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Cutting Guides: 3D Osteotomy Planning

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Disclosures

- Arthroscopy
  Consultant + Royalties : VIMS
  Consultant : Biomet Zimmer

- Arthroplasty
  Consultant + Royalties : FH orthopaedic

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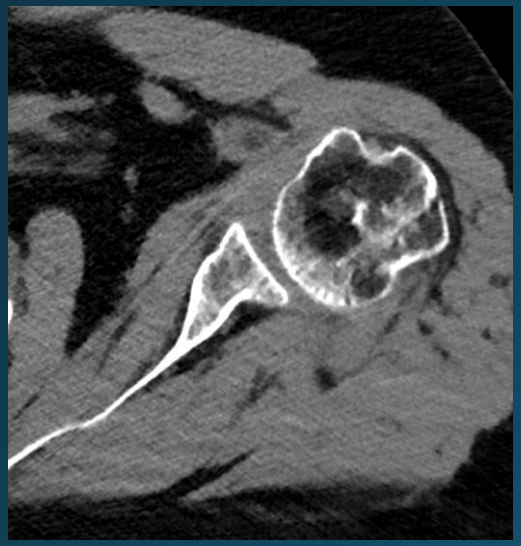
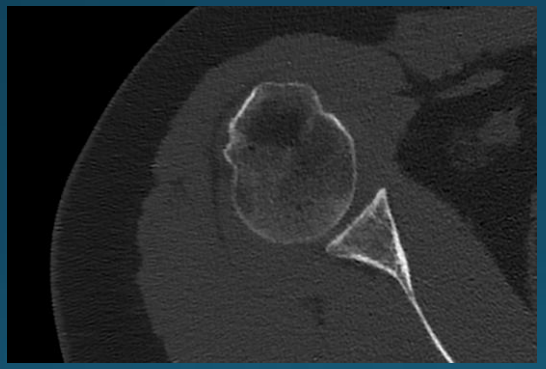
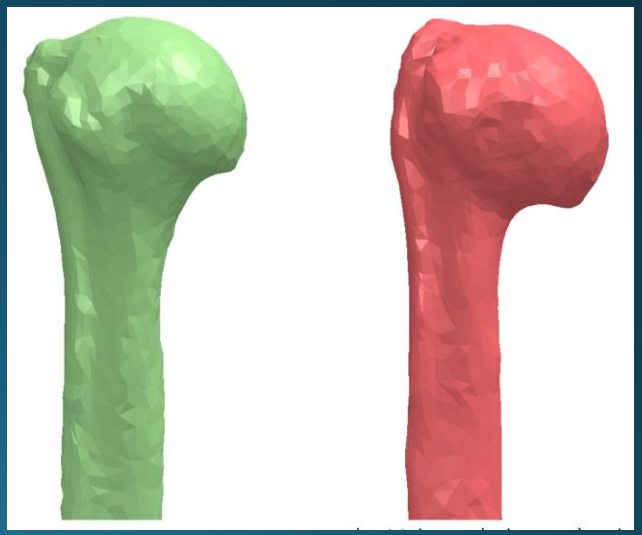
Custom cutting guides From 3D Model

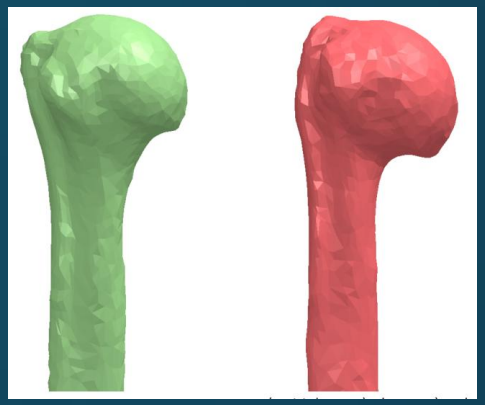




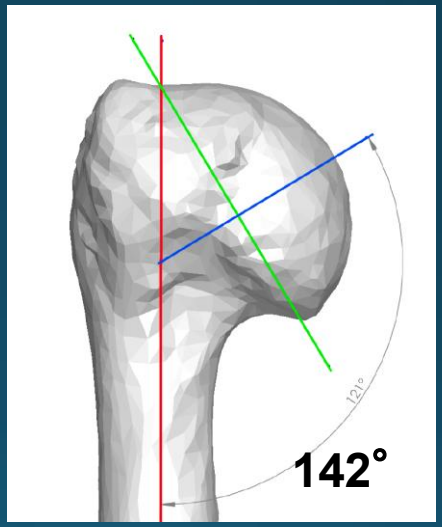


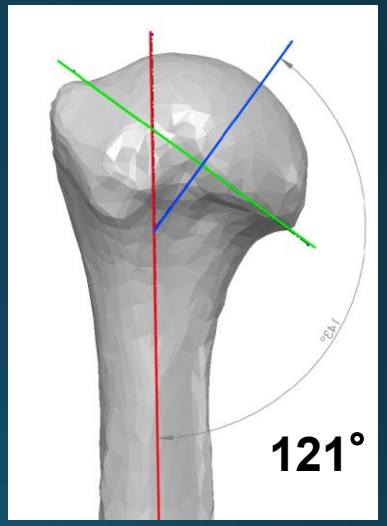
From a CTScan 2D
we make 3D bone models

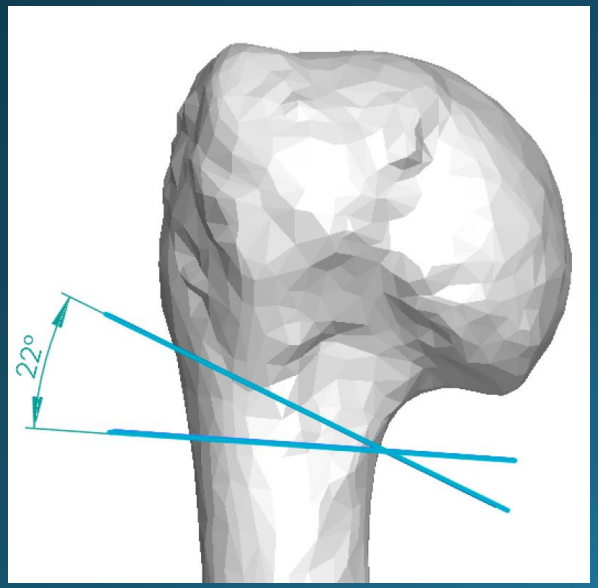
Custom cutting guides From 3D Model



The planned correction is simulated by manipulating the bone models in virtual 3D space







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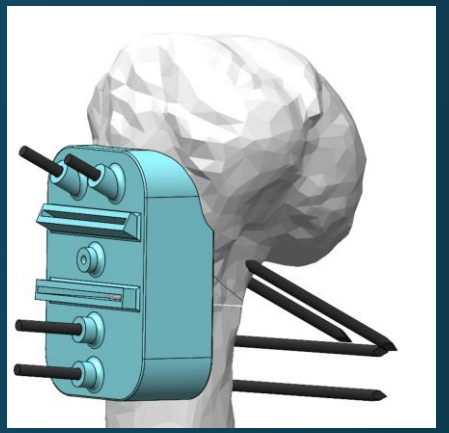
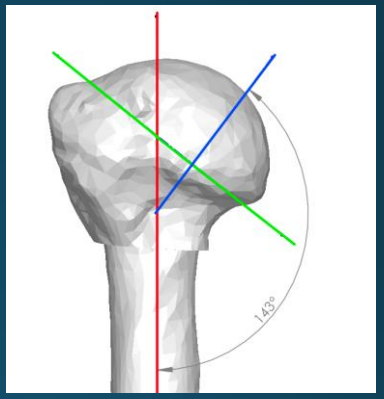
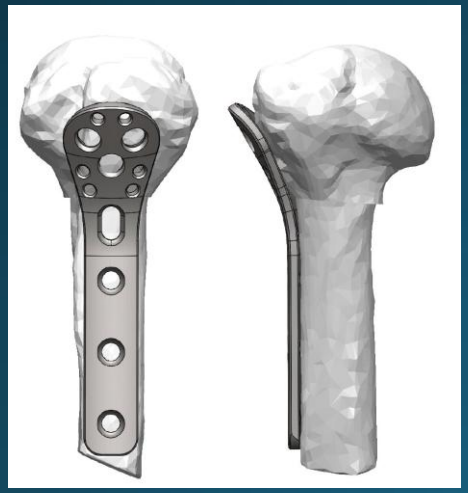
Custom Cutting guides From 3D Model

A Specific 3D Cutting guide is designed
To reproduce exactly the pre op planning

You can predict the holes
for screws and plate
With a specific drill cutting guide







> Acta Orthop Belg. 2012 Aug;78(4):538-42.

