Developing a Patient-Matching 3D-Printed Surgical Guide for Percutaneous Lower Limb Osteotomies

Avani Khatri M.S., Alyssa Glennon, Aiden Reuter, David Frumberg, M.D.

Disclosures

The authors report no relevant financial disclosures.

Background

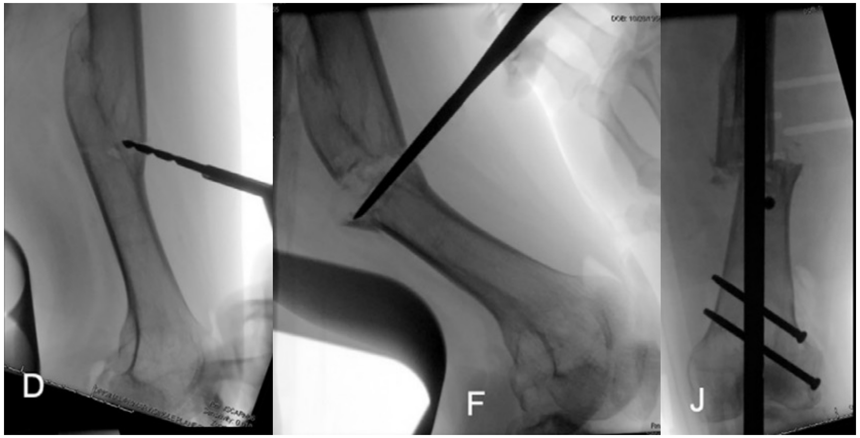
Clinical Background:

- Percutaneous lower limb osteotomies (multiple drill-hole and percutaneous comminuted closing wedge “Perc-Wedge” technique) reduce soft tissue disruption through minimally invasive correction.
- This is particularly beneficial for patients at increased risk of wound-healing complications

Current gaps:

- Percutaneous osteotomies remain technically demanding
- Angular accuracy remains variable across both conventional freehand and percutaneous osteotomy techniques.
- Patient-specific instrumentation (PSI) has improved angular accuracy in traditional osteotomies but has not been investigated for percutaneous lower limb osteotomies.

This study aims to evaluate the feasibility and angular accuracy of a 3D-printed surgical guide by comparing the guide-assisted percutaneous technique with the conventional freehand technique.



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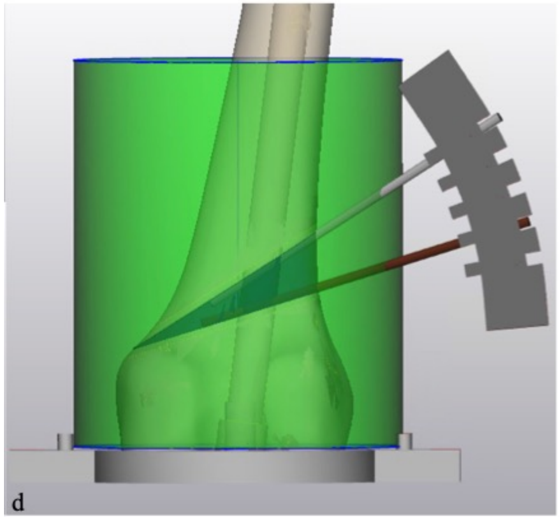
”Perc Wedge” Technique

