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## WORK INSTRUCTION PRE-PLANNING (A) FOCUSED ON PREPARING THE CRANIOPLASTY, ORTHOGNATHIC, AND TMJ CASES.

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## 1. INTRODUCTION

In this section, you will find the entire pre-planning process for the different cranial and maxillofacial cases, where the CT models must be oriented such as bone tissues, soft tissues, and in maxillofacial cases, the dental roots, the open mouth CT and closed together with the mental nerve.

The orientation of the CT model is important to start the design process by ensuring better visualization of the patient's symmetry and identification of the bone defect.

## 2. OBJECTIVE

This work instruction aims to give a detailed overview of all steps to be performed in the pre-planning by company Planning Assistant using 3Matic Medical Materialise software, focused on preparing cranium and maxillofacial cases.

## 3. ANATOMY INTRODUCTION

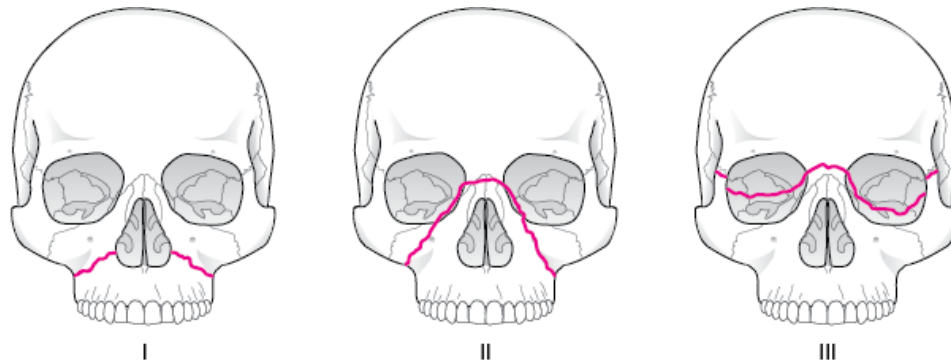
For this session, you need to have previously segmented the closed mouth CT, open mouth, and the mental nerve to carry out the orientation and cuts during the pre-planning of the case.

### 3.1. Orthognathic surgeries

Orthognathic surgeries are a surgical intervention responsible for correcting Dento-Cranio-Maxillofacial deformities, improving dental occlusion, and achieving a balance between all the facial features of a patient, achieving a more aesthetic functional appearance. To make the medical devices and the surgical planning, it is necessary to carry out the pre-planning before the meeting with the surgeon, this step facilitates the planning process and ensures a better result in the company process.

The Le fort cut is a fracture of the middle third of the face that involves the maxillary bone and surrounding structures. The hallmark of Le fort fractures is pterygomaxillary separation, which means fractures between the pterygoid plates and the maxillary sinuses.

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*Figure 1. Le fort cuts (Image by AO foundation)*

### **3.2. Cranioplasty:**

Cranioplasty is a surgical operation on repairing cranial defects caused by previous injuries or operations, such as decompressive craniectomy. It is performed by filling the defective area with a range of materials, usually one piece from the patient or implant plate Titanium, PEEK, or PMMA.

### **3.3. Temporomandibular Joint (TMJ)**

Collaborates with the planning of open joint surgery, this surgery involves making an incision a few inches long over the joint so that your healthcare provider can operate on the joint itself. This type of TMJ surgery is usually reserved for a serious TMJ disorder that involves:

- Too much tissue or bone growth prevents the joint from moving.
- Fusion of joint tissue, cartilage, or bone (ankylosis).
- Inability to reach the joint with arthroscopy.

In this procedure, the patient's condylar joint is removed and replaced with the design patented by Sampedro, which consists of a polyethylene cavity and the design of a titanium plate for fixation in the zygomatic arch.

## **4. 3MATIC TRAINING.**

CT studies must be available for no more than 3 months to start with the pre-planning of orthognathic cases. It is also necessary to have the open mouth and closed mouth studies, the patient's company request, and the patient's occlusion plasters fixed by the doctor.

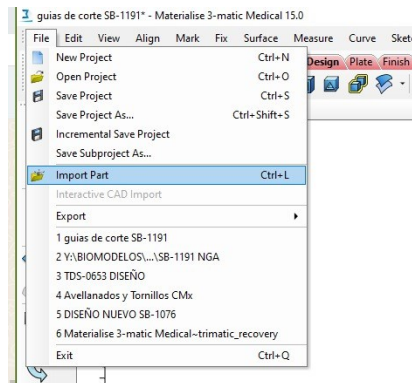
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First, it is necessary to finish the Segmentation in Mimics Medical Materialize Software (see the *WORK INSTRUCTION IMAGE PROTOCOL AND SEGMENTATION*), and you must export 3D models in STL format.

#### 4.1. How to import the STLs

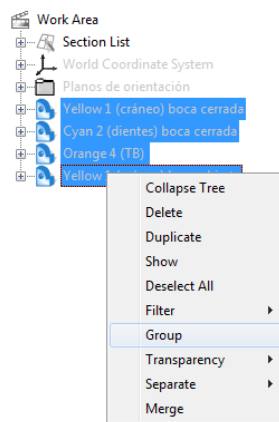
You can have two possible ways. The first option is: To copy the 3D model from Mimics and paste it into 3Matic Medical Materialize Software. These 3D models will be seen in the “Scene Tree” window on the right of the software.

The second option is: You can import the STLs into 3Matic. Go to “File” and select “Import”, choose the patient's STLs, and click “ok”, these 3D models will be seen in the “Scene Tree” window on the right of the software.



**Figure 2. Import part.**

Once the STLs are imported, it is recommended to create a group as [Originals].