3D-corrective osteotomy using surgical guides for posttraumatic distal humeral deformity

Mathias Tricot [1], Khanh Tran Duy, Pierre-Louis Docquier

Affiliations + expand

PMID: 23019789

Objective:

Distal humerus malunion

Three patients CT-based 3D planning.
A custom surgical guide and pre-molded plate were created.
Guides were used intraoperatively to perform precise osteotomies.

- All patients regained full elbow mobility
- **Conclusion:**
  This technique improves surgical accuracy, reduces operating time and incision size, and eliminates the need for intraoperative fluoroscopy.
- Drawbacks include planning time, CT requirement, and cost.

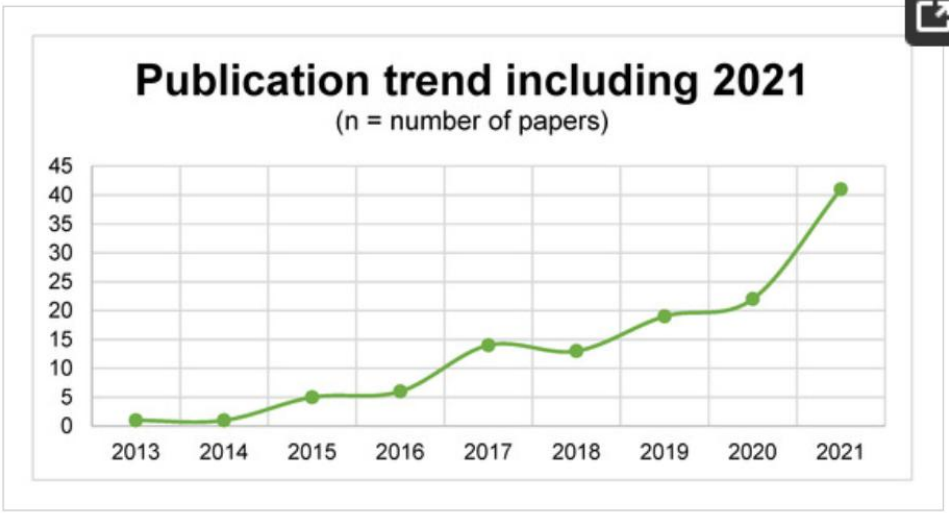
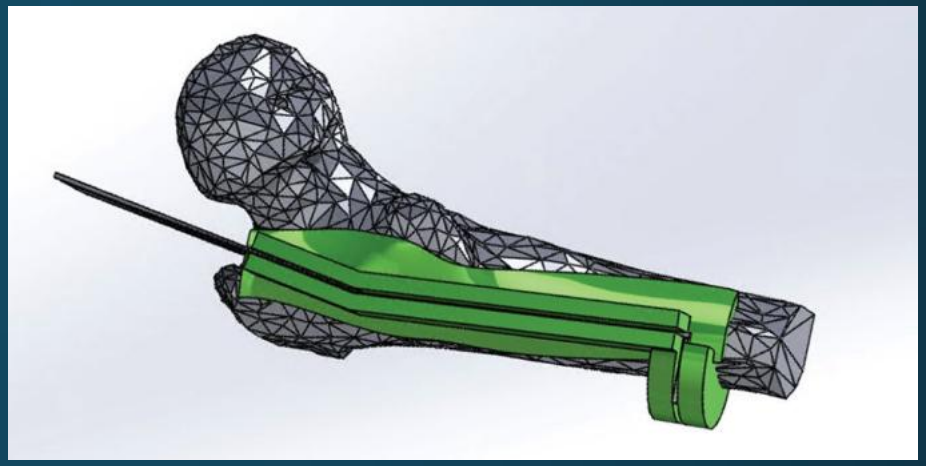


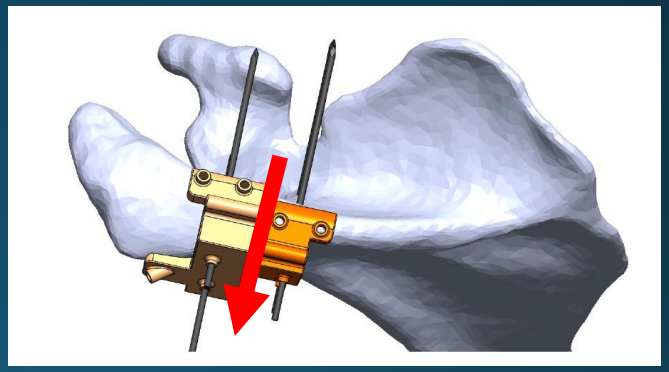
Figure 1. Number of publications relating to 3D printing in upper extremity surgery by year. In *PubMed*, the following search query was used: ("3D" OR "3-dimensional") AND "print*" AND ("upper extremity" OR "upper limb").

- **Complex deformities** (e.g., malunions, congenital anomalies)
- often require multi-planar corrections which are
  - Time consuming (Blood loss, time of surgery)
  - Dependent of radiation in surgery
  - Dependent on Surgeon experience

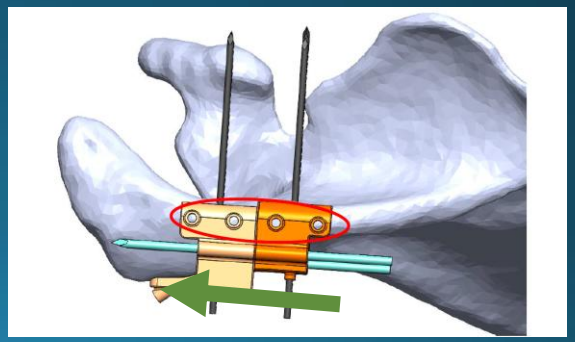
Evolution



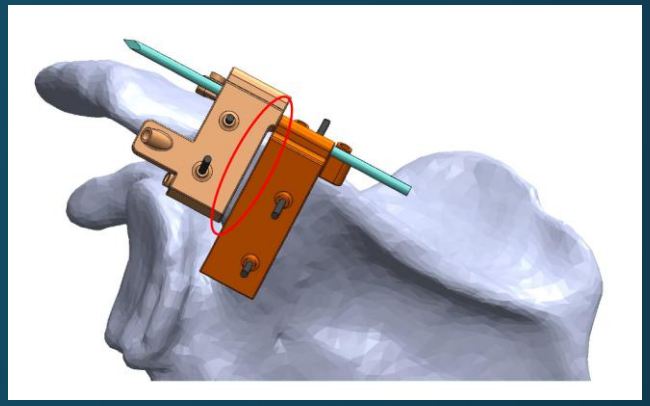
- 1st Generation:
  Basic cutting guides



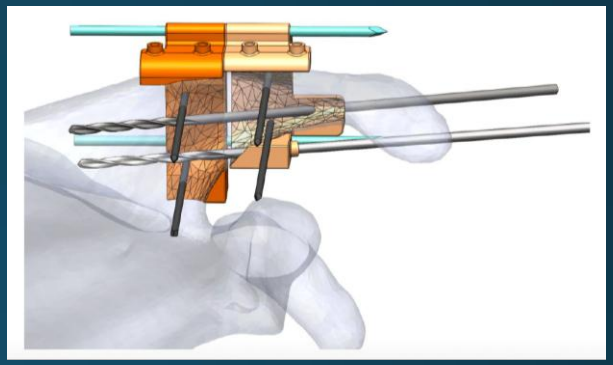
- 2nd Generation:
  Cutting + reduction guides