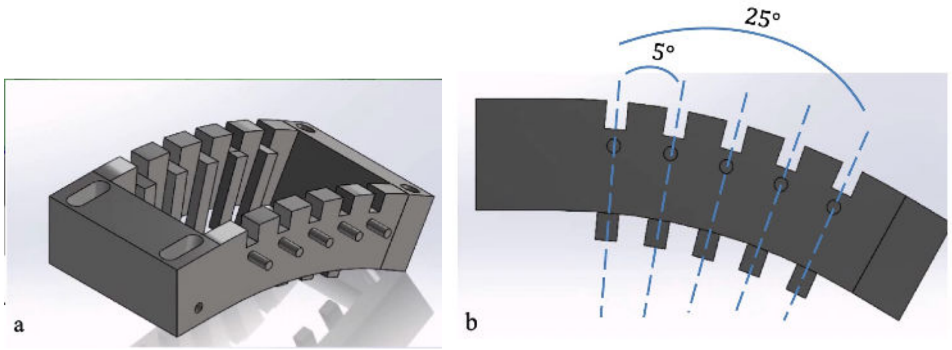


Simulated model of guide placement to converge to a 15-degree closing wedge DFO
The green cylinder is representative of soft tissue & skin surrounding the bone

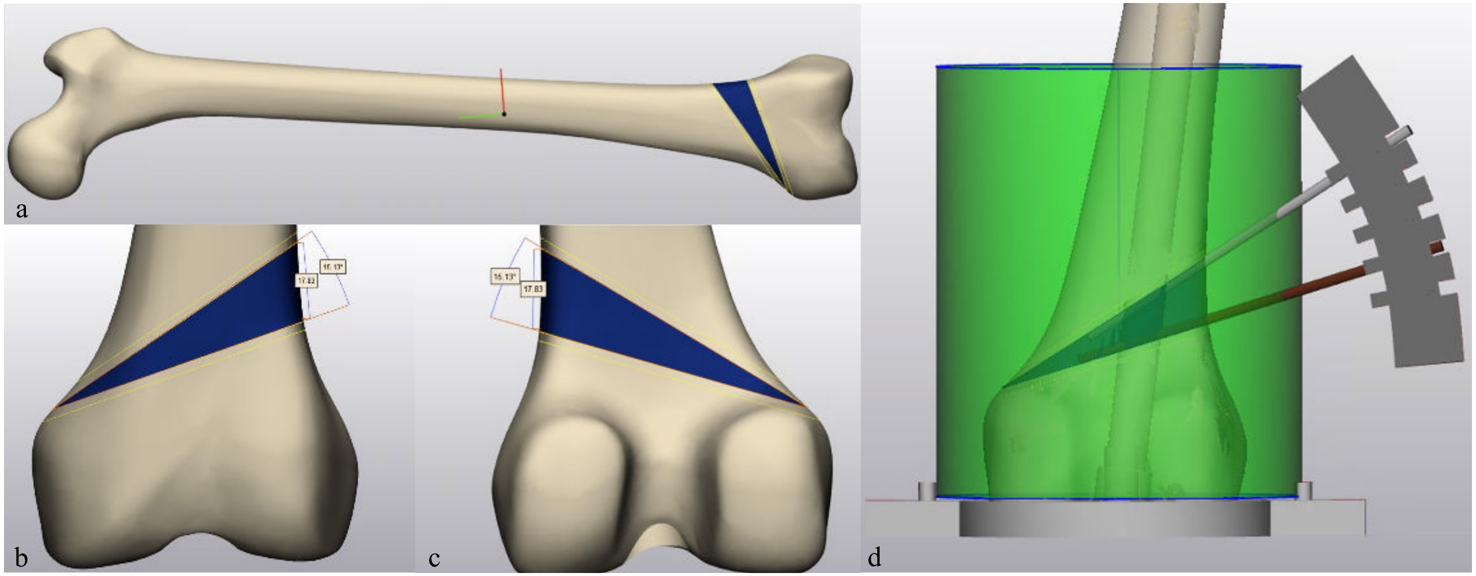
Proof-of-Concept 3D-Printed Surgical Guide

The patient-matching guide is designed to align with the apex of the deformity along its radius of curvature.

It is set to a fixed depth, determined from preoperative planning, and incorporates symmetric cutting planes along either side which will align and converge to the target angle.



CAD models of the proof-of-concept guide, with range of convergence angles



(a-c) Virtual simulation of a 15° valgus inducing lateral closing wedge DFO (wedge highlighted in blue).
(d) Virtual model of surgical guide with guiding tubes aligned to 15° correction angle. The green cylinder represents the soft tissue and skin surrounding the distal femur.

