International Interdisciplinary Congress on Renewable Energies, Industrial Maintenance, Mechatronics and Informatics
Booklets

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Title: Precise Modeling and 3D Printing of Biocompatible Craniofacial Prostheses

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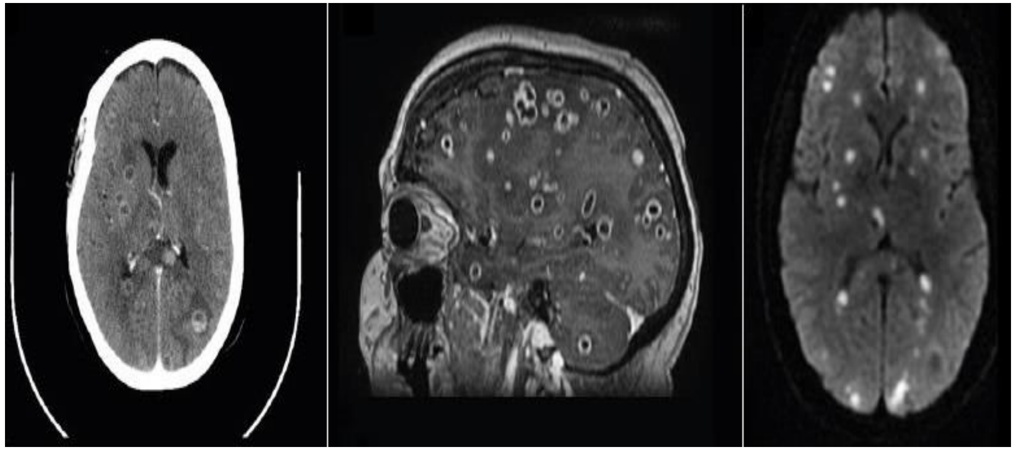

This entails using tomographic scans information in (DICOM) images obtained through computed tomography "CT Scan", free-use software, and 3D printers [I, II].

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Revista Mexicana de Neurociencia:
“Globally, 1.2 million people die annually from Traumatic Brain Injury (TBI - TCE)”

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https://hospiten.com : https://shorturl.at/sM157

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In the case of Mexico, it is the family that bears the costs of creating their patient's prosthesis, the cost of which can range between 250,000 and 700,000 pesos.

Within these costs, only the visualization and stereolithographic modeling of the prosthesis has a considerable weight (around 20,000 pesos) plus approximately 5,000 pesos for extra expenses. The CT scan is valid only for 6 months.

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Methodology.

Objective: Achieve the visualization and generation of 3D models of personalized cranial prostheses for maxillofacial.

It starts from tomographic studies (DICOM images)

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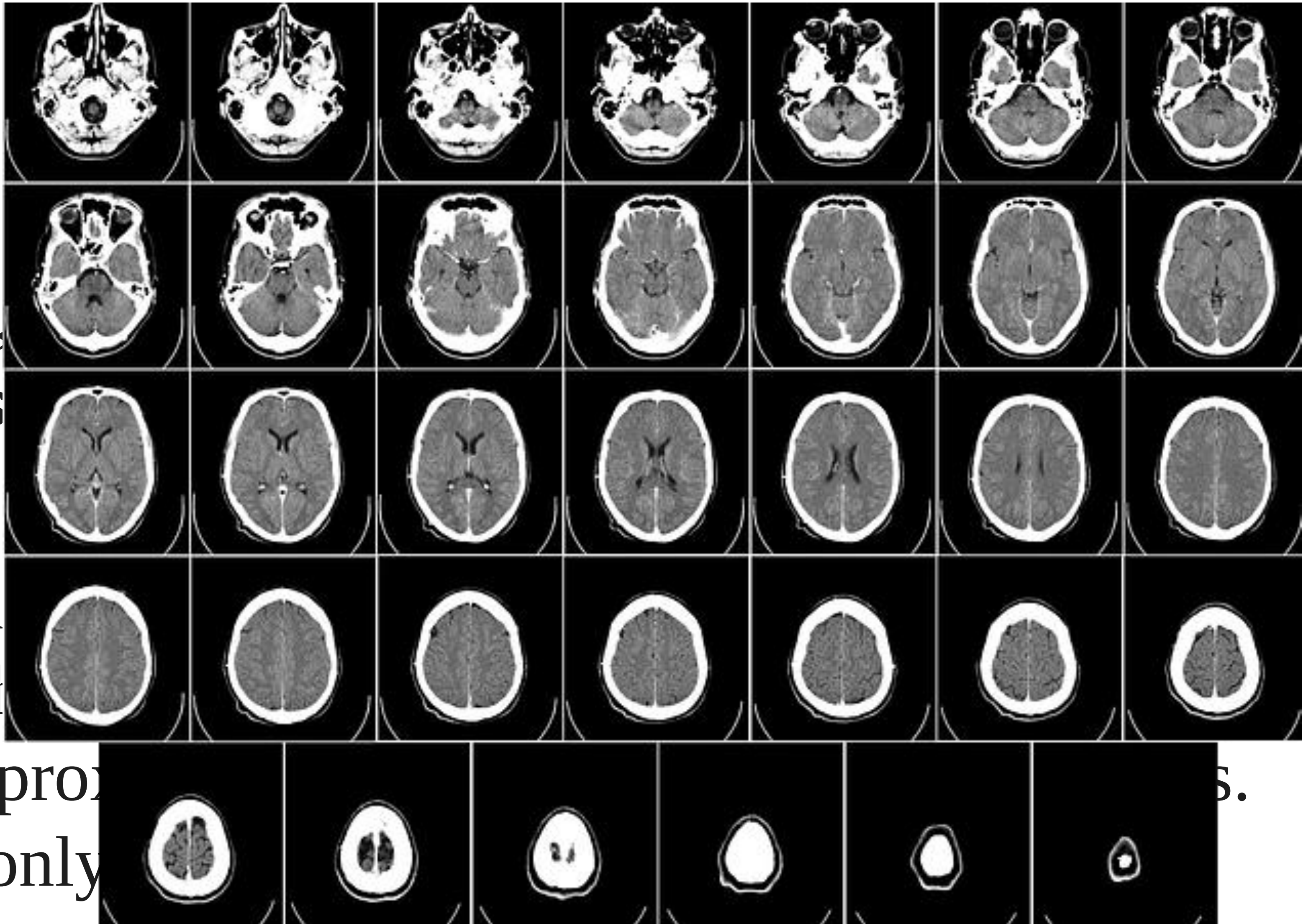

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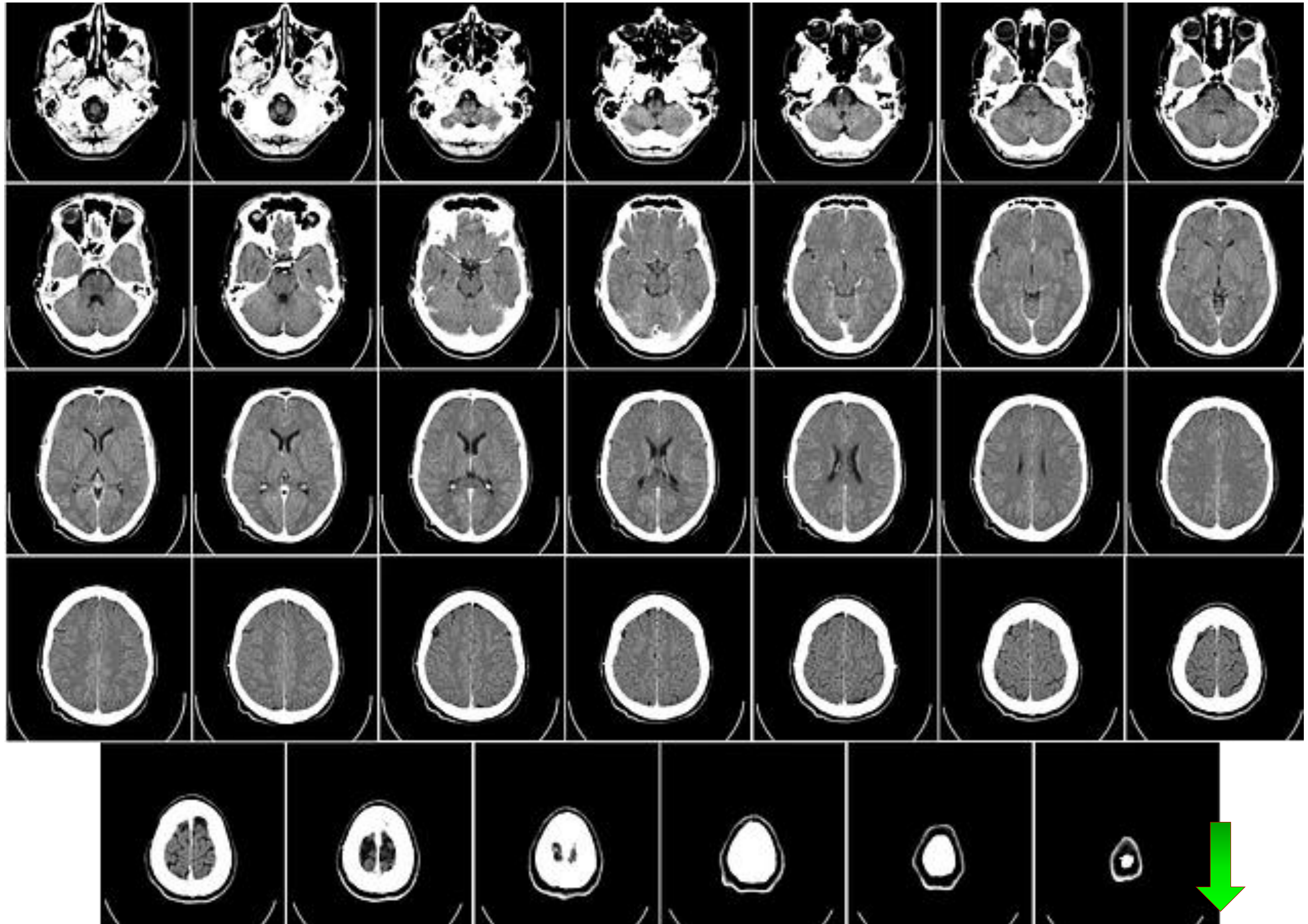