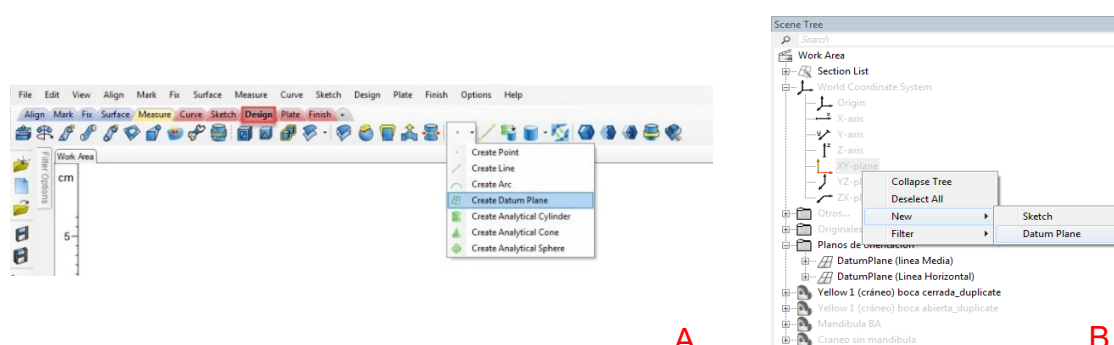
**Figure 3. How creates a group.**

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## 4.2. Head orientation (creation of Frankfurt plane, Midline plane, and Coronal plane).

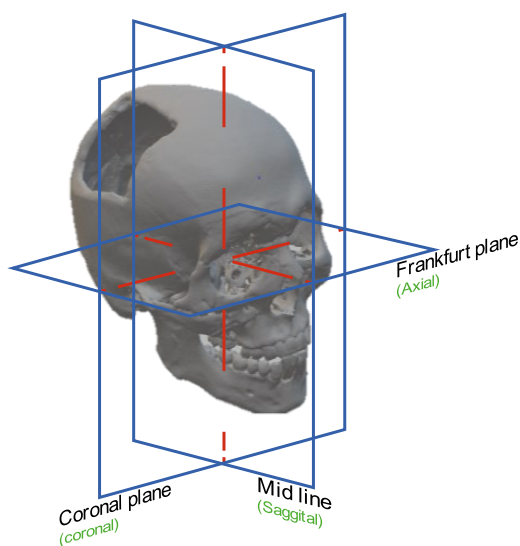
To realize the orientation of the 3D model in 3Matic Medical you must create the orientation plane. The first option is: Select “*design*”, “*create datum plane*”, then you may select one point to the 3D model and click on the “*XY plane*”, “*YZ plane*” or “*XZ plane*”.

The second option could be in the “*World Coordinate System*” tab right-click on “*XY plane*”, “*YZ plane*” and “*XZ plane*” new “*Datum plane*”.



**Figure 4. A: The first option for creating a datum plane – B: The second option for creating a datum plane.**

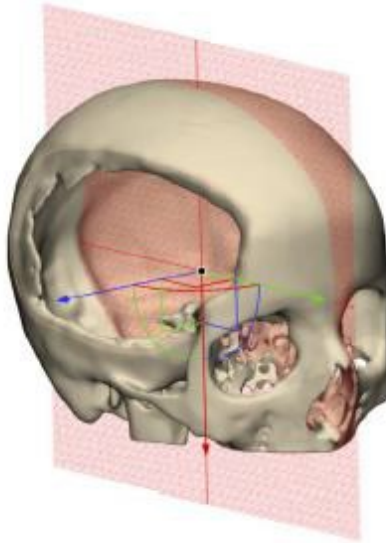
Configure new dimensions of the created planes: (120X120) pointing to the plane and writing the values in the “Delta X” and “Delta Y” boxes.



**Figure 5. Orientation plane**

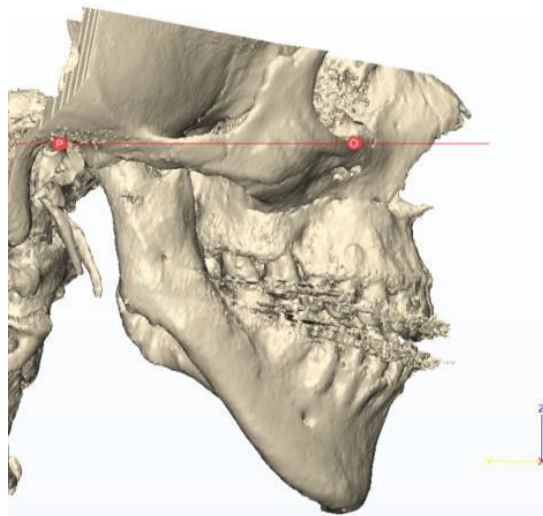
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- LM Midline (Sagittal -YZ): the midline should be positioned in the center of the skull (use the *Nasion N* central cephalometric point and the *Anterior Nasal Spine ANS* cephalometric point). The plane should divide the skull symmetrically into 2 halves.



**Figure 6. Orientation Midline plane**

- Frankfurt Plane (Axial -XY): The 3D model must be positioned according to the Horizontal plane taking the cephalometric points: *Po (auditory canal)* and or (*inferior orbital edges*). This is done from a side view.

