissues.



*Figure 18. Selection of filters.*

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By selecting this icon, we will bring a 3D preview of the selected threshold, then, when you are satisfied with the model, continue clicking on "OK". (Not available for Mimics 20.0)



**Figure 19. Selection of the predefined set of thresholds: Bone, Soft Tissue, Metal, etc.**

- Eliminate noise: The "Region Growing" tool is used on the right side of the Thresholding button to eliminate any noise. The skull is selected by clicking on it.

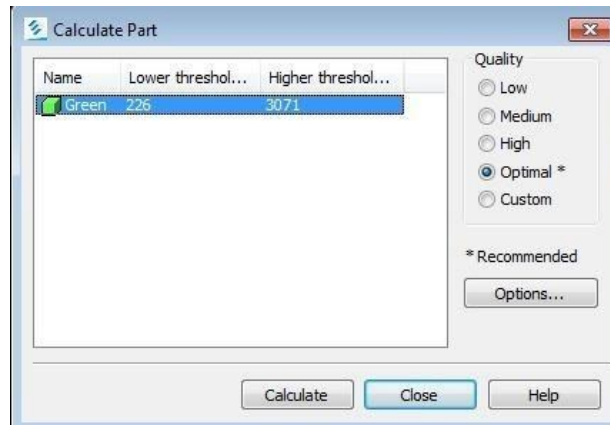


**Figure 20. Noise removal from "Region Growing"**

- Calculate part: The reconstruction of the 3D model is done, selecting "Calculate Part". Choose the option "Quality" – "Optimal" and click on "Calculate"

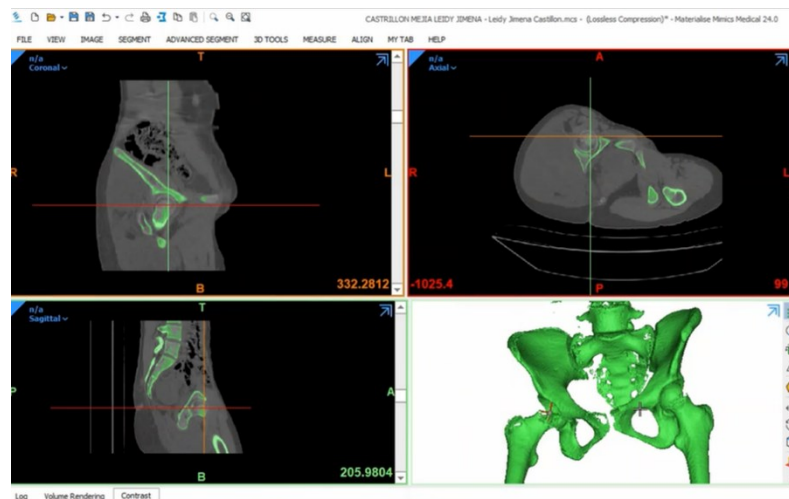


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**Figure 21. Quality settings.**

Finally, the reconstructed 3D model is obtained from the segmentation of the medical images.



**Figure 22. Obtaining the final 3D reconstruction.**

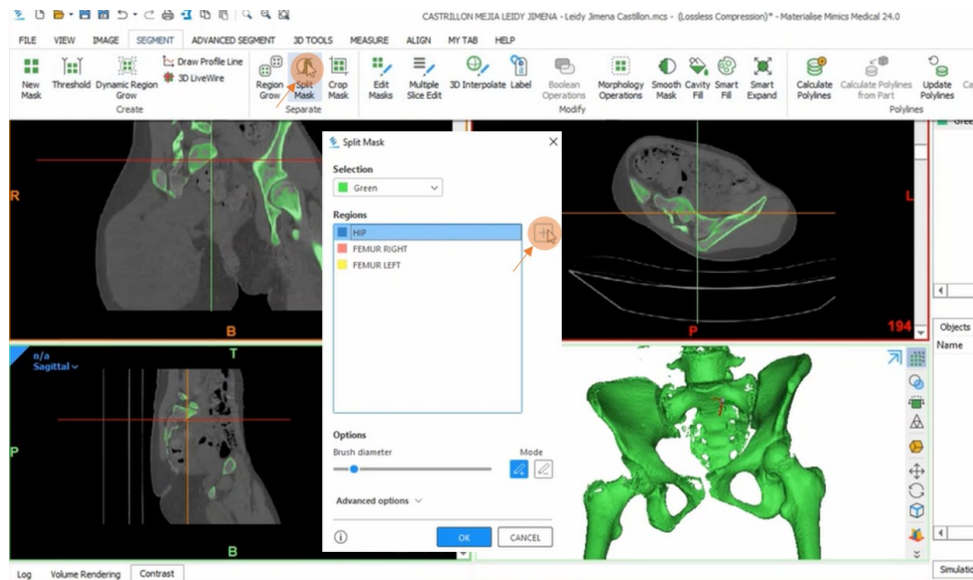
### 6.3. Separate:

- Split mask: Select the “*Split mask*” tool and add the regions that you need separate. Change the names of regions.

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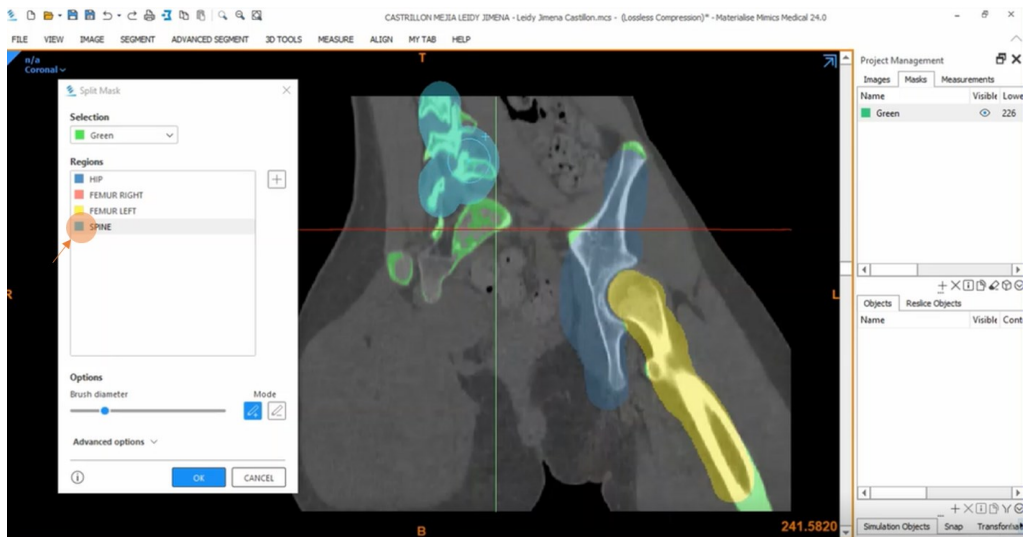
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**Figure 23. Separate with split mask**

Brush the part of the interest and click on “ok”



**Figure 24. Brush Region mask.**



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- Edit mask: You can modify the threshold settings and brush the bone to add the complete part with the “*edit mask*” tool.