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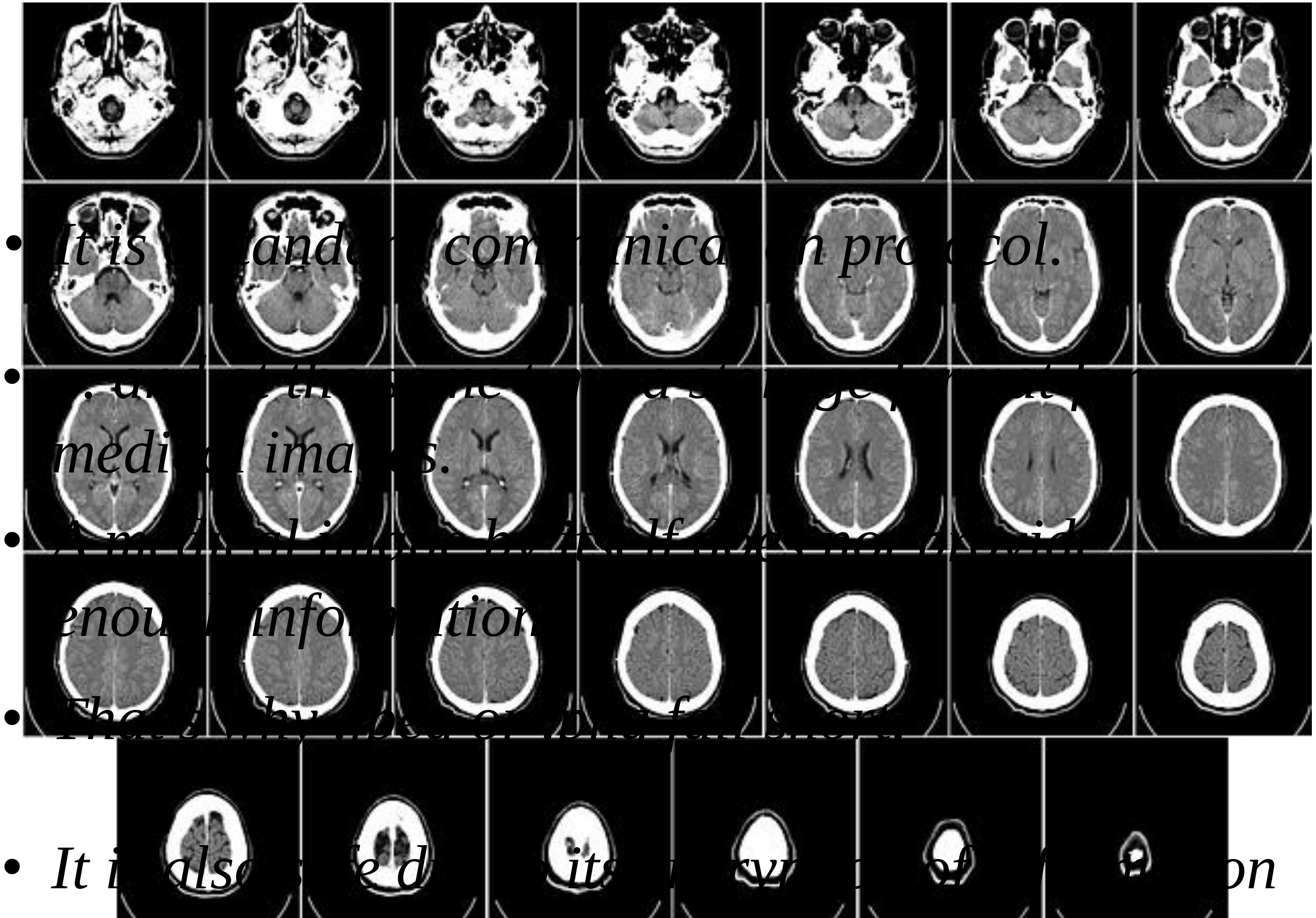
DICOM (acronym for Digital Imaging and Communications in Medicine).

What is it?



- *It is a standard communication protocol.*
- *medical images.*
- *enough information*
- *It is also ... its ... of ... on*

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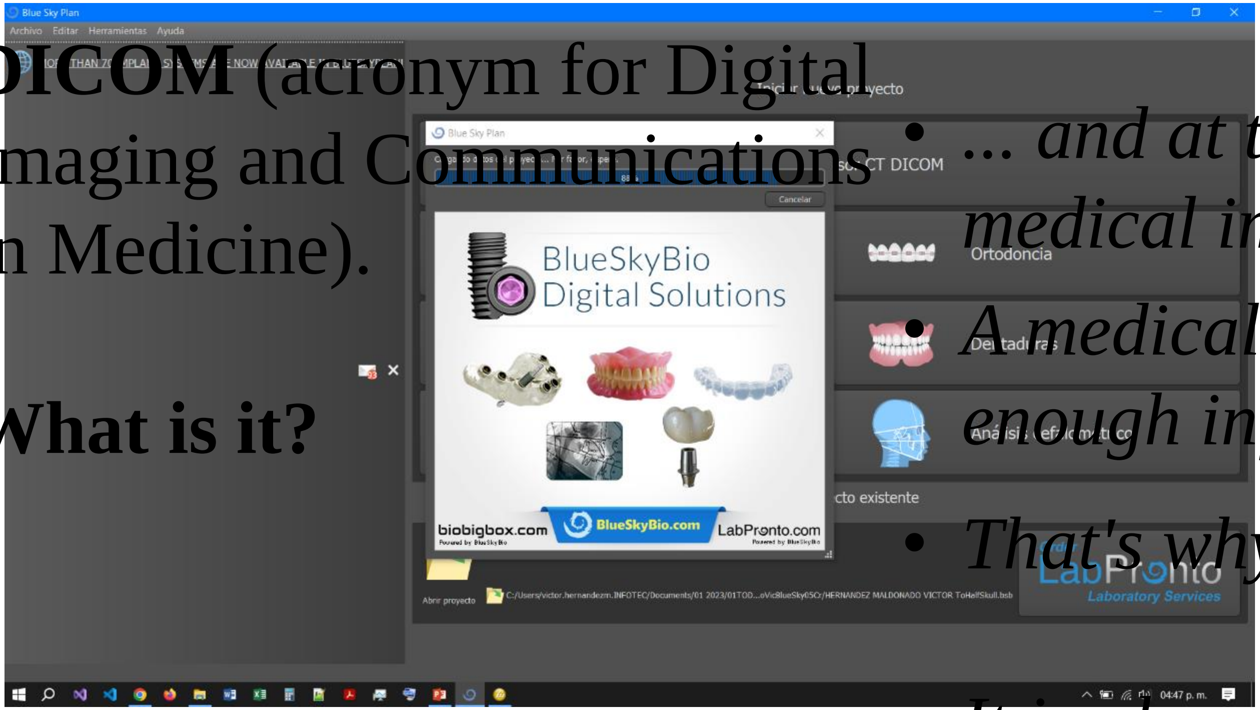
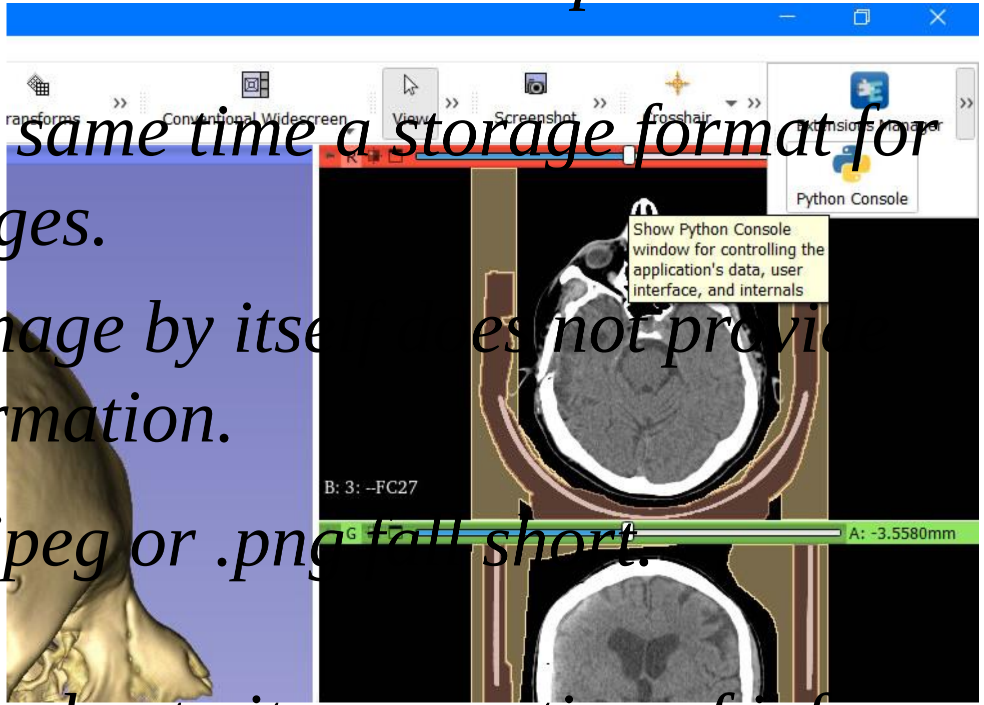
Blue Sky Bio