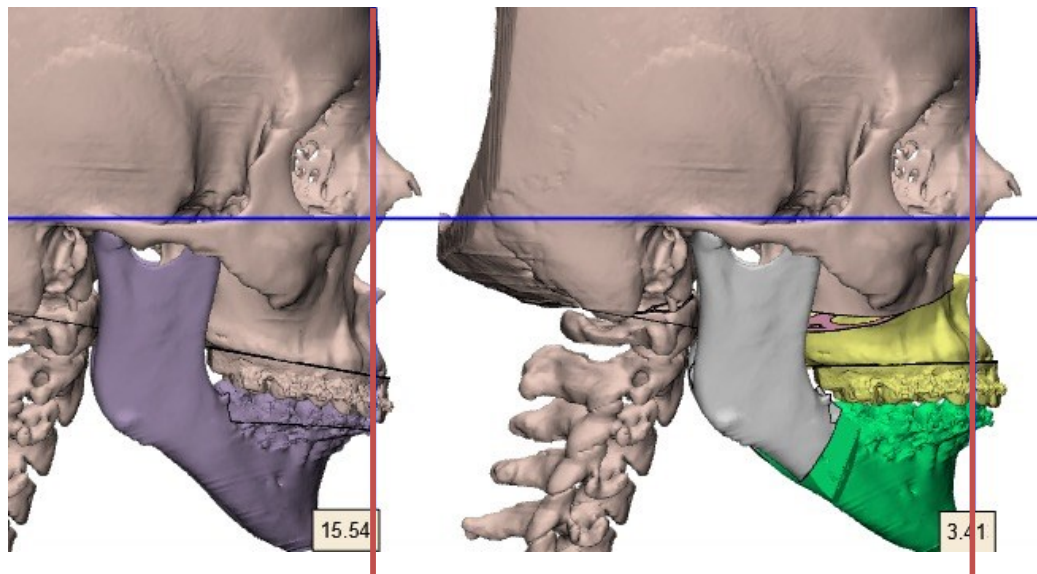


**Figure 7. Orientation Frankfurt plane**

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The Frankfurt plane must coincide with the Horizontal plane. Also, the tooth and soft tissue models must be oriented, therefore these are selected as entities to be moved with the main entity.

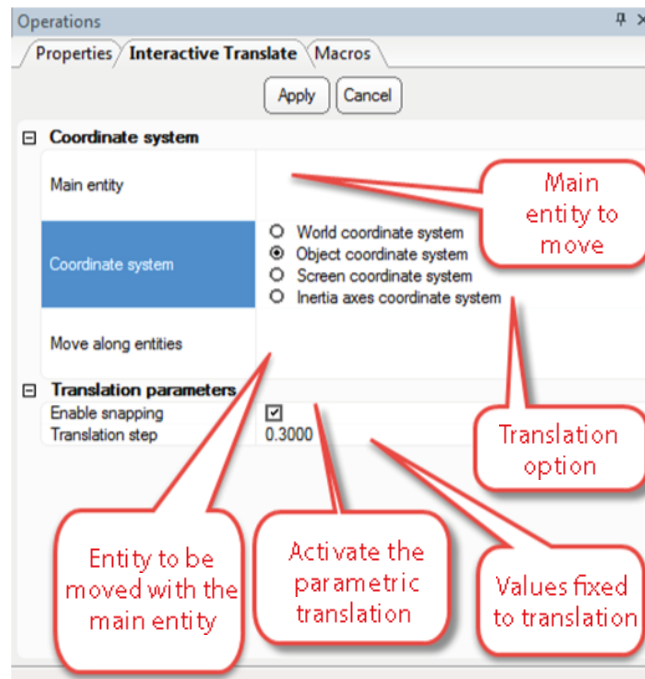
- Coronal plane (XZ): The coronal plane is located from a frontal view, selecting the Nasion point (N) and the parallel plane (XZ). This plane allows visualizing the advancement or regression of the maxilla, mandible, and chin concerning the patient's nasion



**Figure 8. Orientation Coronal plane.**

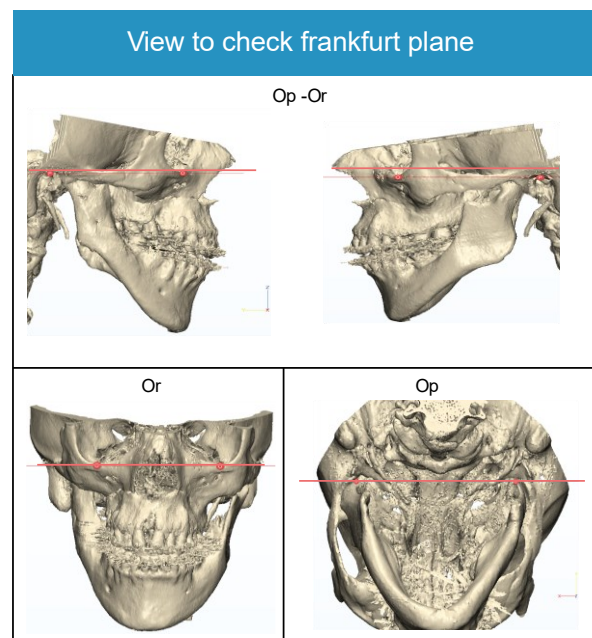
Once the planes have been created, the group of [originals] is duplicated, and we align them concerning the planes. We use the “interactive translate” tool from the “Aling” tab to move the plane or any entity. The tool allows you to align the feature as needed. The Alignment options are 1- Universal coordinate systems, 2- Object’s coordinate system, 3- Screen coordinate system, and 4- Inertia axes coordinate systems.

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**Figure 5. Orientation plane**

Note: For post orientation steps is necessary to orientate teeth and soft tissues models, then they will have been chosen as entities to move with the main entities.



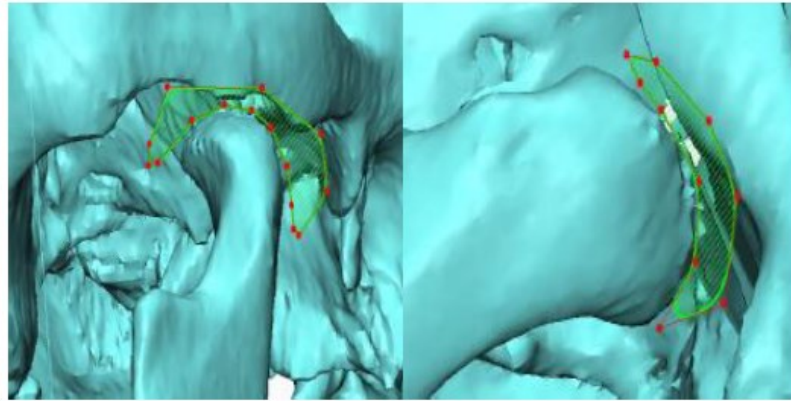
**Figure 6. Verify Orientation (V. right, V. left, Front, Down).**



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#### 4.3. How to separate the mandible

- You should duplicate the oriented open mouth. To separate the mandible, you can use “Trim” and “Mark shell” and use different views to cut with “trim” tools around the condyle.