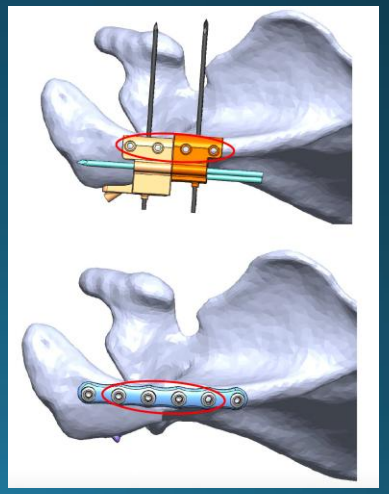


3rd Generation



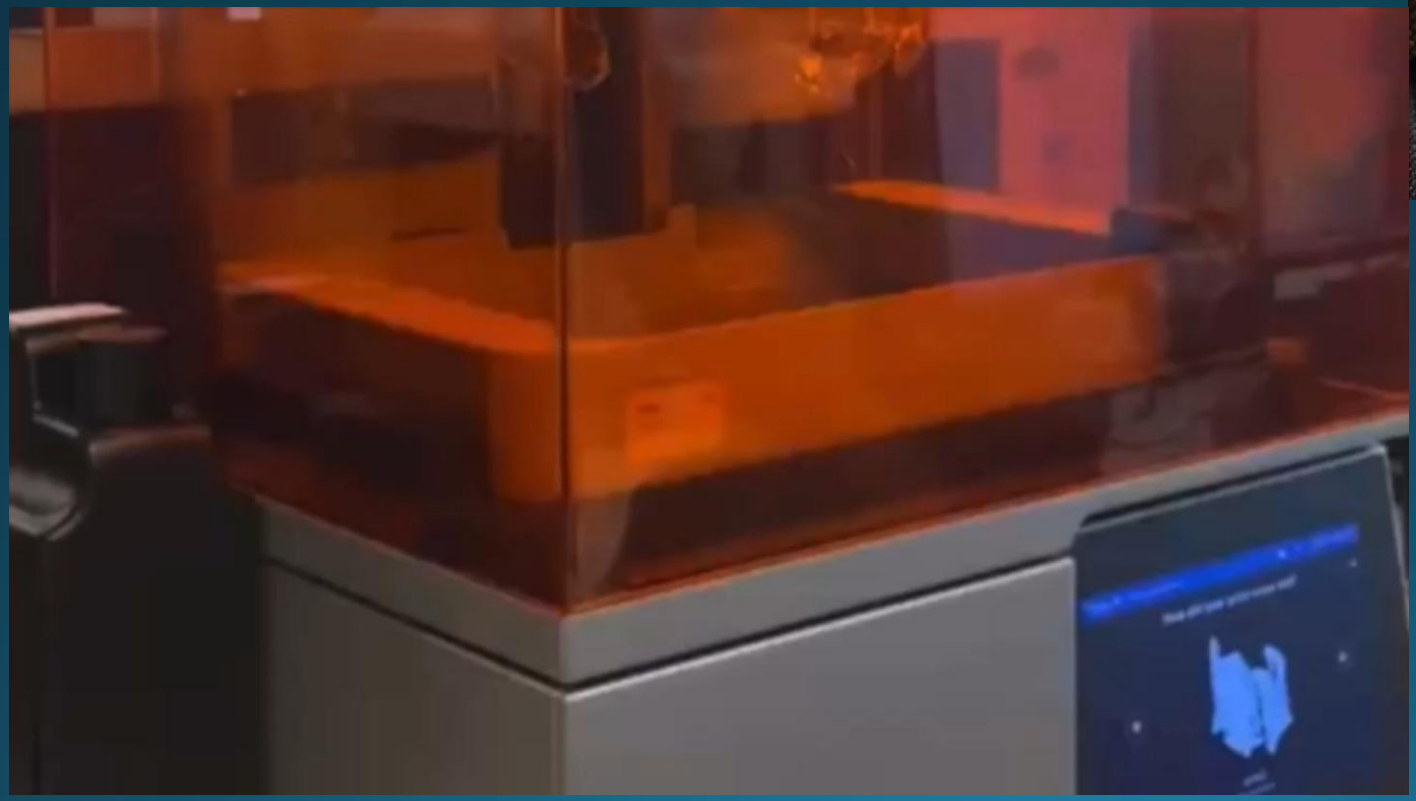
- Integrated with pre-contoured plates
- Drill hole guidance for screws
- Drill hole guidance for screws to fix the plate
- Templates for bone grafts (e.g., glenoid reconstruction)





Evolution

- **4th Generation:** custom made yourself for shoulder arthroplasty
- PSI for glenoid component
- Cutting guide for humeral component



Publications ....

> Acta Orthop Belg. 2012 Aug;78(4):538-42.

3D-corrective osteotomy using surgical guides for posttraumatic distal humeral deformity

Mathias Tricot [1], Khanh Tran Duy, Pierre-Louis Docquier

Affiliations + expand

PMID: 23019789

Distal humerus deformities
(cubitus varus/valgus)

> Orthop Traumatol Surg Res. 2022 Oct;108(6):102925. doi: 10.1016/j.otsr.2021.102925. Epub 2021 Apr 9.

3D planning and patient-specific surgical guides in forearm osteotomy in children: Radiographic accuracy and clinical morbidity

Marie Benayoun [1], Tristan Langlais [2], Romain Laurent [1], Malo Le Hanneur [1], Raphaël Vialle [3], Manon Bachy [1], Franck Fitoussi [3]

Affiliations + expand

PMID: 33845175 DOI: 10.1016/j.otsr.2021.102925

Forearm osteotomies
in children (radius/ulna)

Case Report | Open access | Published: 06 September 2023

Use of patient-specific guides and 3D model in scapula osteotomy for symptomatic malunion

Stefano Cattaneo, Marco Domenicucci, Claudio Galante, Elena Biancardi, Alessandro Casiraghi & Giuseppe Milano

3D Printing in Medicine **9**, Article number: 24 (2023) | Cite this article

2016 Accesses | **2** Citations | Metrics

Scapular osteotomies
for malunions

> J Shoulder Elb Arthroplast. 2023 Mar 14:7:24715492231162285. doi: 10.1177/24715492231162285. eCollection 2023.

3D Printed Patient-Specific Cutting Guides for Bone Grafting in Reverse Shoulder Arthroplasty: A Novel Technique

Jillian N Karpyshyn [1], Aaron J Bois [2 3], Heather Logan [4], Graeme T Harding [1], Martin J Bouliane [1]

Affiliations + expand

PMID: 36937107 PMCID: PMC10017943 DOI: 10.1177/24715492231162285

Glenoid reconstruction
in shoulder arthroplasty

Open Access Review

Clinical Applications of Three-Dimensional Printing in Upper Extremity Surgery: A Systematic Review

by Andrzej Hecker [1,2,3,*], Lukas Tax [4], Barbara Giese [4], Marlies Schellnegger [2,3], Anna-Lisa Pignet [2,3], Patrick Reinbacher [5], Nikolaus Watzinger [4], Lars-Peter Kamolz [2,3] and David Benjamin Lumenta [1,2]

"Nevertheless, the preoperative 3D-assisted planning is more time-consuming and costly. The authors estimated that planning 3D-assisted corrective osteotomy takes **about 2–4 h per patient**, including CT scans from the contralateral side, and an additional cost of **USD 2.415** for planning and producing the patient-specific guide"

Posterior Instability

With dislocation and recurrent subluxation

Mr TEL. Wa.