3D Slicer



Python Console, implements OpenCV

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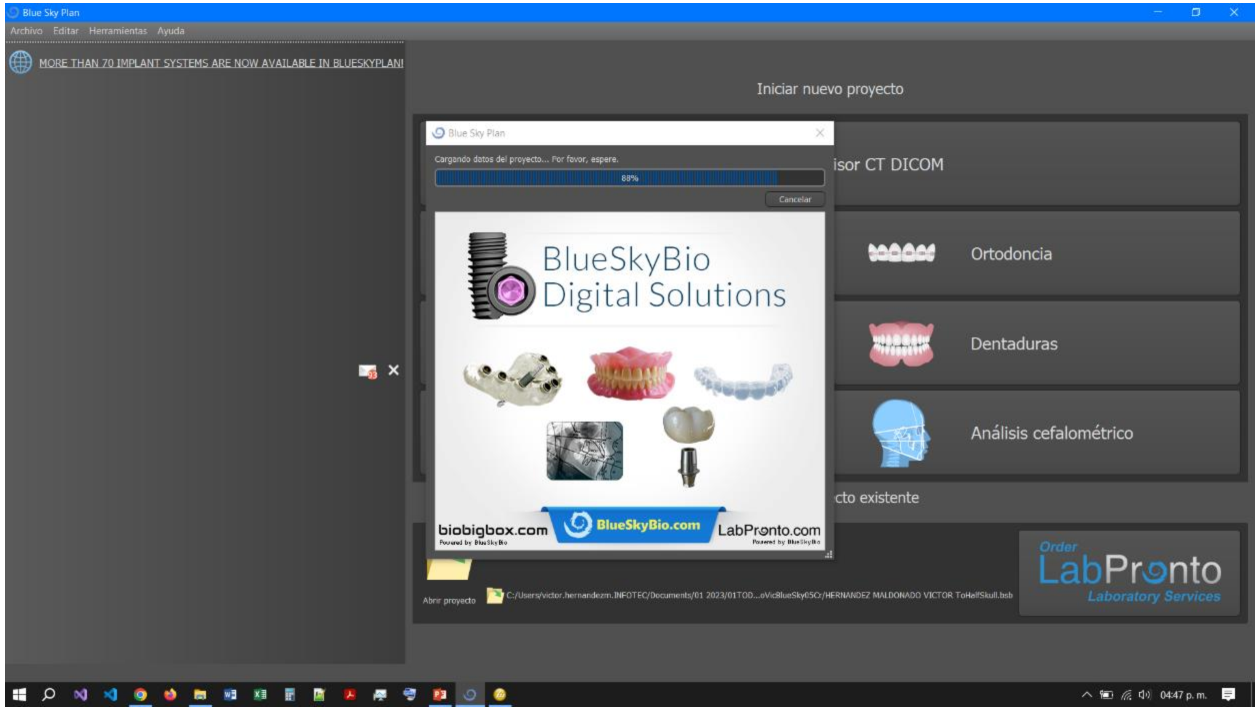
Methodology.

Blue Sky Bio



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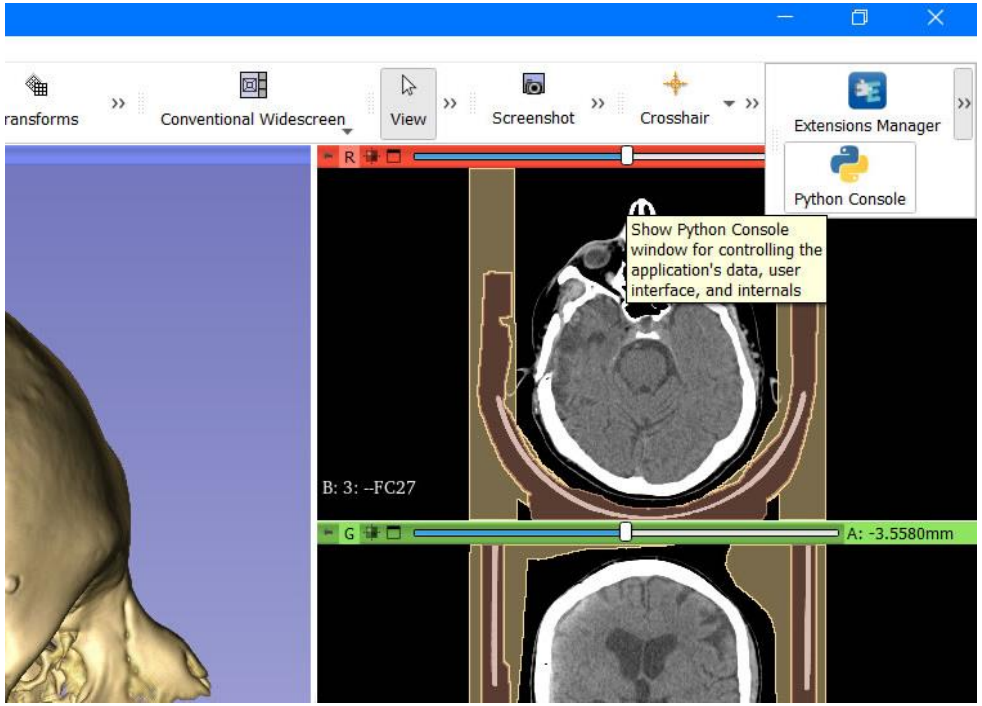

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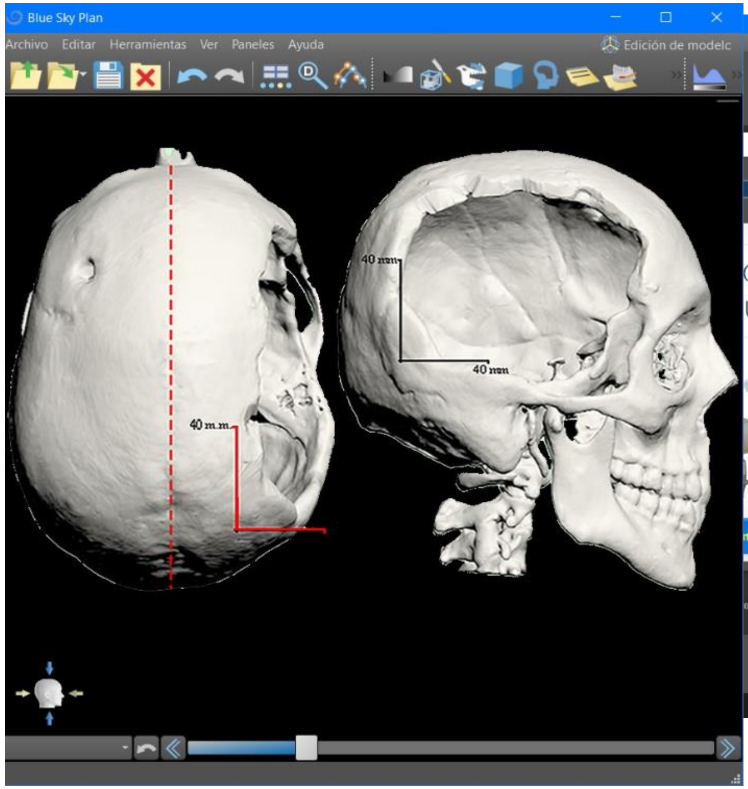