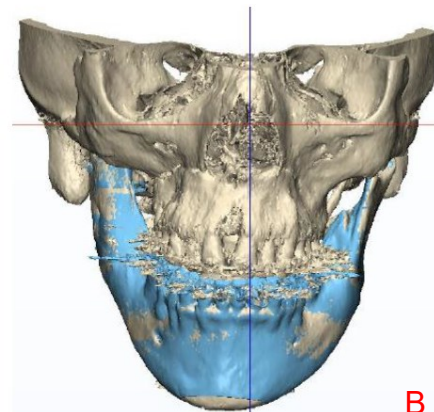
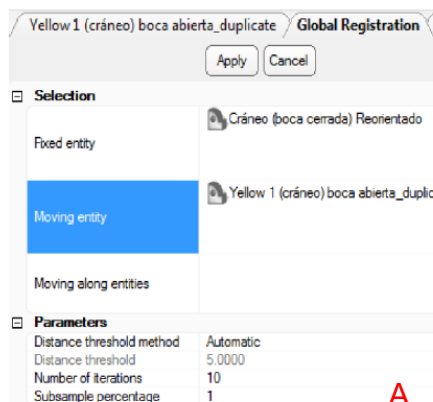


*Figure 7. Cuts around the condyle.*

When you separate the bony structure to the mandible, you may use “Mark shell” to remove the unnecessary, and then you should give a name like Mandible open mouth.

- Use the “Boolean subtraction” tool to separate the mandible from the Skull, and the skull gives a name like a skull without a mandible.

Once the mandible of the open-mouth model it’s separated, you should move the separated mandible to the closed-mouth model, then click “global registration” to obtain the best coincidence.



*Figure 8. A- Global registration tool. B- Open-mouth and closed-mouth models.*

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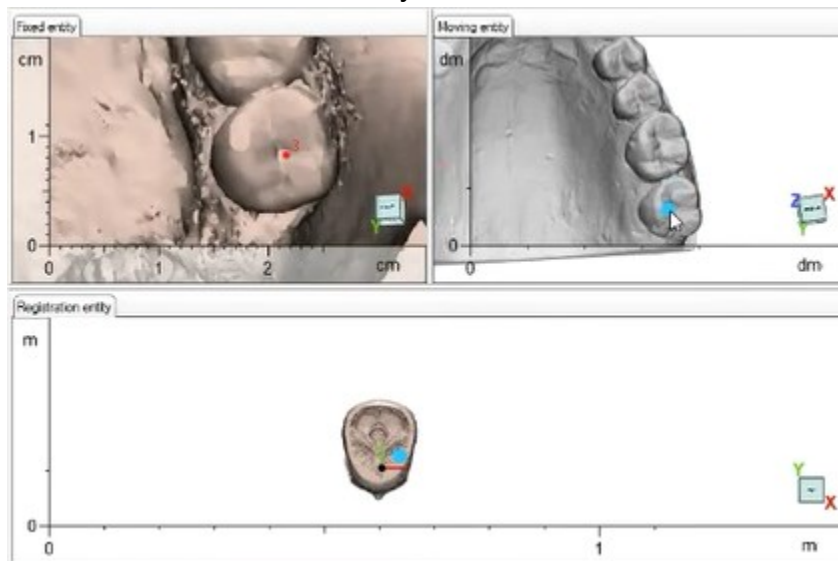
#### 4.4. How Aling the 3D scan model.

- Import the Dental scans models and Aling the teeth with the TAC model. Use the "interactive translate" for close to the bone model of the case.



*Figure 9. Upper arch scan model.*

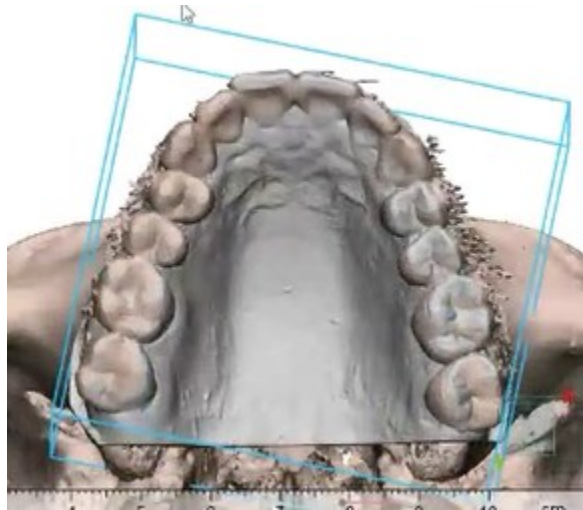
- Step I: Use the "N points registration" tool and in the "fixed entity" part select the bone model, and in "moved entity" select the arch.