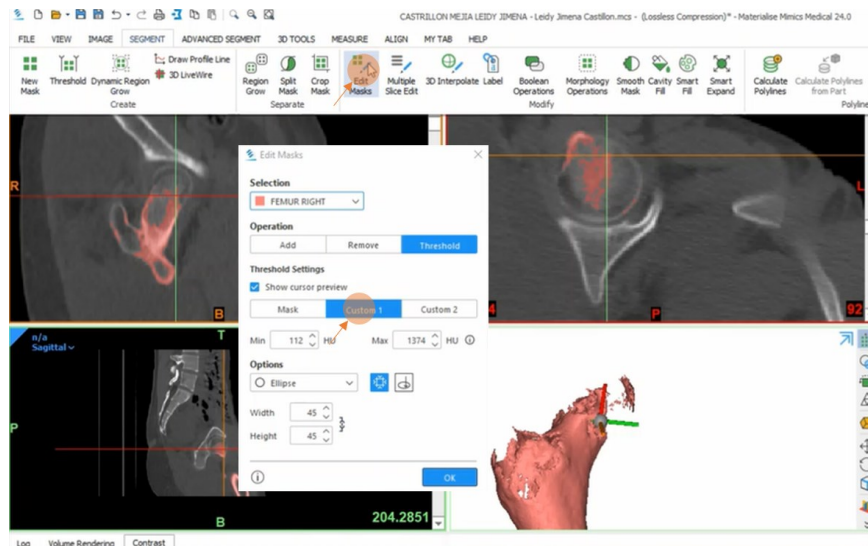


Figure 25. Edit mask

- Edit multiple masks: Use the “*Edit multiple masks*” tool to brush multiple masks and improve the 3D model. You can see the progress in the 3D preview.

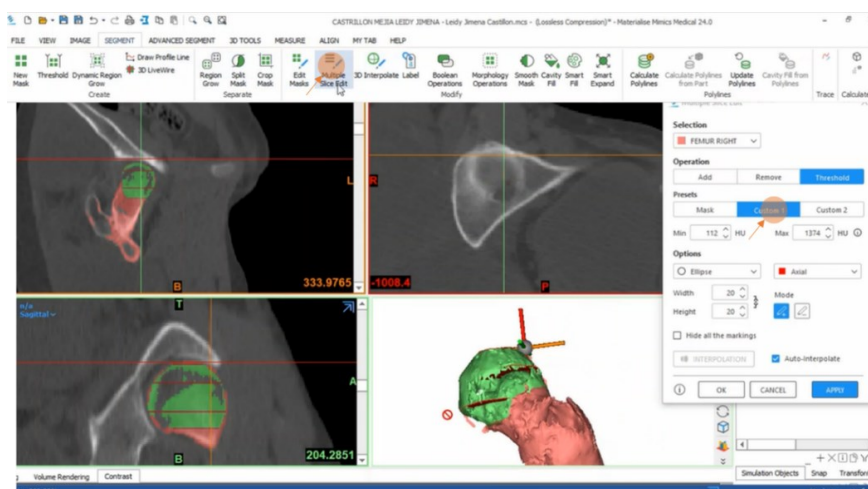


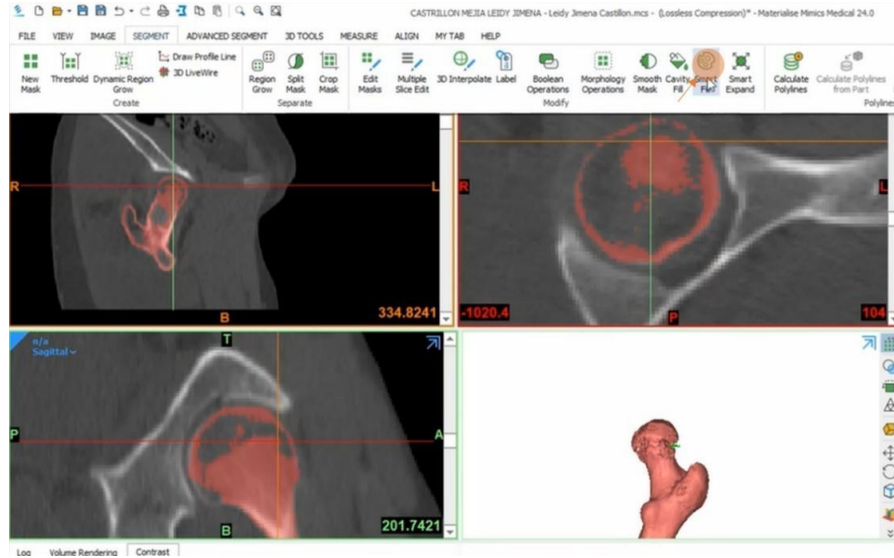
Figure 26. Brush the threshold setting with the edit multiple masks tool.

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- Smart Fill: Fill closed and opened holes automatically with global fill and semiautomatically with local fill.