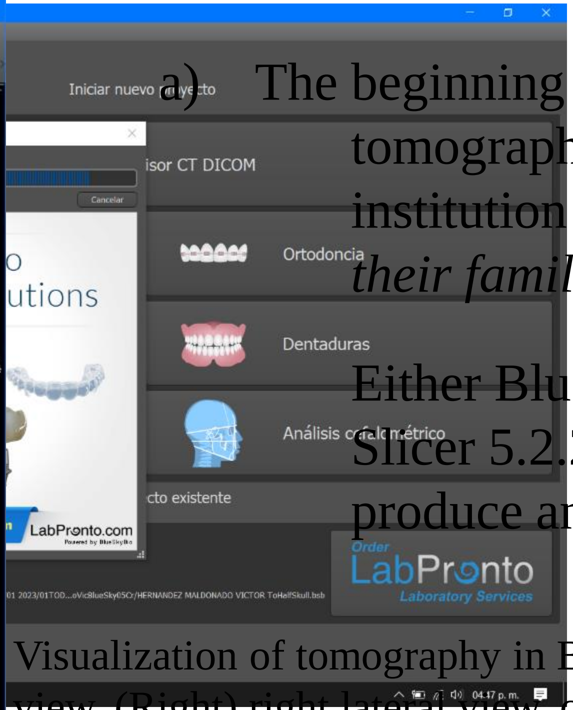

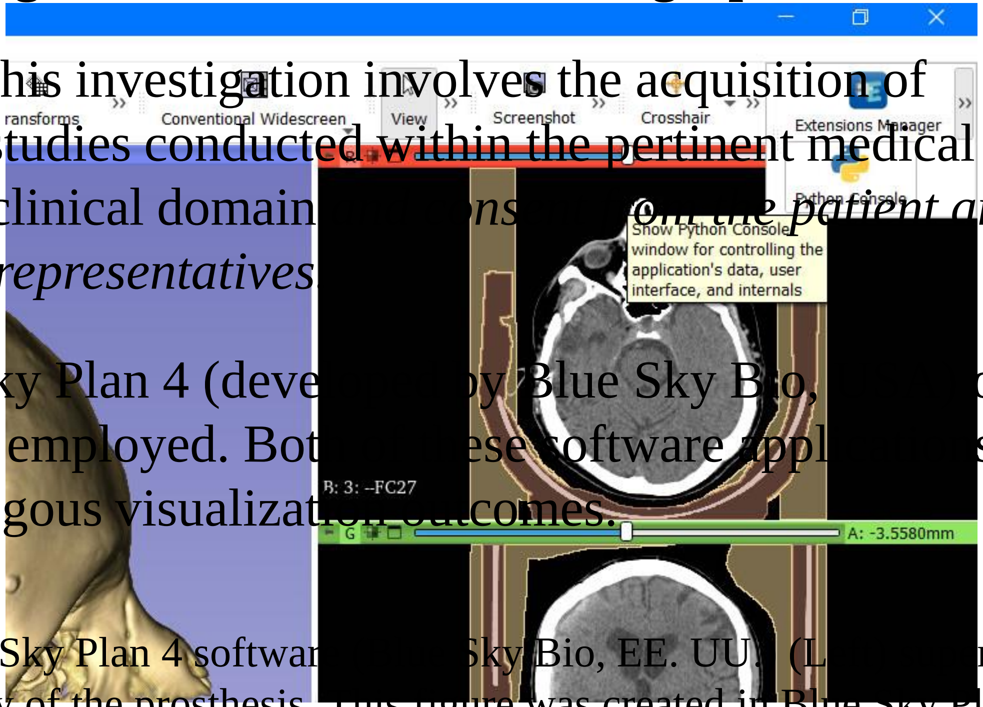

Visualization of tomography in Blue Sky Plan 4 softwar... Sky Bio, EE. UU. (L... rior view, (Right) right lateral view, cavity of the prosthesis. This figure was created in Blue Sky Plan 4 software.

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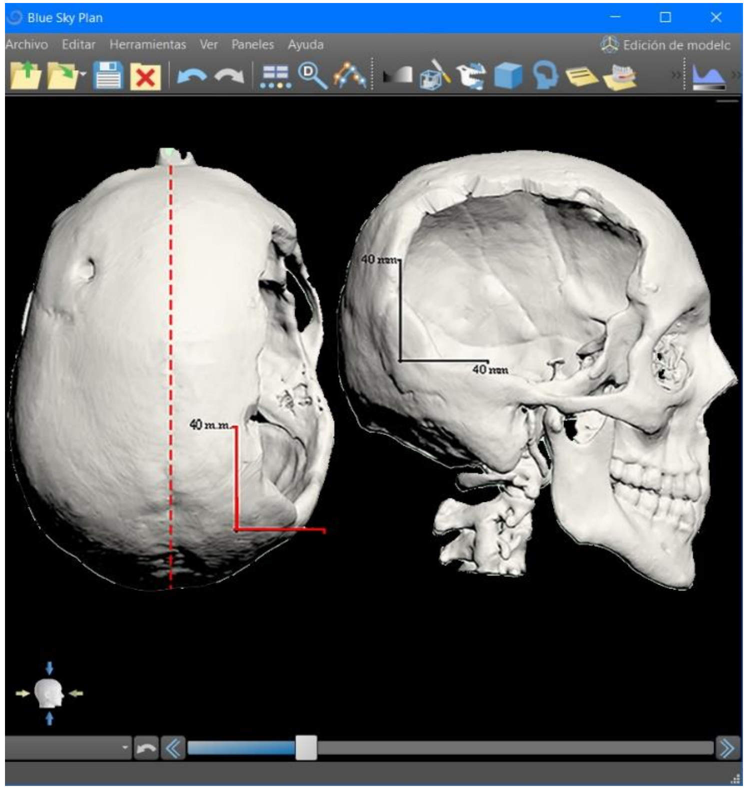
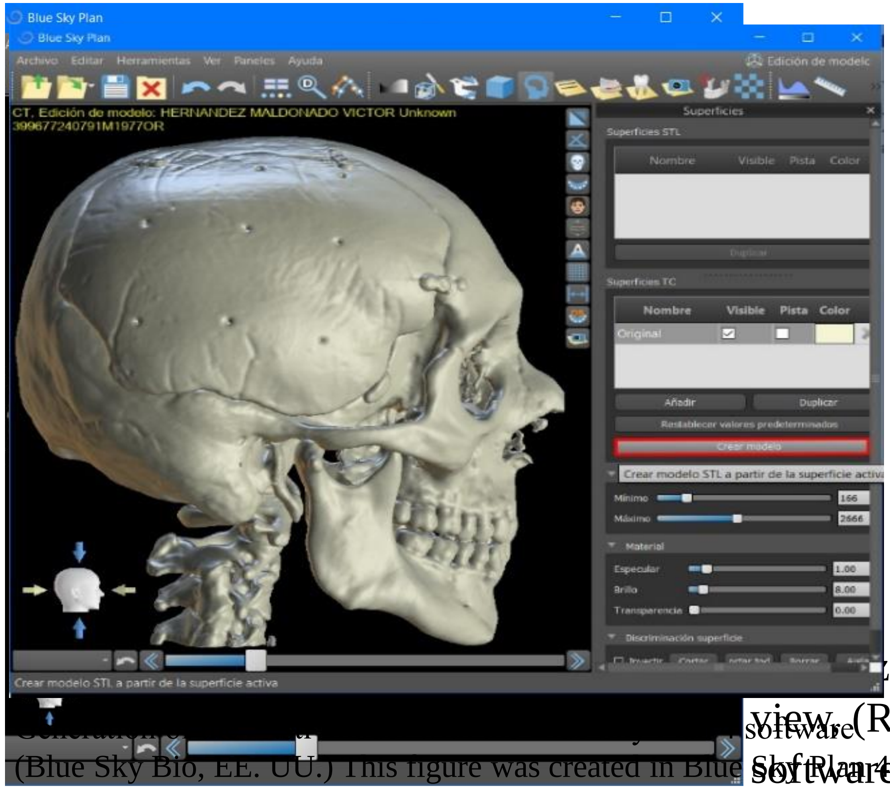


Visualization of tomography in Blue Sky Plan 4 software (Blue Sky Bio, EE. UU.) (Left) superior view, (Right) right lateral view, cavity of the prosthesis. This figure was created in Blue Sky Plan 4 software.

Methodology.



Visualization of tomography in Blue Sky Plan 4 software (Blue Sky Bio, EE. UU.) (Left) superior view, (Right) right lateral view, cavity of the prosthesis. This figure was created in Blue Sky Plan 4 software.

Generation ... software (Blue Sky Bio, EE. UU.) This figure was created in Blue Sky Plan 4 software.

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The generation of the '*.stl' model is subsequently executed via the "create model" directive integrated within the Blue Sky Plan 4 software, a depiction of which is portrayed in this Figure. Swiftly and efficiently, this command engenders the '.stl' model.

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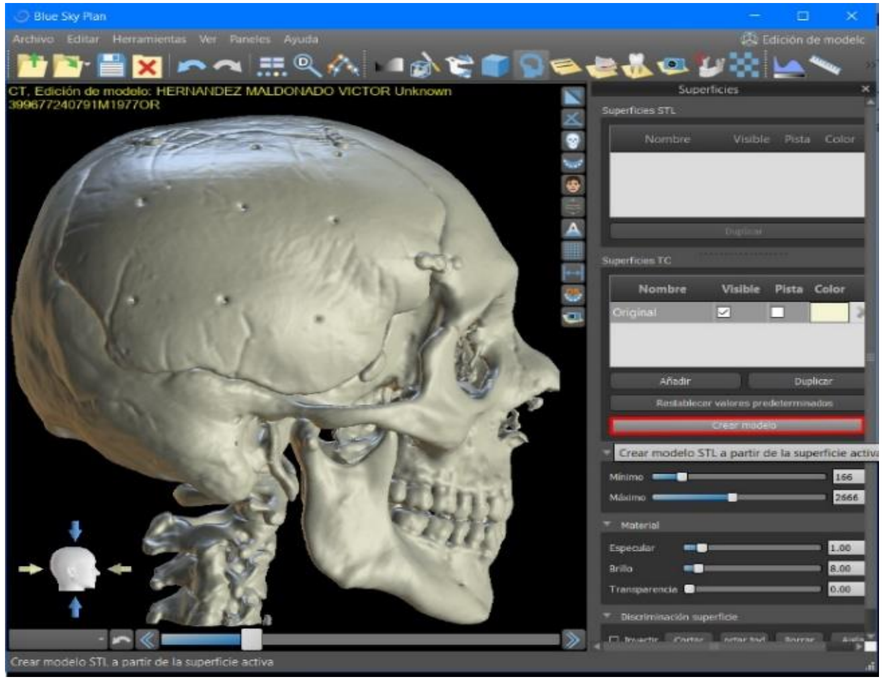
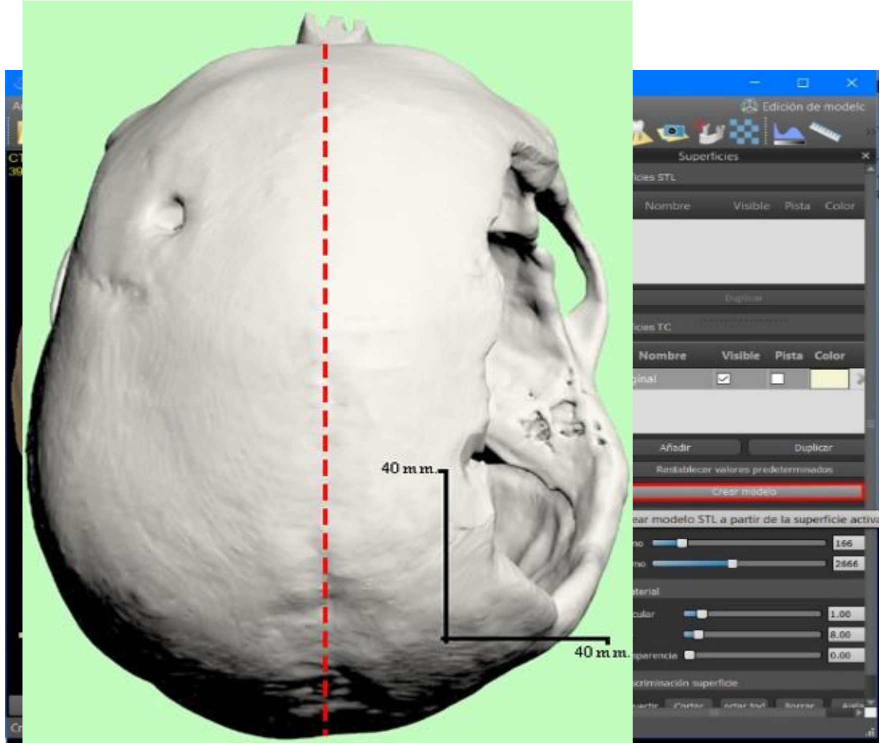