*Figure 10. Mark point to registration.*

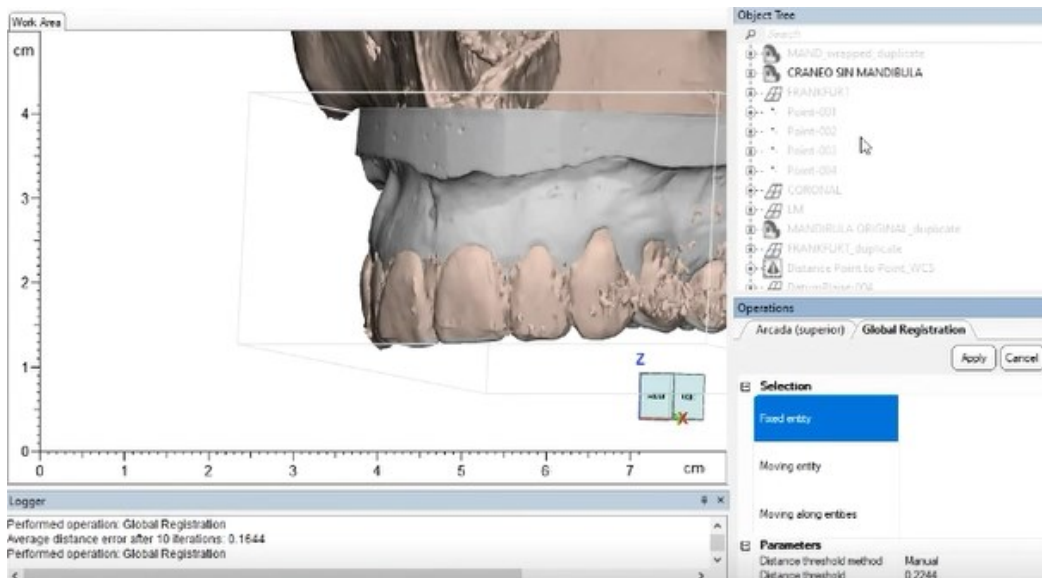
- Step II: Mark the points you want to consider in the bone model in "fixed entity" (2 points in molars 17 and 27, and a third point in the center of incisors 11 and 21) then in "moved entity "Mark approximately the same points on the arch and select "apply".

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**Figure 11. result of the "N point registration" tool**

- Step III: Use the “global registration” tool to obtain the best coincidence.



**Figure 12: The closets to 0 by Global registration tool.**

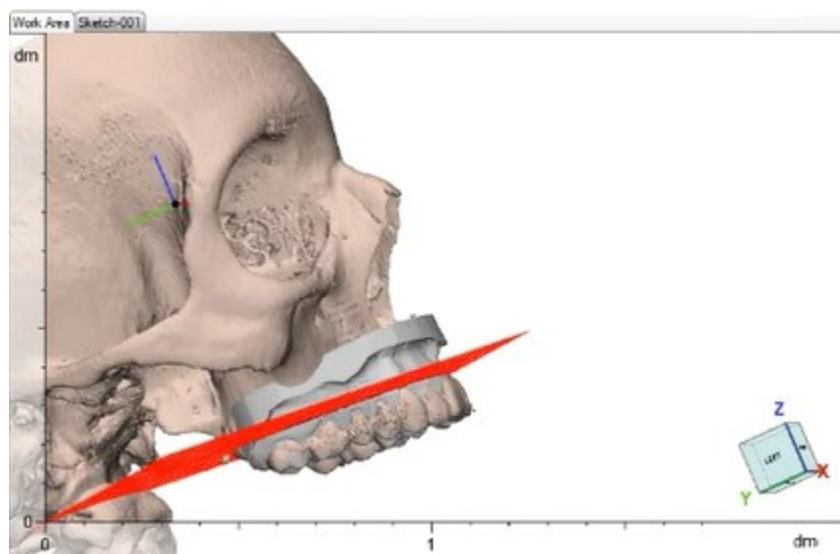
- Step IV: Create a sketch with three locating points and locate it so that it includes the cusps and the lingual part of the arch. then, import the arch to sketch to obtain the cut contour. Next, select the "cut" tool to cut out the bone model and the upper arch. Finally, remove the parts that are not necessary.

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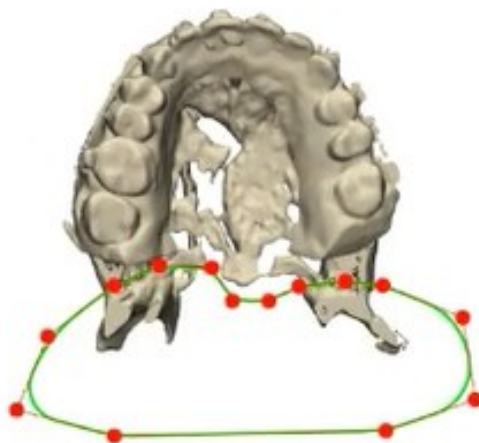
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*Figure 13: Cut the arch and the bone model.*

- Step V: Use the “Trim” tool to cut and separated the pterigoide



*Figure 14: Cut the pterigoide.*

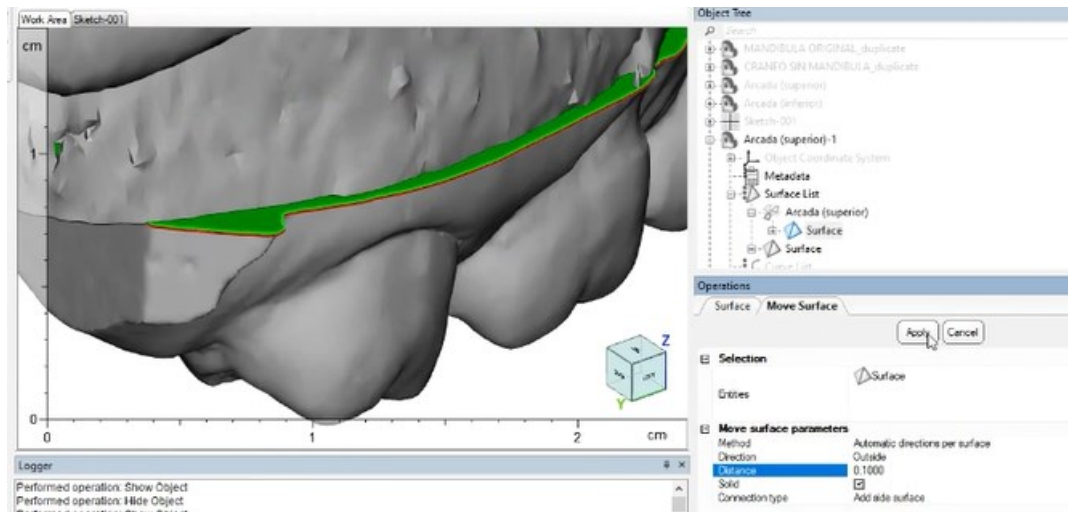
- Step VI: Click on the “Move surface” tool, select the de cut surface of the upper arch with 0,1mm.