**Figure 27. Brush the threshold setting with the edit multiple masks tool.**

### 6.4. Other tools you may need:

- Smooth mask: Use a smooth mask to delete pixels out of the geometry, especially for images with scatter.

Be aware that this tool creates holes in the mask. There are not many features to change. Just by clicking on the tool, it will work.



**Figure 28. Select the Smooth mask tool.**

- Morphological operations: It is used when it is necessary to disconnect two elements that have a contact point that is difficult to identify.

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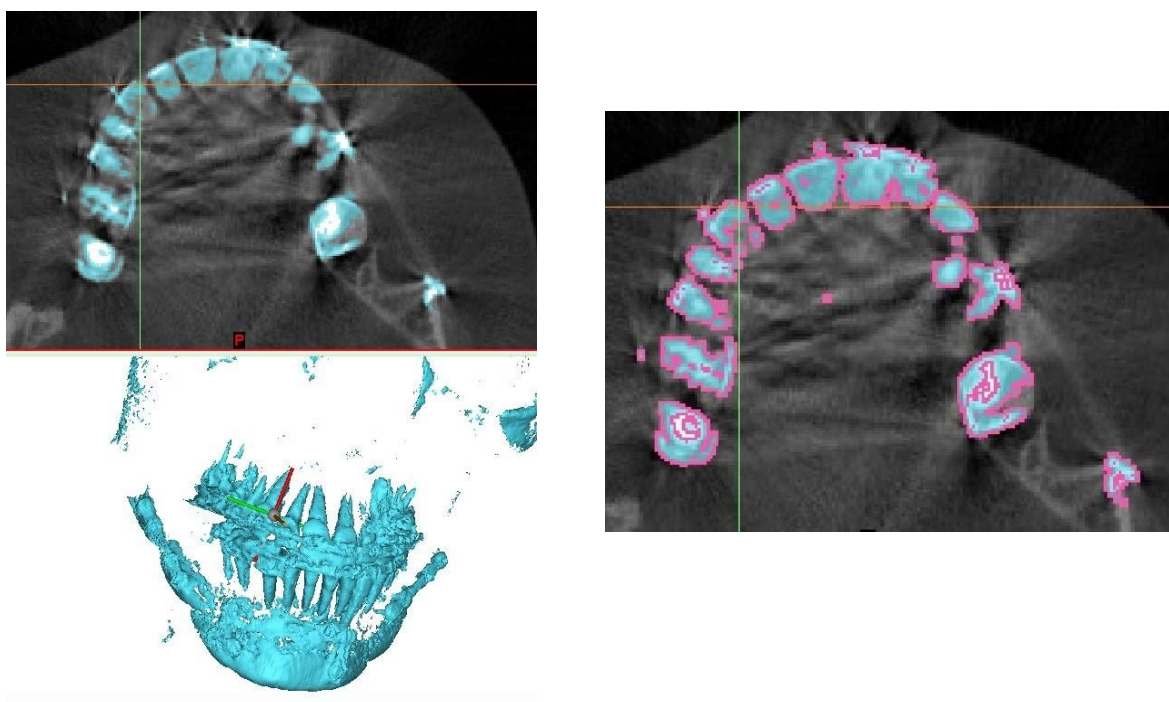
**Figure 29. Select the Morphological operations tool.**

Close: Fill in some of the pixels in the mask.

Dilate: This tool expands the mask out of the perimeter. You can define the number of pixels. Useful to give back the pixels you delete in erode.

Erode: This tool reduces the mask inside of the perimeter. You can define the number of pixels. Useful to separate the teeth.

Open: Create holes in the mask, it is useful before using region growing to separate isolated parts.



**Figure 30. Morphological operations view.**

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- Boolean operation: It allows to unite, subtract, or intersect masks. It is helpful to separate teeth roots



*Figure 31. Select the Boolean operation tool.*

Minus (Subtraction): Where the Threshold value parameter equals the Threshold value mask A parameter.

Intersection: Where the Lower threshold parameter is equal to the max parameter (low mask A, low mask B) and the Higher threshold parameter is equal to the min parameter (high mask A, high mask B).