Generation of the '*.stl' model with the Blue Sky Plan 4 software (Blue Sky Bio, EE. UU.) This figure was created in Blue Sky Plan 4.

Methodology.



It is displayed the CT* Scan of the patient from a superior viewpoint. The left side depicts a healthy skull, while the right side reveals a huge absence of bone. This figure was created in 3DS Max.

Generation of the '.stl' model with the Blue Sky Plan 4 software (Blue Sky Bio, EE. UU.) This figure was created in Blue Sky Plan 4.

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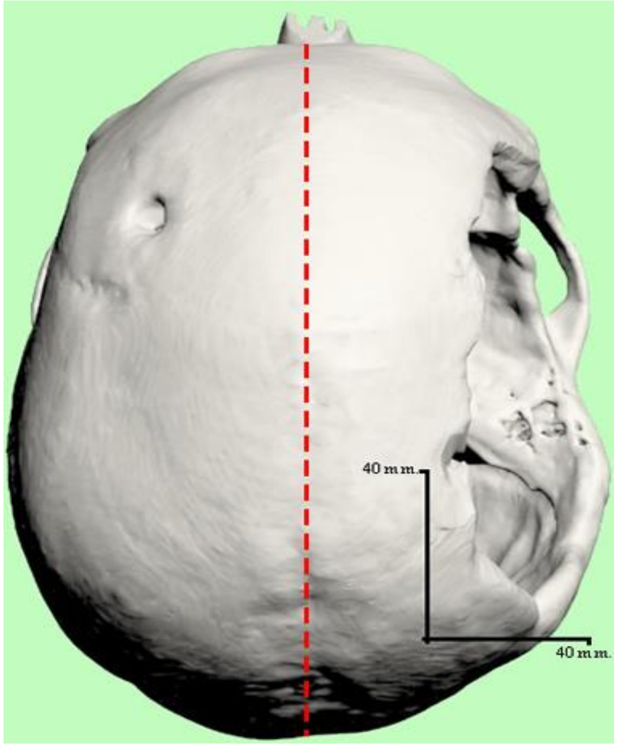
2. Refining the model and obtaining the final prosthesis.

b) Moreover, the patient manifests a distinctive attribute within their case, necessitating the application of two distinct prosthetic interventions across both hemispheres of the cranial structure. The initial and more imperative prosthesis finds its placement on the right parietal region, which previously underwent a craniotomy procedure. Equally imperative is the requirement for a perforation on the left frontal region to accommodate a drainage valve. Both of these prerequisites are graphically elucidated in this Figure, demarcated by the dashed red line.

Methodology.



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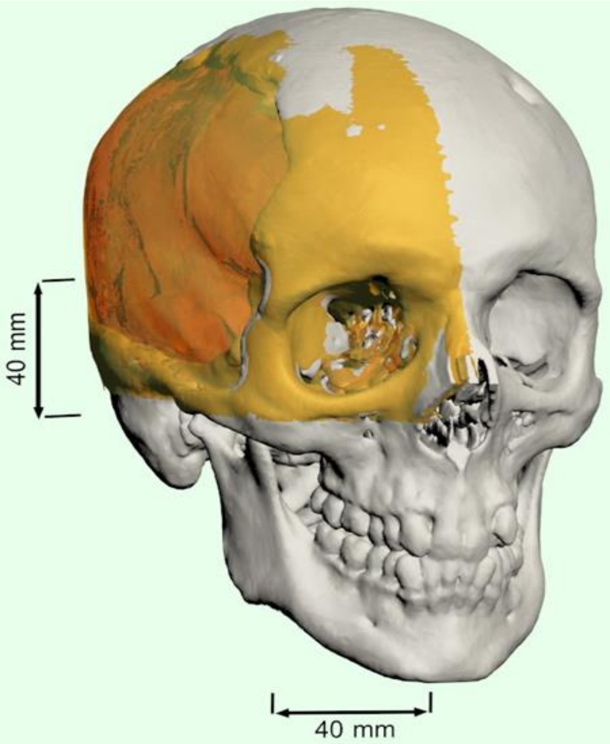

It displays a contrast between two zones, the healthy and the loss of bone. The left side depicts a healthy skull, while the right side reveals a huge absence or loss. This figure was created in 3DS Max. 2023

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2. Refining the model and obtaining the final prosthesis.

The procedure for designing entailed the implementation of the mirroring technique, which involved referencing the intact side of the skull. This approach ensured the alignment of the skull while concurrently establishing the precise insertion for the cranial parietal region, which previously underwent a craniotomy procedure. Notably, this strategy is pivotal in achieving accurate implant alignment and positioning. The mirroring technique appears to yield promising results, and now it is tasked to exclusively model the area that the prosthesis covers.

Moreover, the patient manifests a distinctive attribute within their case, necessitating the application of two distinct prosthetic interventions across both hemispheres of their cranial structure. The initial and more intricate prosthesis finds its placement on the right parietal. This methodology is visually illustrated in this Figure. Equally imperative is the requirement for a perforation on the left frontal region to accommodate a drainage valve. Both of these prerequisites are graphically elucidated in this Figure, demarcated by the dashed red line.

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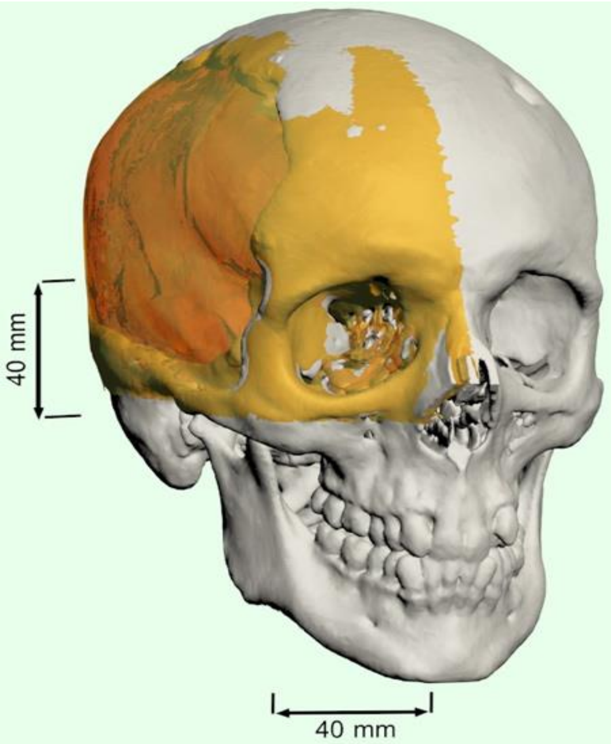

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The procedure for designing entailed the implementation of the mirroring technique, which involved referencing the intact side of the skull. This approach ensured the alignment of the skull while concurrently establishing the precise orientation for the cranial implant. This methodology is visually illustrated in this Figure. Moreover, this strategy is pivotal in achieving accurate implant alignment and positioning.