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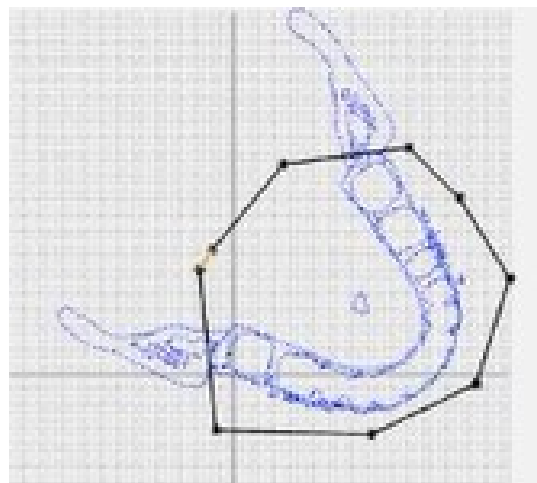


*Figure 15: Move surface of the upper arch.*

- Step VII: Use Boolean Union between bone model and the upper arch. the result is advisable to name it as "skull without mandible".

For the lower arch, the same steps from I to III must be carried out.

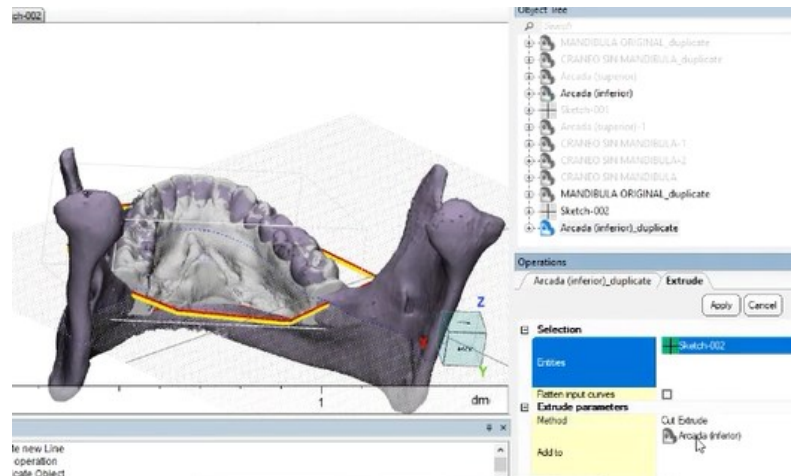
- Step VIII: Create a sketch with three locating points and locate it so that it includes the cusps and the lingual part of the arch. then, import the arch to sketch to obtain the cut contour. Within the sketch, you must create a spline that groups the teeth.



*Figure 16: Spline to cut.*

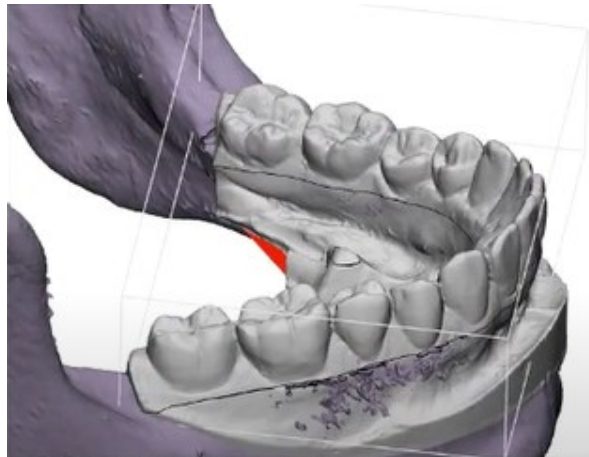
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- Step IX: with the "extrude" tool select the sketch and then the jaw with 10mm in the direction of the teeth. Remove teeth.



**Figure 17: Select the spline to cut.**

- Step X: Next, click on the "cut" tool, select the sketch to cut the lower arch. Finally, remove the pieces that are not necessary.

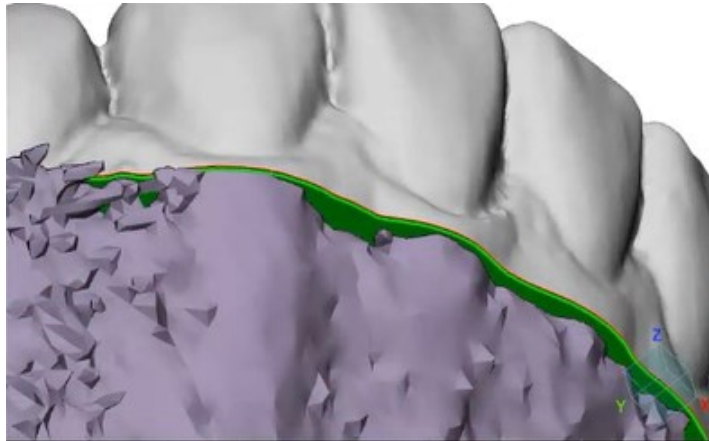


**Figure 18: Cut the lower arch.**

- Step XI: Click on the "Move surface" tool, select the de cut surface of the lower arch with 0,1mm.