AGE: 24 YEARS OLD

DOMINANT SIDE: Right

INJURED SIDE: Left

OCCUPATION: Bookkepper

MEDICAL HISTORY:

Posterior subluxation during adolescence

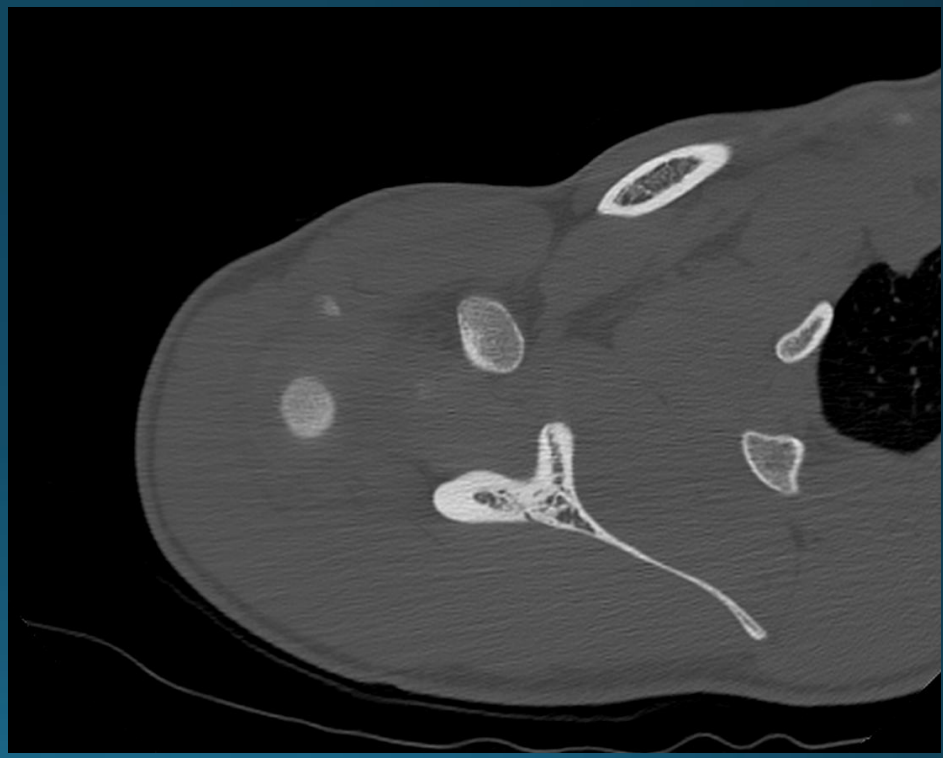
SPORT ACTIVITY	competition
TYPE OF SPORT	Boxe
TRAUMA	3 years ago
NUMBER OF DISLOCATION	3
NUMBER OF SUBLUXATION	Several
HYPERLAXITY	NO
PAIN	NO
APPREHENSION	YES

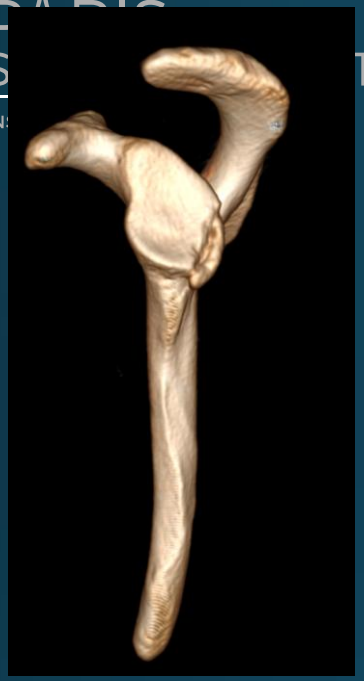
Complete ROM

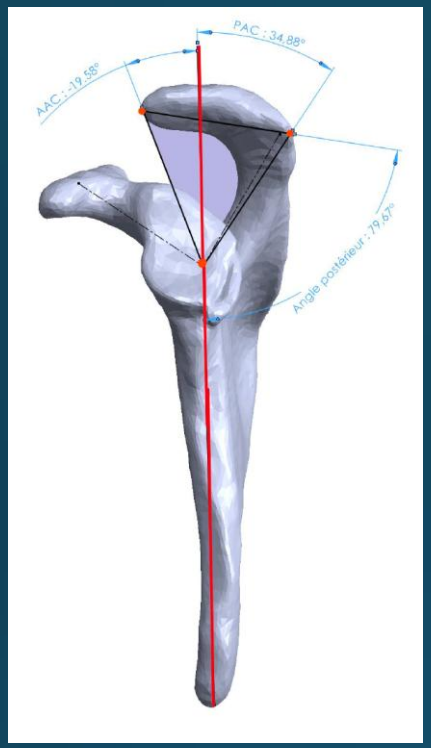
IMAGING - CT Scan

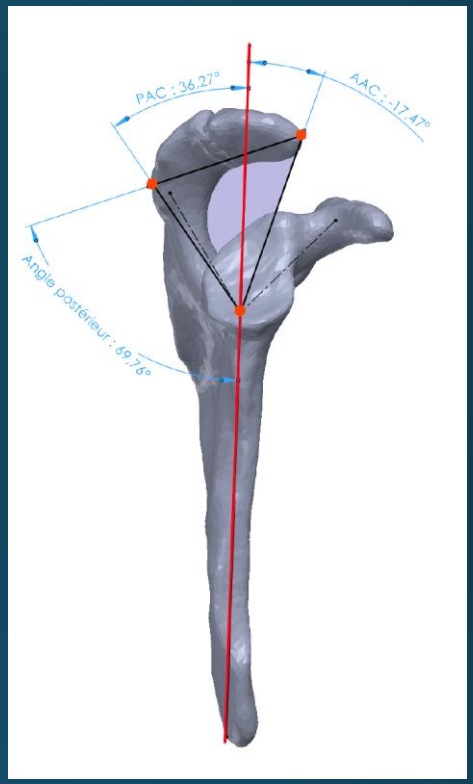
LEFT

RIGHT









Patient				Valeurs de référence		
Epaule	Angle postérieur (°)	AAC (°)	PAC (°)	Angle postérieur (°)	AAC (°)	PAC (°)
	Mesures 3D					
Gauche	79.7	-19.6	34.9	59	-5	57
Droite	69.8	-17.5	36.3			

> J Bone Joint Surg Am. 2019 Jul 17;101(14):1253–1260. doi: 10.2106/JBJS.18.00541.

Posterior Acromial Morphology Is Significantly Associated with Posterior Shoulder Instability

Dominik C Meyer [1], Lukas Ernstbrunner [1], Glenn Boyce [1], Mohamed A Imam [1], Rany El Nashar [1], Christian Gerber [1]