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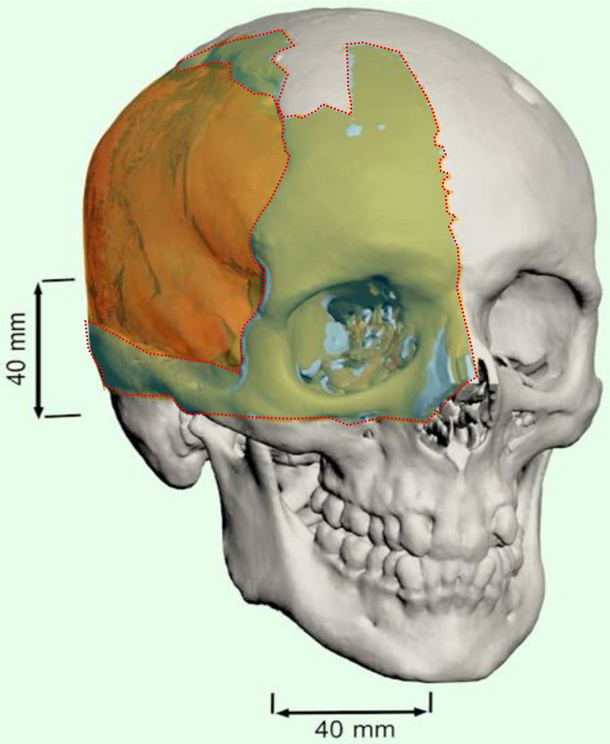

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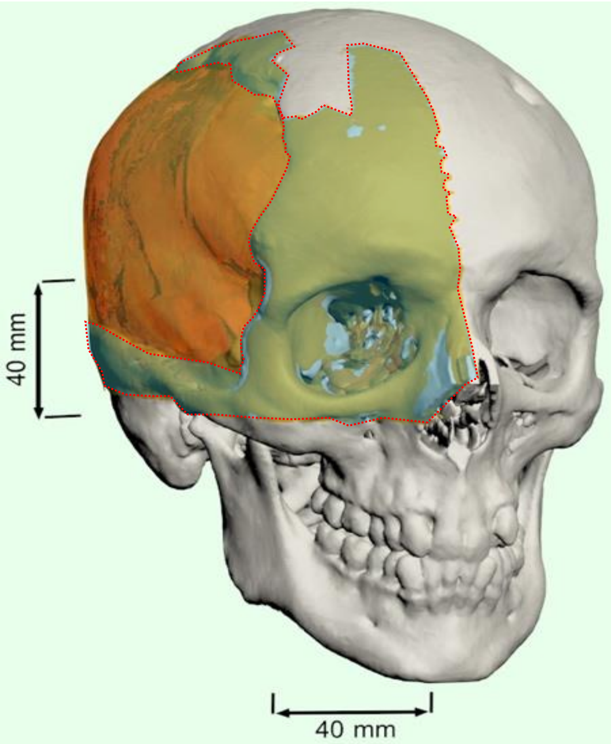
2. Refining the model and obtaining the final prosthesis.

It is of utmost importance to carefully adhere to the boundary set by the skull recipient, which involves defining the contact side of the skull. This approach ensures the alignment of the skull concurrently establishing the precise orientation for the cranial implant. This methodology is visually illustrated in this Figure. Moreover, this strategy is pivotal in achieving a complete implant alignment and positioning. The machining phase is poised to yield promising results, and now it is time to exclusively model the part that the prosthesis covers.

The procedure for designing entailed the implementation of the morphing technique, matrix when generating the prosthesis model. <u>This aspect represents the major contribution of this study.</u> While certain functionalities within the Python software, such as Slicer 3D 5.2.2, are harnessed to execute this task, the resultant prosthesis does not attain the state of "absolute accuracy" as defined by Pöppe, J. P., et al. [11]. Consequently, there remains a potential divergence between the final fabricated prosthesis and the precise contours of the recipient's cranial architecture. This discrepancy underscores the imperative for further refinements in pursuit of enhanced precision.

Methodology.

2. Refining the model and obtaining the final prosthesis.



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It is of utmost importance to carefully adhere to the boundary set by the skull or recipient matrix when designing the prosthesis model. This aspect represents the major contribution of this study. While certain functionalities within Python software, such as Slicer 3D 5.22, are harnessed to execute this task, the resultant prosthesis does not attain the state of "absolute accuracy" as defined by Pöppe, J.P., et al. [III]. Consequently, there remains a potential divergence between the final fabricated prosthesis and the precise contours of the recipient's cranial architecture. This discrepancy underscores the imperative for further refinements in pursuit of enhanced precision.

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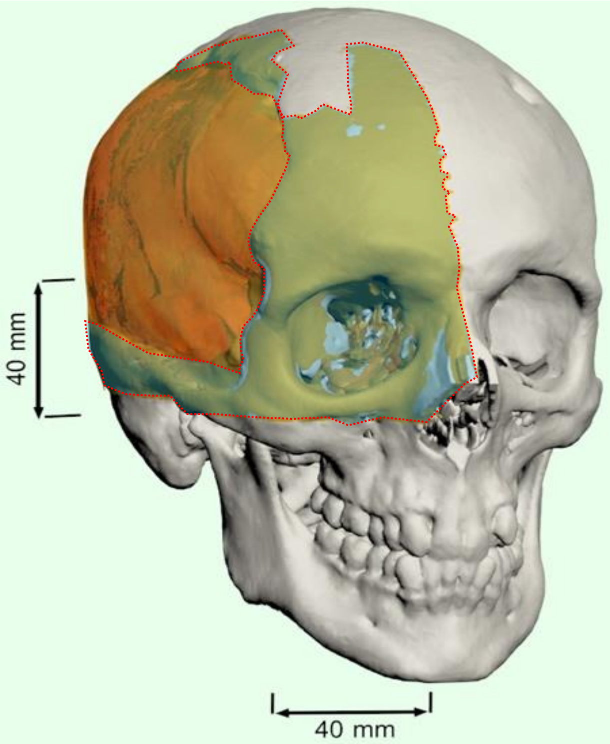

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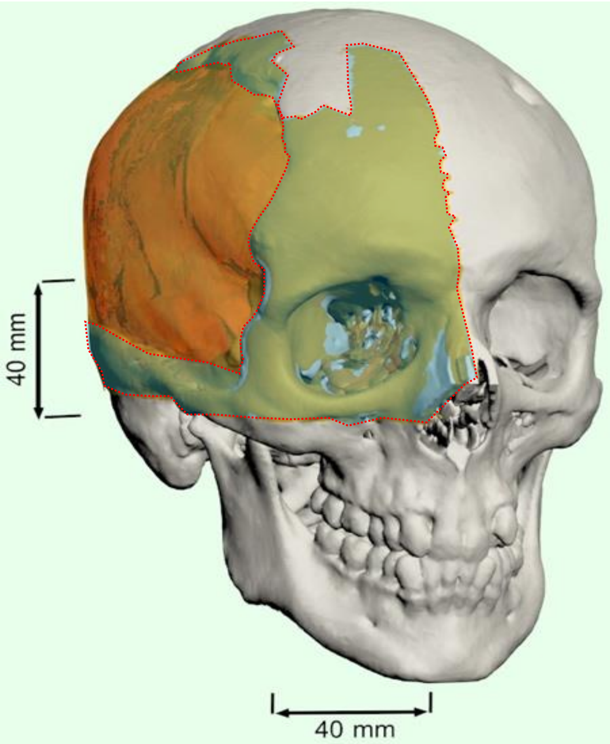
Therefore, the suggested methodology can be outlined as follows:

1. Meticulously trim the surplus region that intersects between the prosthesis model and the recipient matrix, with careful consideration for precision and alignment.
2. Subsequently, it becomes imperative to ensure the "closure" of the model, guaranteeing absolute continuity of the surface of the prosthesis model.
3. During this phase, it becomes apparent that certain regions within the mesh of the prosthetic model persist in overlapping with the patient's cranial structure. the vertices of the mesh are subject to manual modification or manipulation to rectify these imperfections.

Methodology.



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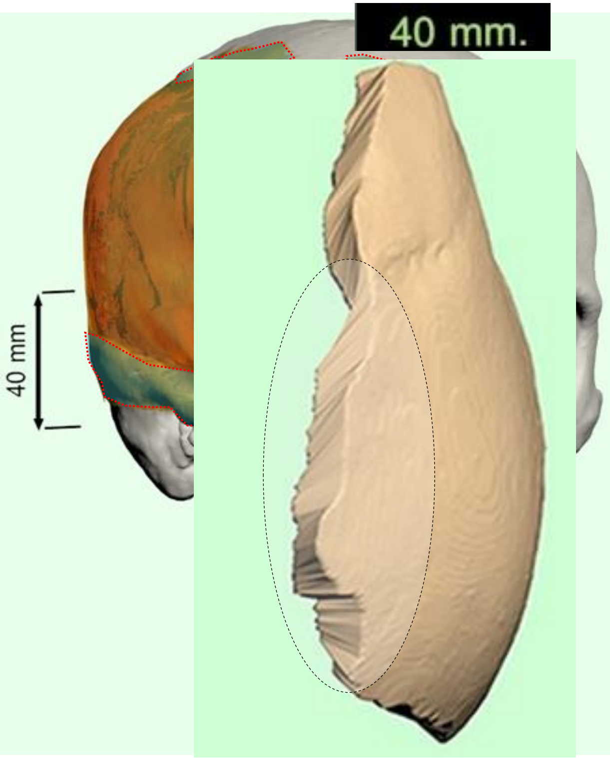

It displays a contrast between both zones, the healthy and the loss of bone.
The Spline interpolation technique is deployed.
This figure was created in 3DS Max 2023.

2. Refining the model and obtaining the final prosthesis.

Therefore, the suggested methodology can be outlined as follows:

1. Meticulously trim the surplus region that intersects between the prosthesis model and the recipient matrix, with careful consideration for precision and alignment.
4. In the estimate stage, the Spline interpolation technique is deployed, leveraging a mathematical function to estimate values with the goal of minimizing the aggregate curvature of the surface.
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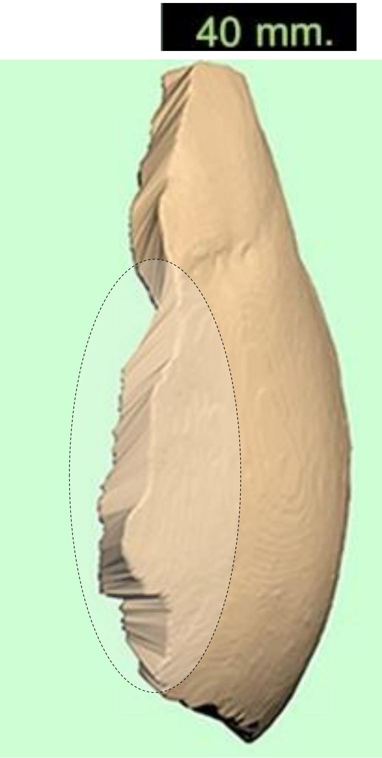

The Spline interpolation technique is deployed.
This figure was created in 3DS Max 2023.