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**Figure 19: Move surface of the lower arch.**

- Step XII: Use Boolean Union between the mandible and the lower arch. the result is advisable to name it as "skull with mandible".

#### **4.5. Osteotomies.**

##### **4.6. Le fort cuts**

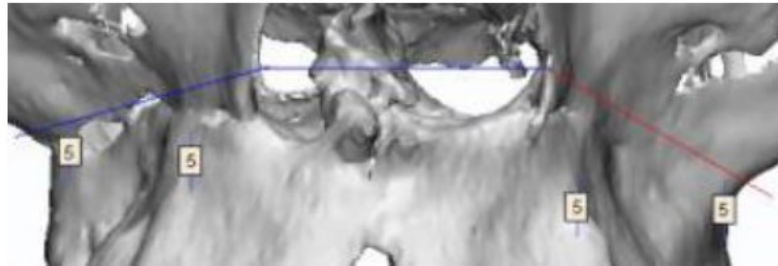
- It should measure 5mm from the last molars' roots and the canine roots. These measurements are verified from side and front views. Then group the measure as "Le fort measures".
- To perform osteotomies, company has pre-designed templates that help in the pre-planning process in orthognathic cases. These files are in the following path: *D://Diseño(\\Srv-fsims017\idi)(Y:)BIOMODELOS/OSTEOTOMIAS*
- Then select the template that you require to make the orthognathic cuts in the 3D model, this process is done in the 3Matic Materialize medical software.

Diseño (\\Srv-fsims017\idi) (Y:) > BIOMODELOS > OSTEOTOMIAS				
	Nombre	Fecha de modificación	Tipo	Tamaño
✦	Planilla Lefort escalon	18/02/2019 1:33 p. m.	3-matic Document	6.143 KB
✦	Plantilla Lefort en S	14/04/2016 8:37 p. m.	3-matic Document	8.454 KB
✦	Plantilla planos, lefort 1 y Sagitales	31/05/2018 4:33 p. m.	3-matic Document	2.477 KB

**Figure 19. Templates for orthognathic osteotomies.**

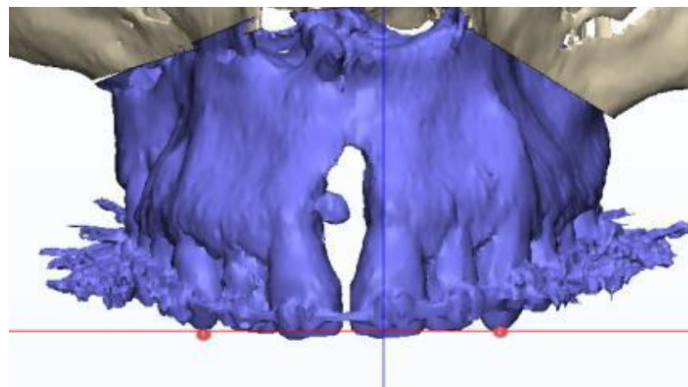
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- With the “translation” and “rotation” tools you are going to Alling the planes above the measurements taken from the dental roots as shown in the figure.



*Figure 20. ublication of the cut planes.*

- click in the “Boolean Subtraction” between the *skull without a mandible* and *cut planes*.
- The maxillary is separated from the skull with the “Mark shell” tool as a new entity and makes the same with the skull without a maxilla.
- You should give a name like *Skull without a maxilla* and *maxilla*
- Finally, the maxilla is duplicated and is ready to be moved according to the indications given by the surgeon.



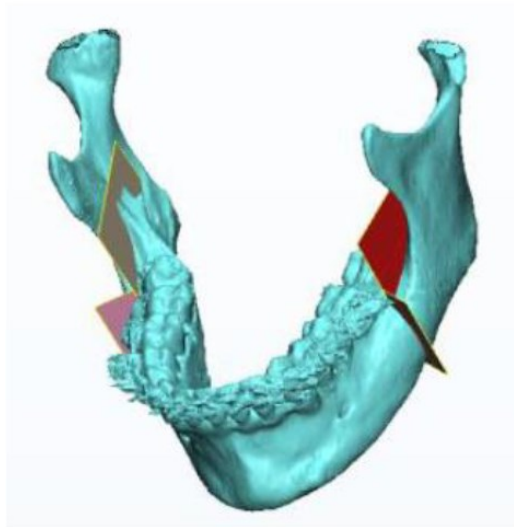
*Figure 21. Maxilla and Skull separated.*

#### **4.6.1. Separation of Sagittal Ramus:**

- First, show and duplicate the mandible to make sagittal cuts.
- Import the sagittal cuts templates previously designed by company. Locate and align in interest to cut.

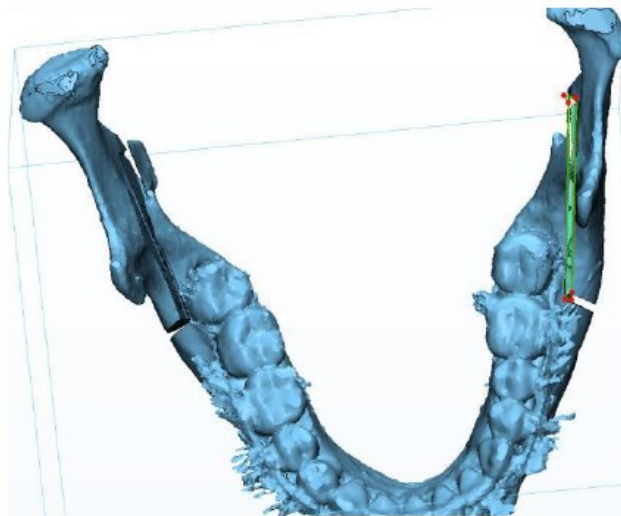


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*Figure 22. Sagittal cuts planes for the separation of the mandible ramus.*

- Perform "Boolean subtraction" to separate the jaw ramus. Then with "mark shell" select each branch and name them as Left Ramus, Right Ramus, and Mandibular Body. If necessary, use the "Trim" tool to separate the branches.