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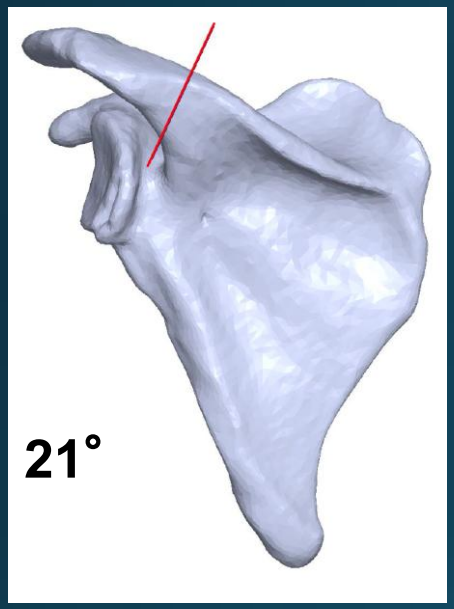
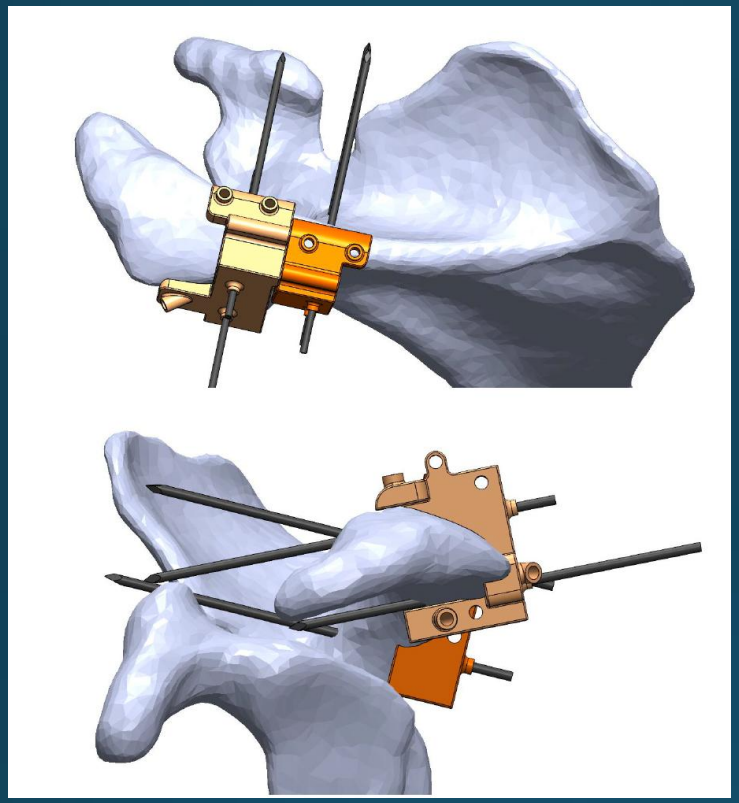
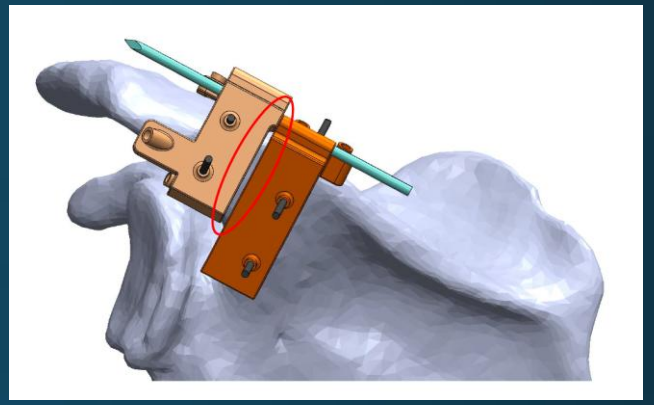
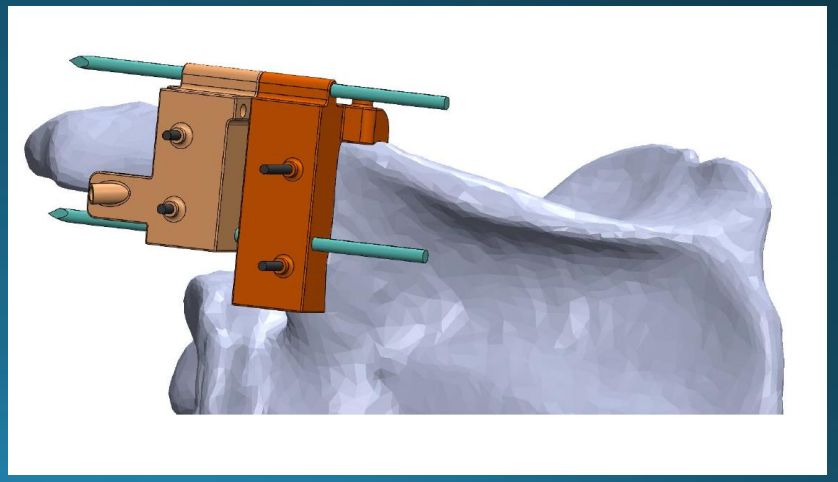
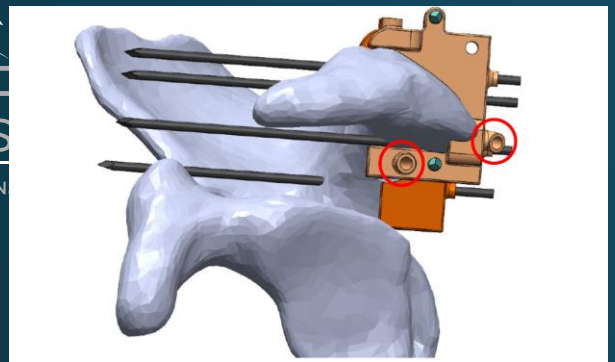
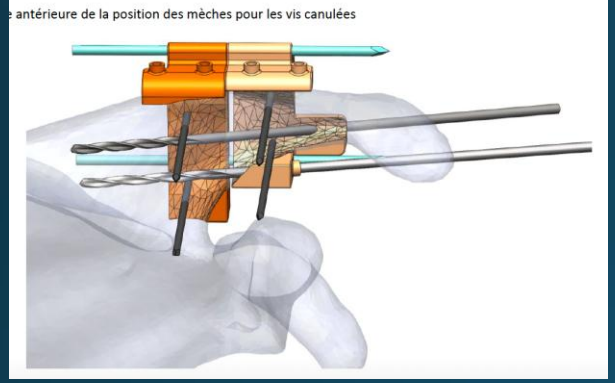