2. Refining the model and obtaining the final prosthesis.

Therefore, the suggested methodology can be outlined as follows:

4. In the ultimate stage, the Spline interpolation technique is deployed, leveraging a mathematical function to estimate values with the goal of minimizing the aggregate curvature of the surface.

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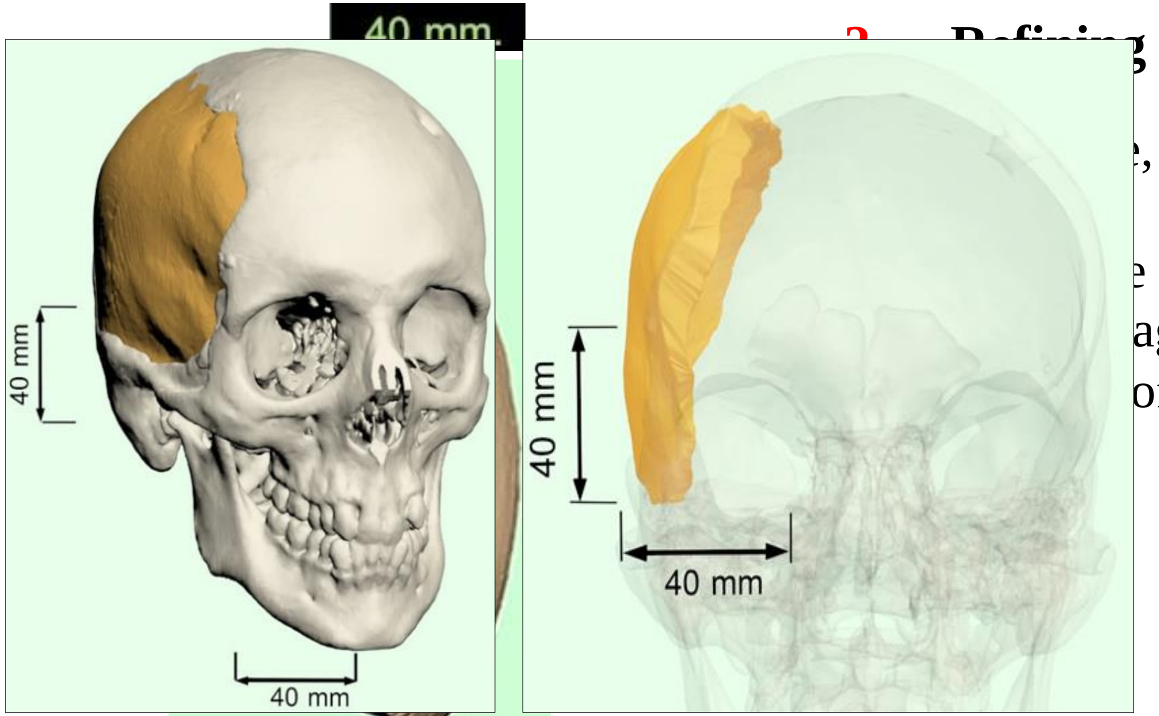
Methodology.

Results.

3. Refining the



Displays the result of steps 4.2.1, 4.2.2 and 4.2.3; For prostheses 1. The excess mesh of the prosthesis was trimmed. This figure was created in 3DS Max 2023.

The Spline Interpolation technique is deployed.
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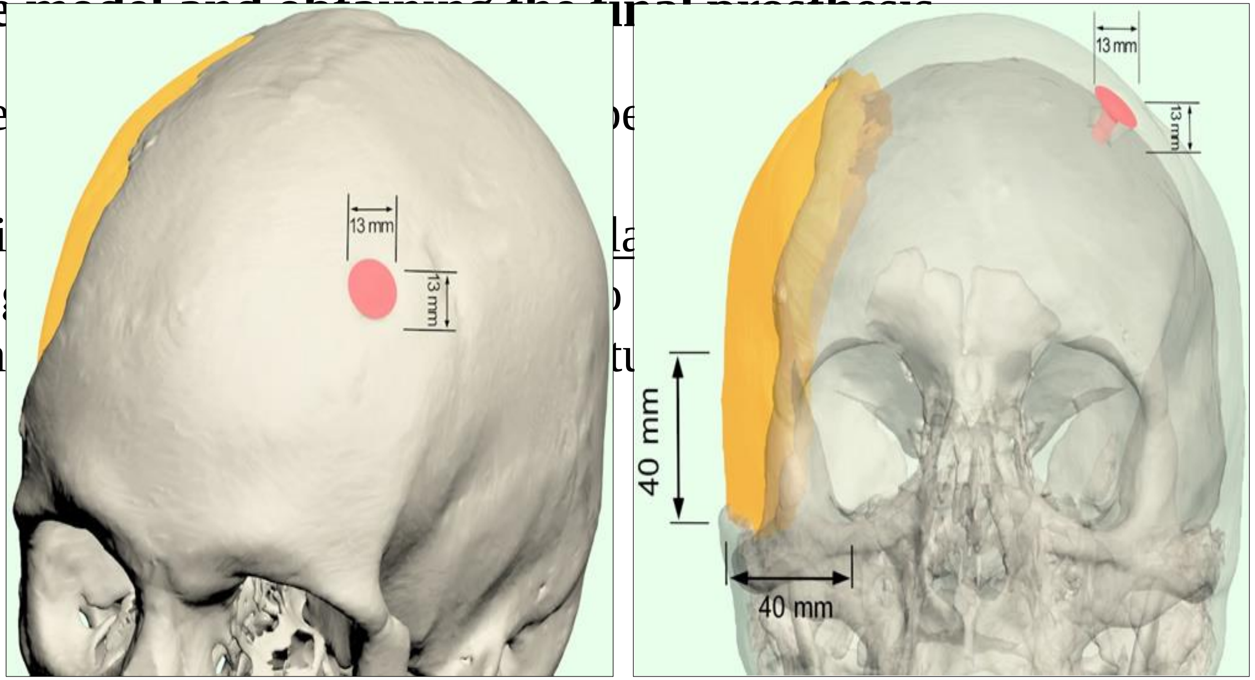
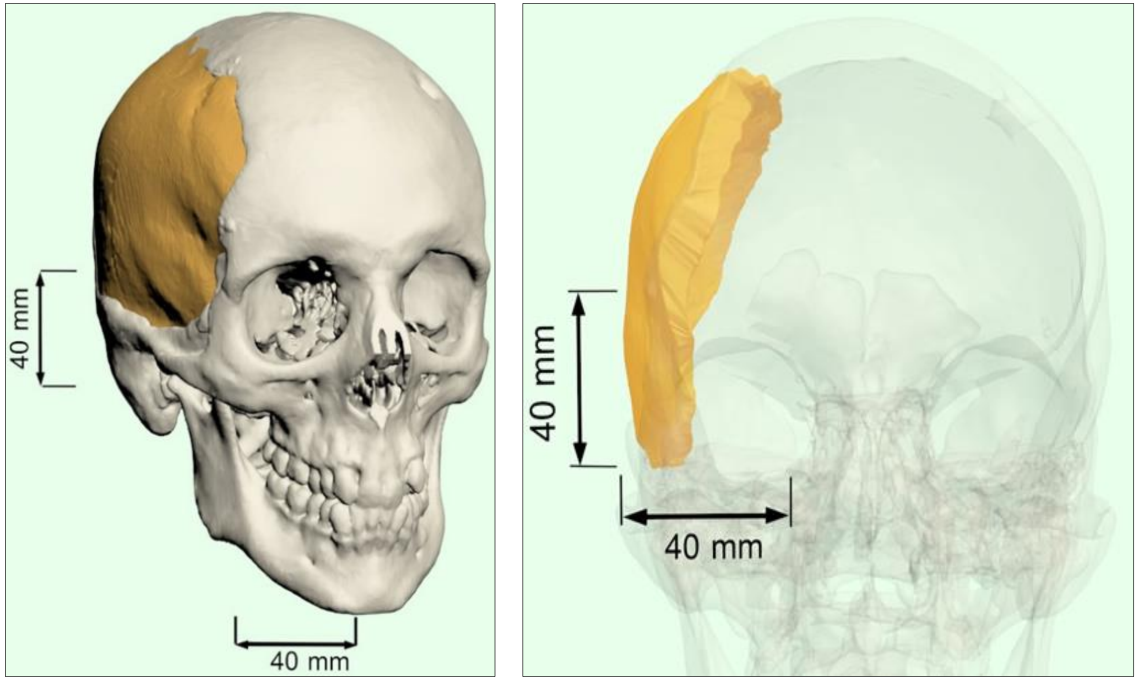


Displays the result of steps 4.2.1, 4.2.2 and 4.2.3; For prostheses 2. The excess mesh of the prosthesis was trimmed. This figure was created in 3DS Max 2023.

Results.