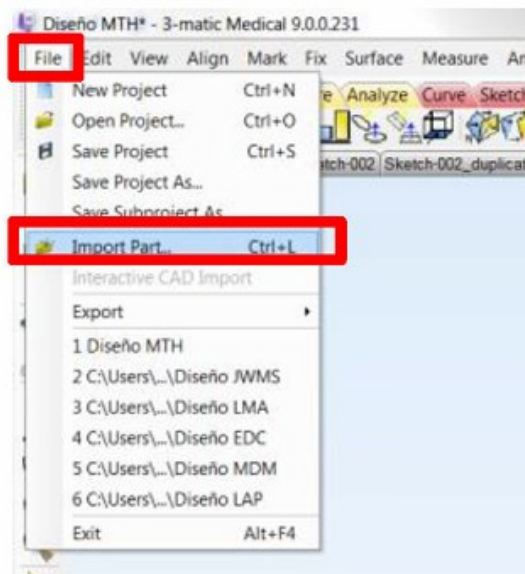
*Figure 23. Separate branches of the mandible.*

- Finally, the mandible is duplicated and is ready to be moved according to the indications given by the surgeon.

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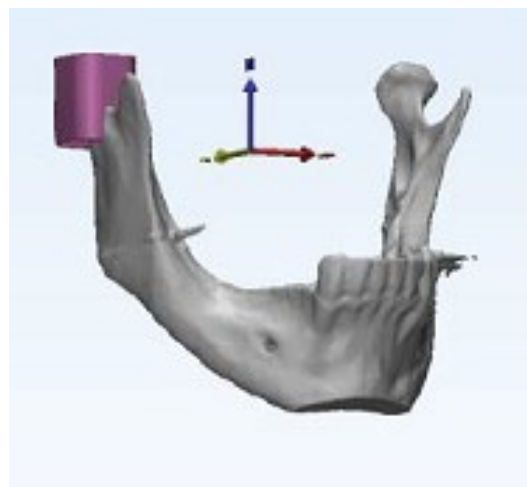
#### 4.7.Import TMJ Template.

Import to part “Cavidad glenoide paredes largas huequito atrás” located in the company design folder files.



**Figure 24. Import to part.**

Align the glenoid cavity with the condyle of the mandible for later placement during planning with the surgeon. The rotational surface of the condyle should be located between 12 and 15mm from the glenoid cavity as shown in the figure.

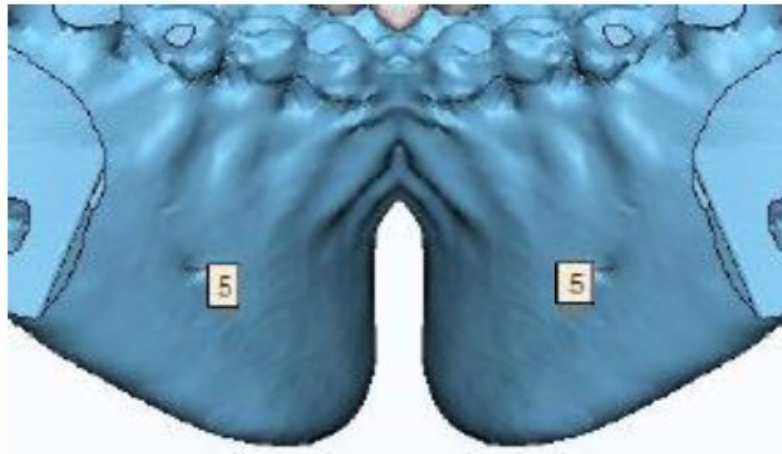


**Figure 25. Aling the Glenoid cavity.**

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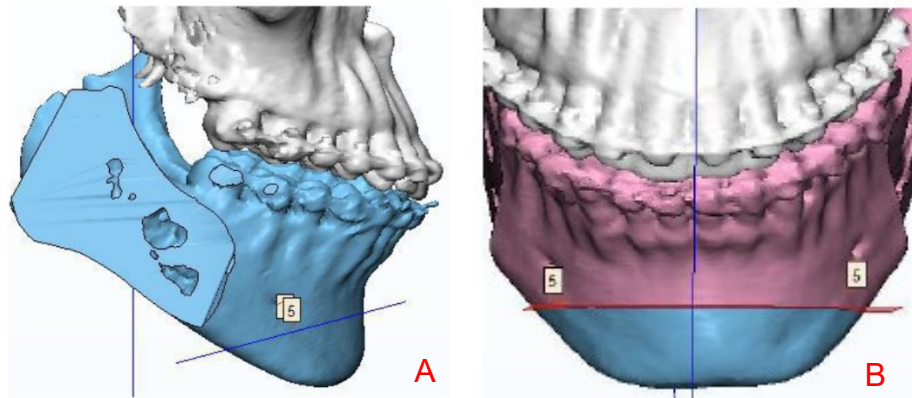
#### 4.8. Genioplasty.

- Take two measurements at the height of the mental foramen of 5 mm to leave a tolerance in the cut of the chin, it should have an approximate angle of 15 degrees.



*Figure 26. Measurements from the mental foramen.*

- Click “Create datum plane” to create the osteotomy plane, and with the “Interactive Rotate” tool rotate it approximately 15 degrees and then position it 5mm from the nerve according to the measurements taken.
- Use the “Cut” tool from the “Design” tab, selecting the jaw and the plane created.



*Figure 27. A- Cut plane to the chin. B- Chin cut result.*