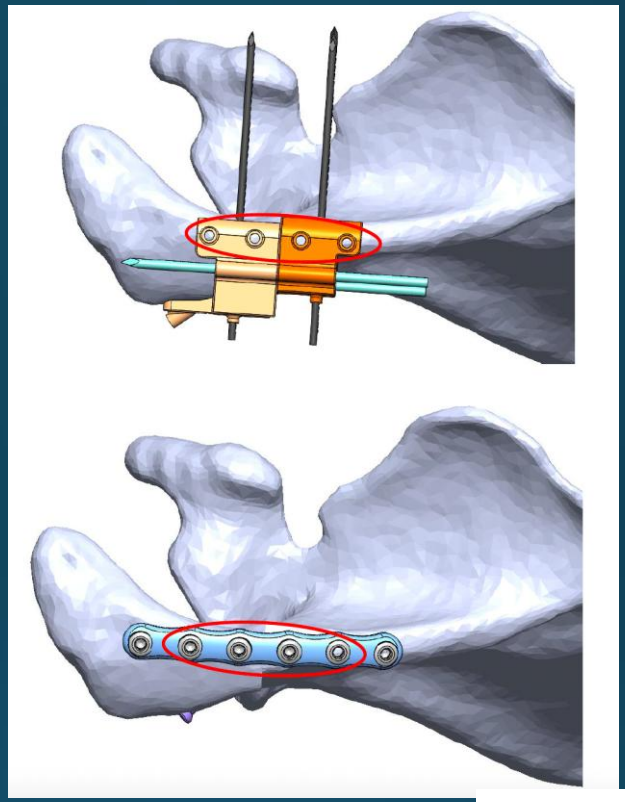


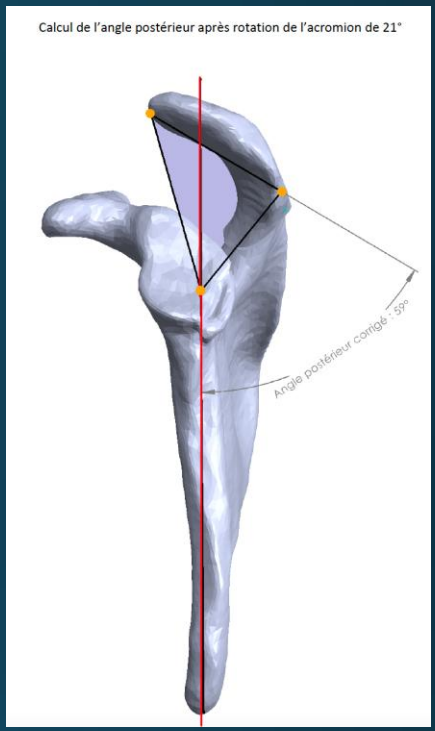


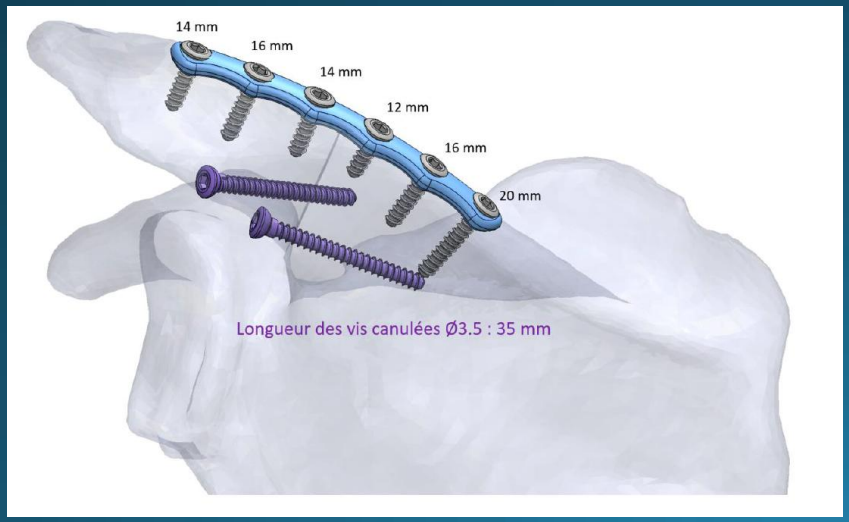


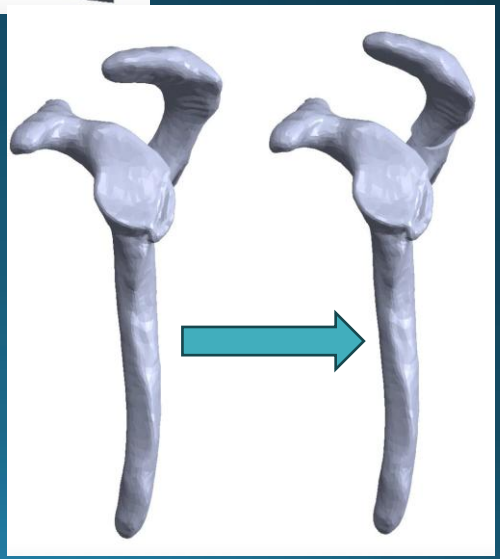


antérieure de la position des mèches pour les vis canulées









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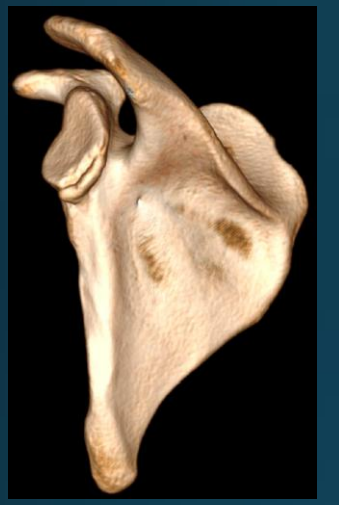
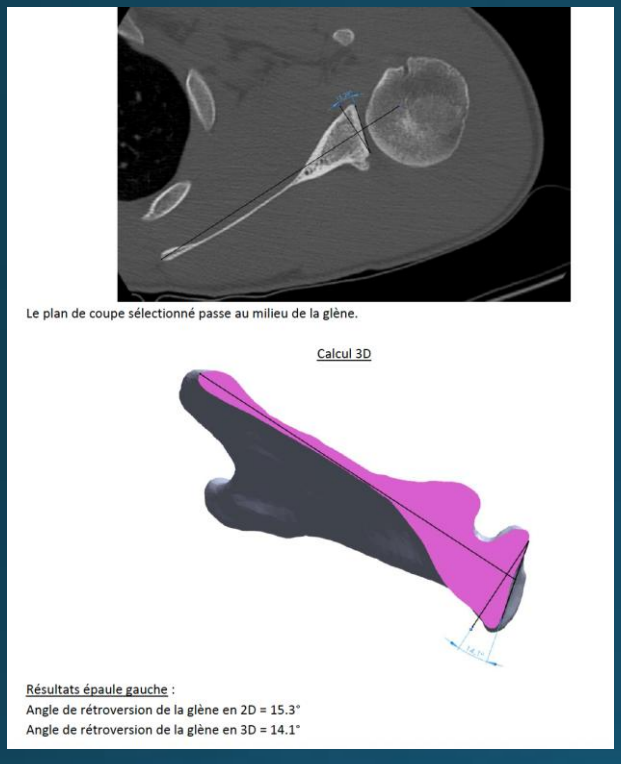
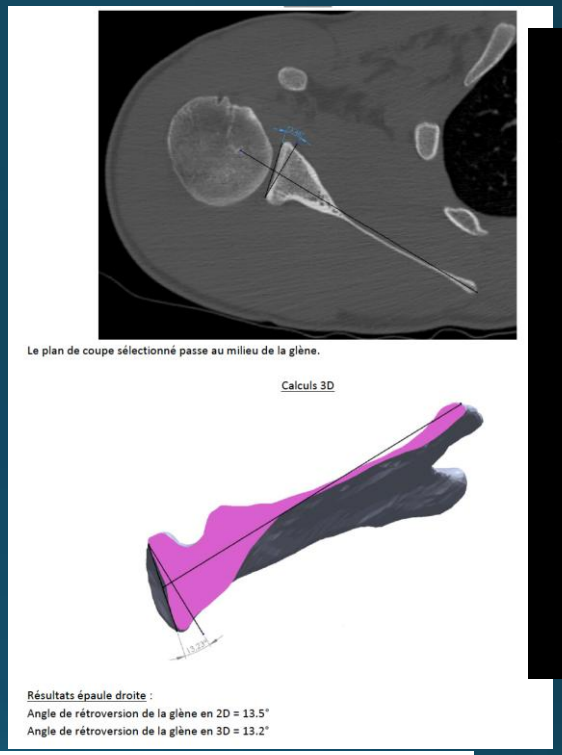
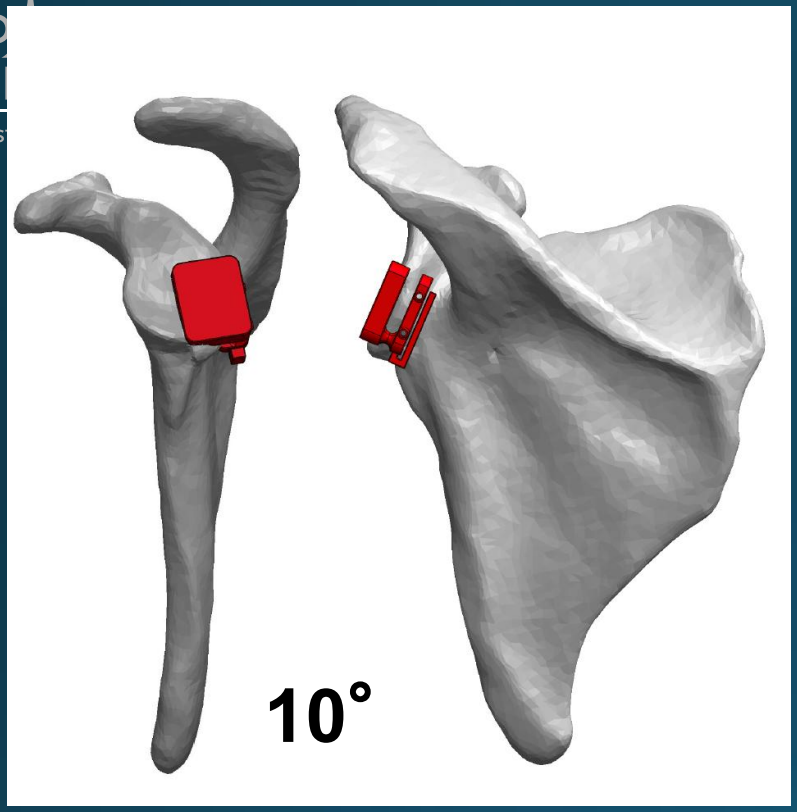


