

High-Precision 3D Printing Supporting Costa Rica's First In-House Custom Cranial Implant

Asiga Ultra | DentaMODEL anatomical models + Keystone KeyPrint KeyGuide planning components

Introduction - Background

This case represents an important milestone for public healthcare in Costa Rica: the successful planning and implantation of a custom cranial prosthesis developed through an in-house workflow within the Costa Rican Social Security Fund (CCSS).

The achievement was based on an integrated process combining medical imaging, biomedical engineering, additive manufacturing and close collaboration between engineers and neurosurgeons. High-precision resin 3D printing supported the planning and validation stages before the definitive implant was manufactured.

Clinical challenge

Patient-specific cranial reconstruction requires accurate reproduction of complex skull geometry. The design must follow the remaining anatomy closely so that contours, edge transitions and the relationship between the prosthesis and existing bone can be evaluated before surgery.

To strengthen this verification process, the team used the Asiga Ultra with Asiga DentaMODEL to produce accurate patient-specific anatomical models, while Keystone KeyPrint KeyGuide was used as a third-party material for selected planning and guide components.

CASE SUMMARY

INSTITUTION

Hospital San Juan de Dios / CCSS

CLINICAL AREA

Neurosurgery / Cranial reconstruction

3D PRINTER

Asiga Ultra

MATERIALS

Asiga DentaMODEL

Keystone KeyPrint KeyGuide (third-party)

APPLICATION

Anatomical models, design verification, surgical planning and guide components

COUNTRY

Costa Rica

64% reported cost reduction

~7 days reported workflow turnaround



Figure 1. Physical verification model used to evaluate the relationship between the patient-specific cranial anatomy and the proposed reconstruction.

Digital workflow & the role of the Asiga Ultra

From medical imaging to a physical validation model

Patient-specific workflow

1. **Medical imaging:** CT data captures the patient-specific anatomy and defect.
2. **Segmentation:** The relevant cranial anatomy is isolated from the medical image data.
3. **3D reconstruction:** A digital representation of the skull and defect is generated.
4. **Implant design:** The patient-specific reconstruction is developed and reviewed digitally.
5. **Physical models and guide components:** Patient-specific anatomical models were printed on the Asiga Ultra using DentaMODEL, while selected planning and guide components were produced using Keystone KeyPrint KeyGuide.
6. **Physical validation:** Engineers and surgeons inspect fit, contour and geometry before definitive manufacturing.

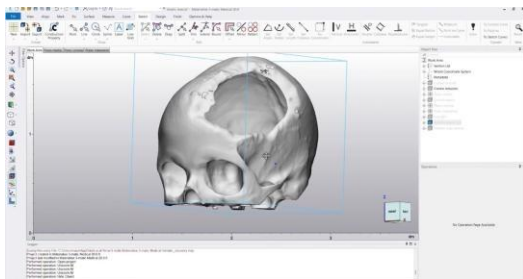


Figure 2. Digital cranial reconstruction and defect assessment during the 3D planning stage.

Asiga + Keystone - materials in the workflow

The Asiga Ultra served as a high-precision validation platform, allowing the team to rapidly convert patient-specific digital data into detailed physical models and planning components that could be handled, inspected and discussed by engineering and clinical personnel.

Asiga DentaMODEL was used for the patient-specific anatomical models and physical design verification. Keystone KeyPrint KeyGuide, used as a third-party material within the same workflow, was used for selected planning and guide components. Together, these materials supported physical verification of the anatomy and translation of the digital plan into tangible references for the clinical team.

The 3D printing workflow helped the team to:

- Review the geometry and boundaries of the cranial defect.
- Evaluate cranial contours and anatomical continuity.
- Verify the relationship between the implant design and the patient-specific anatomy.
- Support multidisciplinary discussions between engineers and neurosurgeons.
- Identify possible adjustments before definitive implant manufacturing.
- **Increase confidence in the planned reconstruction while integrating both manufacturer and third-party materials for their respective planning roles.**

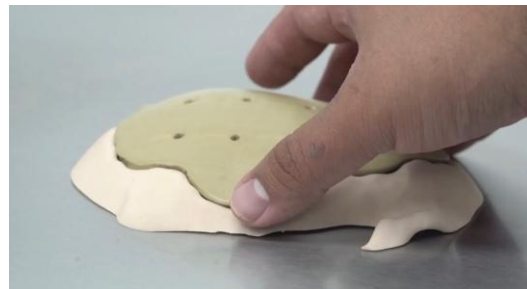


Figure 3. Physical evaluation of the prosthesis geometry against the patient-specific anatomical model.

From validation to surgery

A multidisciplinary workflow linking digital design, physical verification and clinical execution

Collaborative design and physical validation

A critical element of the project was direct collaboration between biomedical engineering and neurosurgery. The printed anatomical models created a shared physical reference between both disciplines, allowing the team to evaluate the patient-specific reconstruction beyond the computer screen.

This additional verification stage was especially valuable before final production. The model could be physically inspected for overall contour, defect boundaries and design continuity, while the surgical team could provide feedback based on the planned operative approach.

The Asiga workflow, using DentaMODEL for anatomical modeling and Keystone KeyPrint KeyGuide for selected planning and guide components, therefore contributed not simply as a prototyping step, but as part of the engineering and clinical validation process supporting the definitive patient-specific solution.

KEY IMPACT

- Faster in-house iteration during planning.
- Physical validation of patient-specific geometry.
- Improved communication between engineering and surgery.
- **Flexible integration of manufacturer and third-party materials within the planning workflow.**
- Foundation for future patient-specific medical workflows.



Figure 4. Definitive cranial prosthesis prepared for surgical placement.



Figure 5. Intraoperative view of the patient-specific cranial prosthesis during placement.

Conclusion

For this case, the Asiga Ultra, Asiga DentaMODEL and Keystone KeyPrint KeyGuide contributed directly to the planning and validation workflow. DentaMODEL enabled accurate patient-specific anatomical models for physical design verification, while KeyPrint KeyGuide was used for selected planning and guide components. Together, these physical references helped the team evaluate the proposed reconstruction, better understand the patient-specific anatomy and strengthen communication between engineering and neurosurgery before the definitive implant reached the patient.

AUTHOR STATEMENT

I confirm that the information above accurately describes the role of the Asiga Ultra, Asiga DentaMODEL and Keystone KeyPrint KeyGuide in the planning and validation workflow used in this patient-specific cranial reconstruction case.

NAME

Rosa Sanchez
Valenciano

PROFESSIONAL TITLE

Prosthetist

DEPARTMENT / INSTITUTION

Caja Costarricense
de Seguro Social

DATE

10-19-2026

COUNTRY

Costa Rica