Union: Where the Lower threshold parameter equals the min parameter (low mask A, low mask B). and the Higher threshold parameter equals the max parameter (high mask A, high mask B).

## 7. INFERIOR ALVEOLAR NERVE SEGMENTATION (MIMICS TRAINING).

You will use this session only when you need nerve segmentation to view the nerve for position and create a cut in the bone.

### 7.1. Separate:

If you need to separate the bones, first you will need to perform the 6.3 parts in this document.

### 7.2. Draw / Manipulate nerve:

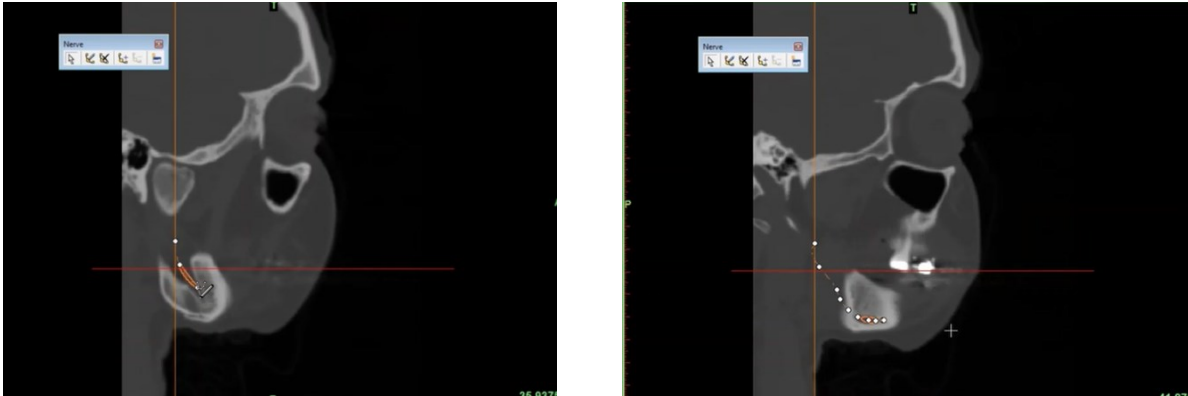
You should generally add points through the mandibular nerve canal from the sagittal view. It is not necessary to place too many points because the program creates an irregular shape. Once you have the 3D visualization it is possible to modify the location of the points

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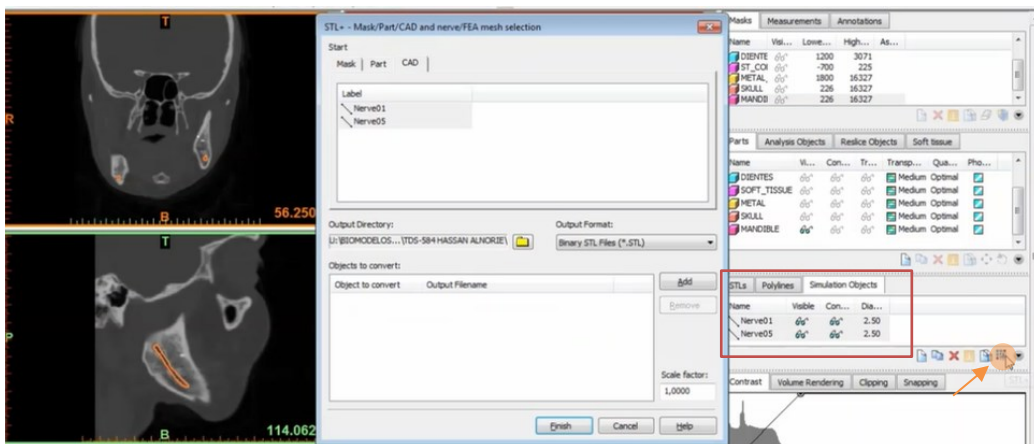
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**Figure 32.** Add point through the mandibular nerve.

Finally, in the nerve simulation part, select convert to STL and save to patient folder to import them into the 3Matic file.



**Figure 33.** Export nerve as STL file.