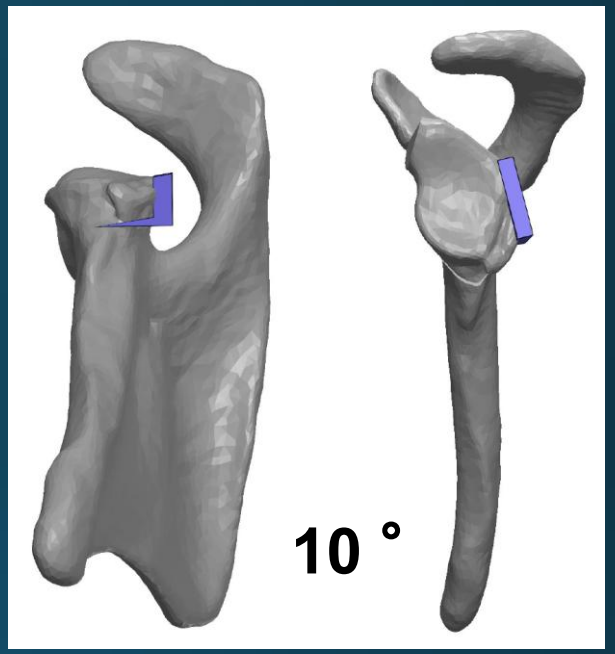


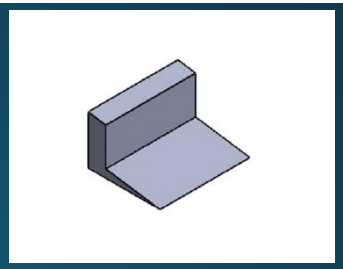


Patient				Etude sur l'épaule saine		Littérature épaule saine
Angle de rétroversion de la glène (°)				Moyenne de l'angle de rétroversion de la glène (°)		
Epaule	2D	3D	Moyenne	2D	3D	
Gauche	15.3	14.1	14.7	6.7	4.7	Entre 5 et 10°
Droite	13.5	13.2	13.4			

Nyffeler RW, Sheikh R, Atkinson TS, Jacob HA, Favre P, Gerber C.
Effects of glenoid component version on humeral head displacement and joint reaction forces: an experimental study.
J Shoulder Elbow Surg. 2006 Sep-Oct;15(5):625-9. doi: 10.1016/j.jse.2005.09.016. PMID: 16979061.

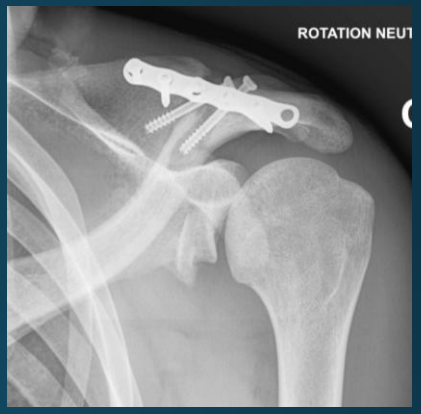






Posterior Open-wedge Osteotomy and Glenoid Concavity Reconstruction Using an Implant-free, J-shaped Iliac Crest Bone Graft in Atraumatic Posterior Instability with Pathologic Glenoid Retroversion and Dysplasia: A Preliminary Report *(2021)*
Auteurs : Ernstbrunner L, Häller T, Waltenspül M, Wieser K, Gerber C.

POST OP IMAGING – Xray *M+4*



CLINIQUE *M+4*

SUMMARIZE
CUTTING GUIDES: 3D pre op planning

ADVANDTAGES

- Enhanced **accuracy** in angular, translational rotational correction
- Shorter operative time
- Less bleeding
- Less radiation
- Less difficulties for the surgeon per op
- Better fit for complex deformities
- Facilitates pre-conturing of plates or grafts

SUMMARIZE
C UTTING GUIDES: 3D pre op planning

Limitations

- Higher **cost** and longer preparation time
- Requires high-quality imaging and segmentation
- Risk of **guide misfit** if soft tissue interferes or surface anatomy is irregular
- Fragility of printed guides; must ensure correct sterilization
- Workflow not always available in all centers (logistics + expertise)

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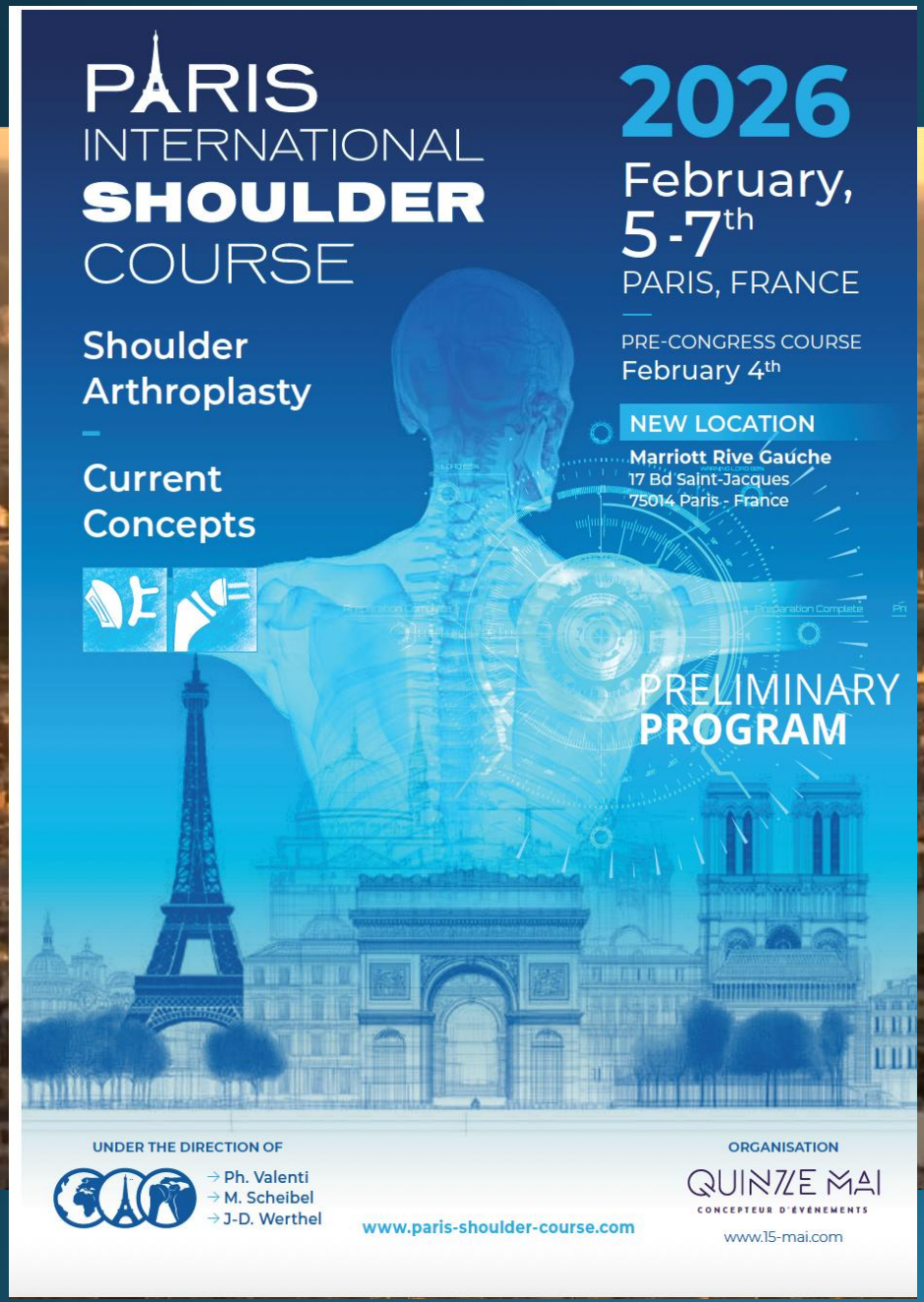