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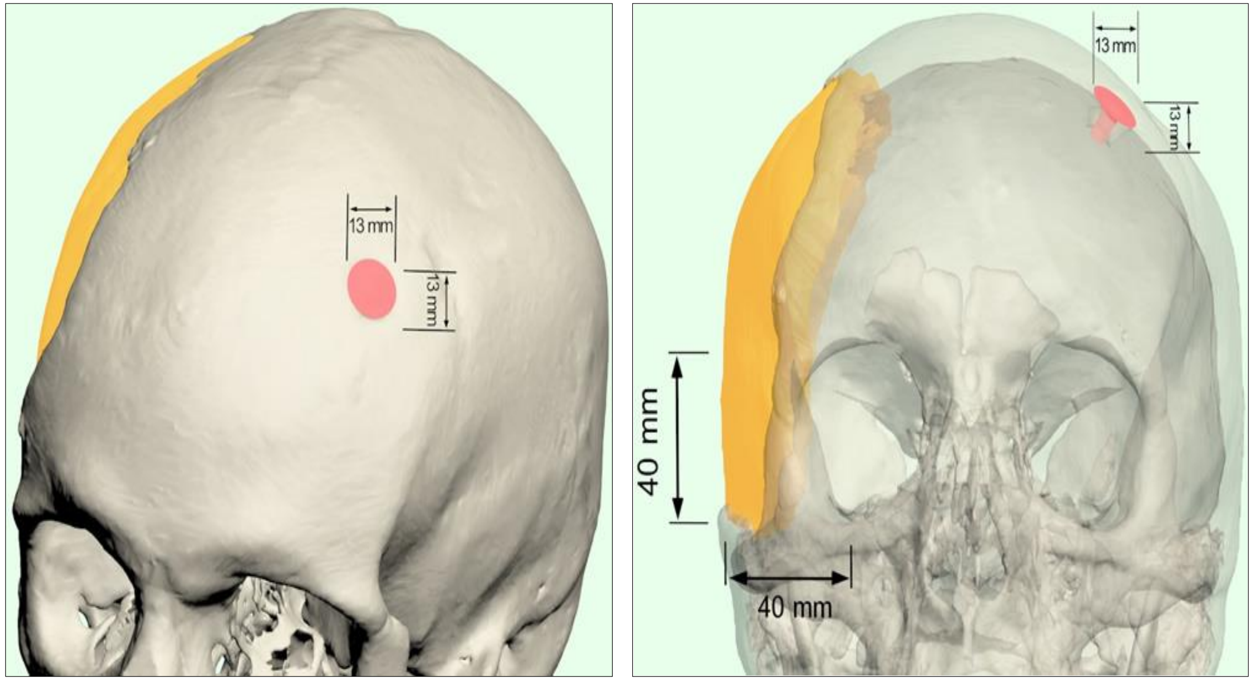

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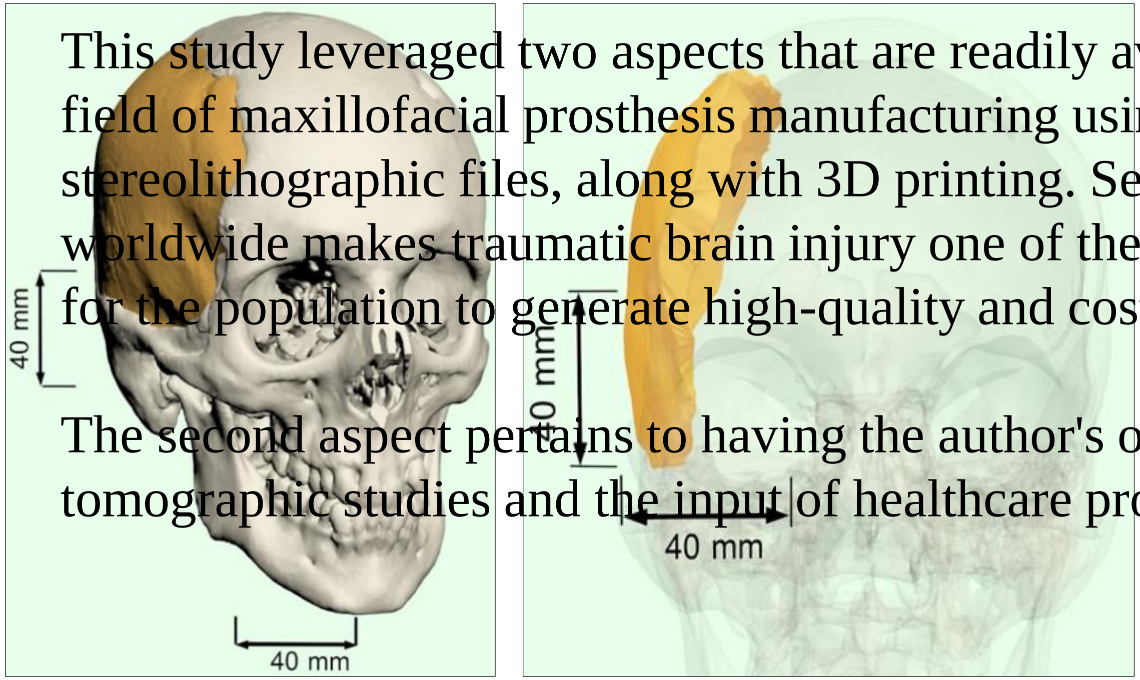
Results.

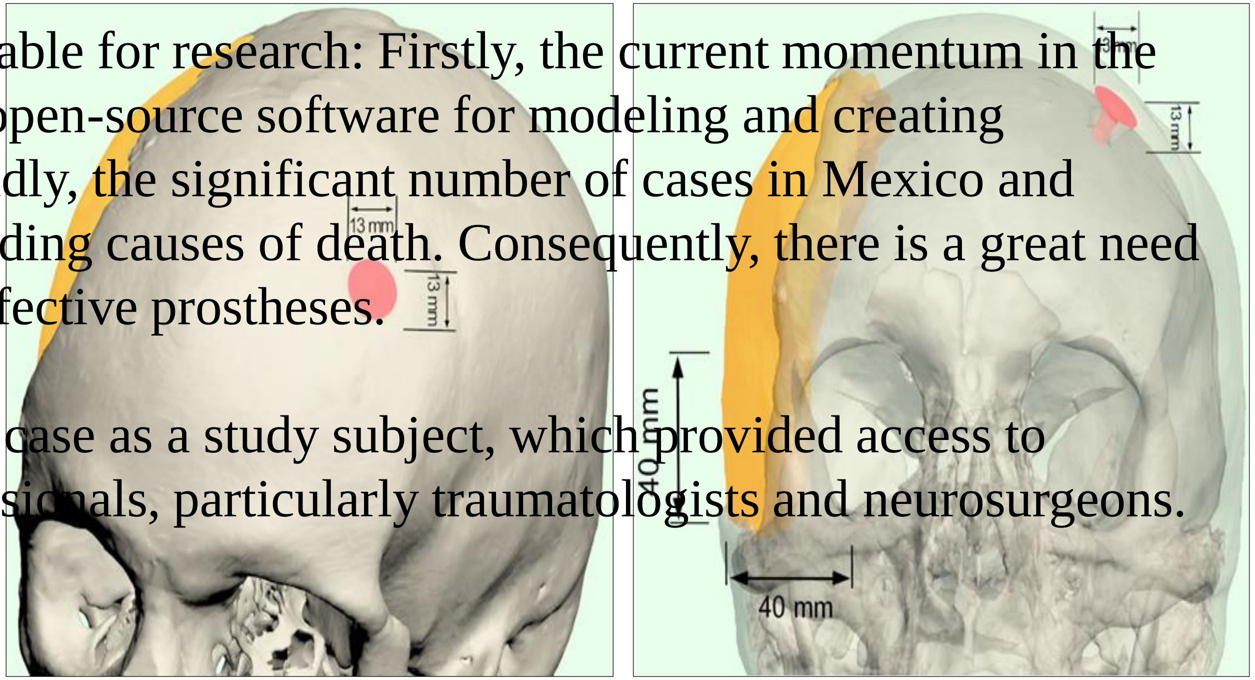
Conclusions.

This study leveraged two aspects that are readily available for research: Firstly, the current momentum in the field of maxillofacial prosthesis manufacturing using open-source software for modeling and creating stereolithographic files, along with 3D printing. Secondly, the significant number of cases in Mexico and worldwide makes traumatic brain injury one of the leading causes of death. Consequently, there is a great need for the population to generate high-quality and cost-effective prostheses.

The second aspect pertains to having the author's own case as a study subject, which provided access to tomographic studies and the input of healthcare professionals, particularly traumatologists and neurosurgeons.



Displays the result of steps 4.2.1, 4.2.2 and 4.2.3; For prostheses 1. The excess mesh of the prosthesis was trimmed. This figure was created in 3DS Max 2023.



Displays the result of steps 4.2.1, 4.2.2 and 4.2.3; For prostheses 2. The excess mesh of the prosthesis was trimmed. This figure was created in 3DS Max 2023.

Conclusions.

This study leveraged two aspects that are readily available for research: Firstly, the current momentum in the field of maxillofacial prosthesis manufacturing using open-source software for modeling and creating stereolithographic files, along with 3D printing. Secondly, the significant number of cases in Mexico and worldwide makes traumatic brain injury one of the leading causes of death. Consequently, there is a great need for the population to generate high-quality and cost-effective prostheses.

The second aspect pertains to having the author's own case as a study subject, which provided access to tomographic studies and the input of healthcare professionals, particularly traumatologists and neurosurgeons.

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