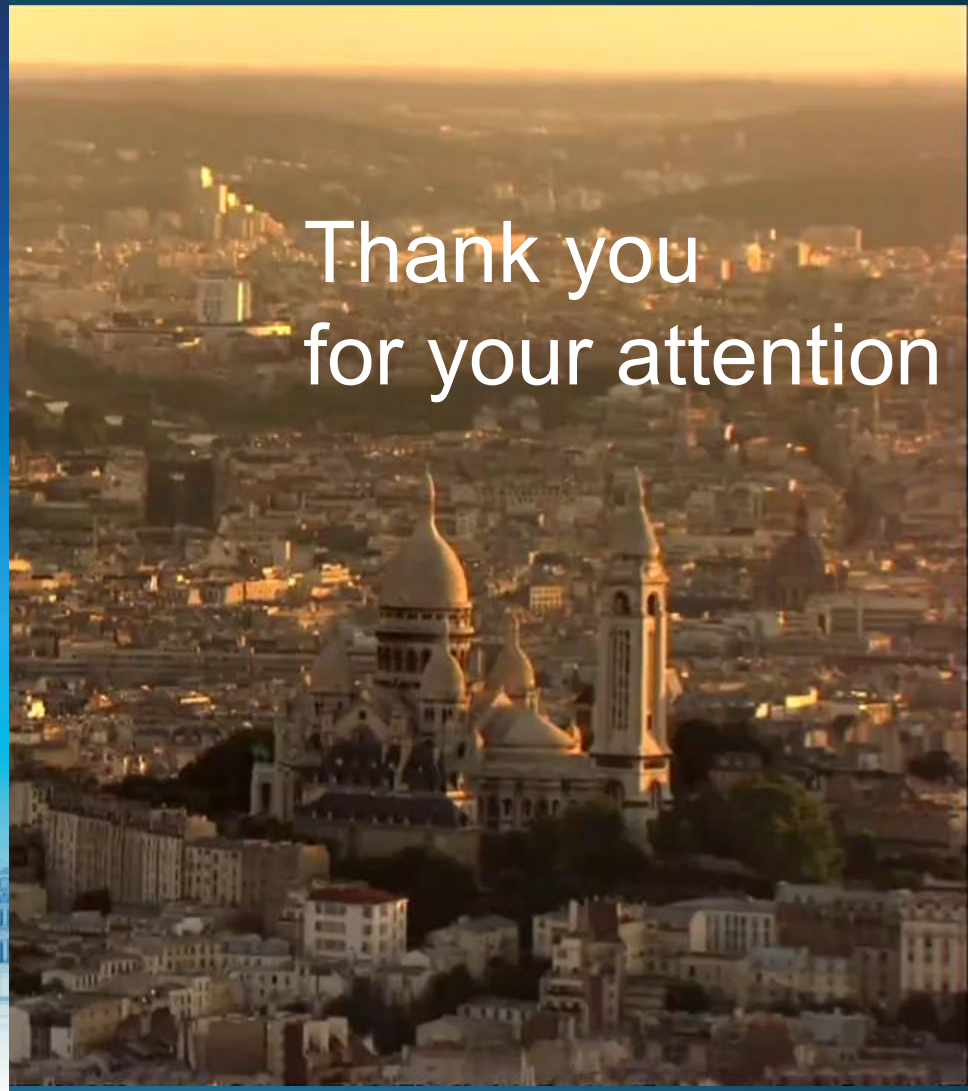

Does It work, is it useful

Research | Open access | Published: 29 April 2021

3D-printed saw guides for lower arm osteotomy, a comparison between a synthetic CT and CT-based workflow

Koen Willemsen ✉, Mirte H. M. Ketel, Frank Zijlstra, Mateusz C. Florkow, Ruurd J. A. Kuiper, Bart C. H. van der Wal, Harrie Weinans, Behdad Pouran, Freek J. Beekman, Peter R. Seevinck & Ralph J. B. Sakkers

3D Printing in Medicine **7**, Article number: 13 (2021) | Cite this article

- **Objective:**
  To evaluate MRI-based synthetic CT (sCT) as a radiation-free alternative to CT for designing 3D-printed patient-specific saw guides.
- **Methods:**
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3D planning and patient–specific surgical guides in forearm osteotomy in children: Radiographic accuracy and clinical morbidity

Marie Benayoun [1], Tristan Langlais [2], Romain Laurent [1], Malo Le Hanneur [1], Raphaël Vialle [3], Manon Bachy [1], Franck Fitoussi [3]

Affiliations + expand

PMID: 33845175 DOI: 10.1016/j.otsr.2021.102925

Free article

- **Objective:**
  To evaluate the reliability and outcomes of 3D planning and patient-specific surgical guides in pediatric forearm osteotomies.
- **Methods:**
  23 children (48 osteotomies) were retrospectively analyzed: 9 with guides (G+), 14 without (G-). Mean age: 14.8 years. Guides were 3D-printed from CT-based models. Mean follow-up: 22.1 months.
- **Results:**
  - **Correction accuracy (G+):** 5.3° (frontal), 4.2° (sagittal)
  - **Surgery time:** 42 min shorter in G+ ($p=0.02$)
  - **Radiation dose:** Higher in G+ ($p<0.0001$)
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  3D planning with patient-specific guides is a reliable

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BMC Musculoskelet Disord. 2018 Oct 15;19:374. doi: 10.1186/s12891-018-2279-0

Improving accuracy of opening-wedge osteotomies of distal radius using a patient-specific ramp-guide technique

Simon Roner [1,✉], Fabio Carrillo [1], Lazaros Vlachopoulos [2], Andreas Schweizer [2], Ladislav Nagy [2], Philipp Fuernstahl [1]

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PMCID: PMC6190568 PMID: 30322393

Editor's choice

Conventional Versus Computer-Assisted Corrective Osteotomy of the Forearm: a Retrospective Analysis of 56 Consecutive Cases

David Ephraim Bauer MD *, Stefan Zimmermann MD *, Alexander Aichmair MD *, Andreas Hingsammer MD *, Andreas Schweizer MD *, Ladislav Nagy MD *, Philipp Fürnstahl PhD †

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The results demonstrate that the computer-assisted method facilitates shorter operation times while providing similar clinical results.

Original Article

3D printing-assisted percutaneous fixation makes the surgery for scaphoid nonunion more accurate and less invasive

Hua-Wei Yin [a b ☆], Jun-Tao Feng [a b ☆], Bao-Fu Yu [a], Yun-Dong Shen [a b], Yu-dong Gu [a f], Wen-dong Xu [a b c d e f g]

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Open Access Review

Clinical Applications of Three-Dimensional Printing in Upper Extremity Surgery: A Systematic Review

by Andrzej Hecker [1,2,3,*], Lukas Tax [4], Barbara Giese [4], Marlies Schellnegger [2,3], Anna-Lisa Pignet [2,3], Patrick Reinbacher [5], Nikolaus Watzinger [4], Lars-Peter Kamolz [2,3] and David Benjamin Lumenta [1,2]

- "Nevertheless, the preoperative 3D-assisted planning is more time-consuming and costly. The authors estimated that planning 3D-assisted corrective osteotomy takes **about 2–4 h per patient**, including CT scans from the contralateral side, and an additional cost of **USD 2.415** for planning and producing the patient-specific guide"

Does It work, is it useful

Research | Open access | Published: 29 April 2021

3D-printed saw guides for lower arm osteotomy, a comparison between a synthetic CT and CT-based workflow

Koen Willemsen, Mirte H. M. Ketel, Frank Zijlstra, Mateusz C. Florkow, Ruurd J. A. Kuiper, Bart C. H. van der Wal, Harrie Weinans, Behdad Pouran, Freek J. Beekman, Peter R. Seevinck & Ralph J. B. Sakkers

3D Printing in Medicine **7**, Article number: 13 (2021) | Cite this article

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