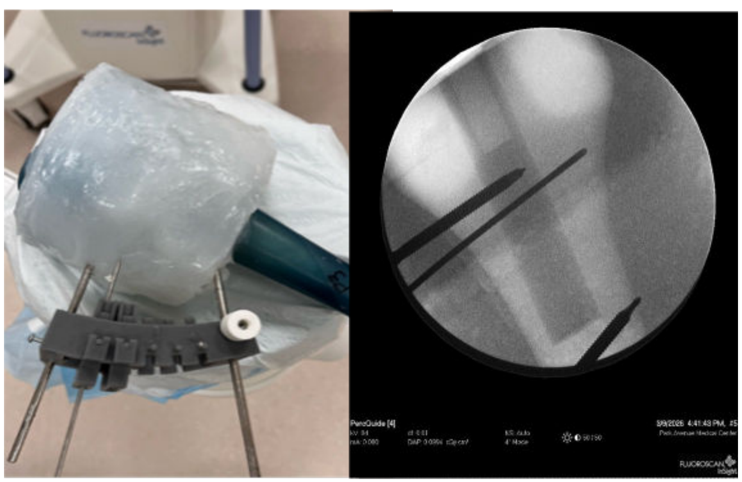
Methods

Feasibility Study Design:

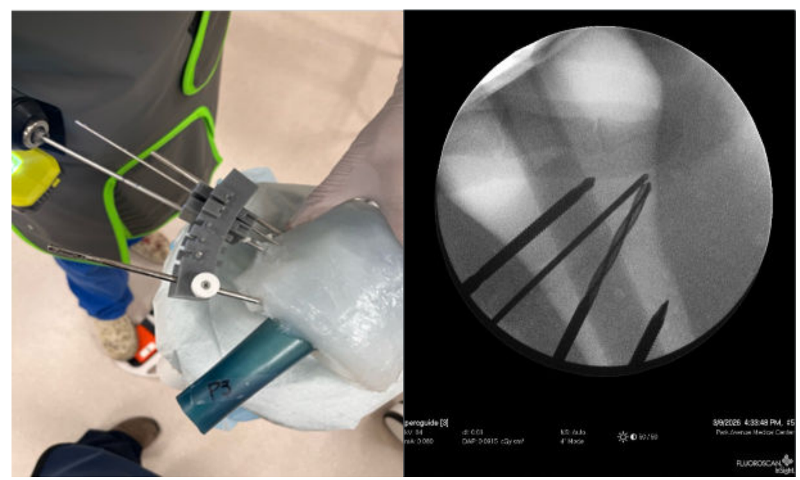
- ***30 Sawbones™ distal femur***
- ***Performed lateral distal femoral closing wedge osteotomy across correction angles of 5°, 10° and 15°***

Angular correction was evaluated using a clinical threshold of ±3° and a tighter-tolerance threshold of ±1°

A multi-layered silicone model was used to simulate muscle, adipose, and skin layers surrounding the distal end of the synthetic femur



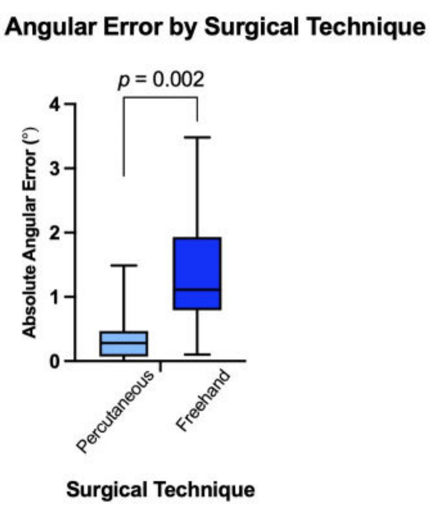
initial depth placement with 2mm k-wire

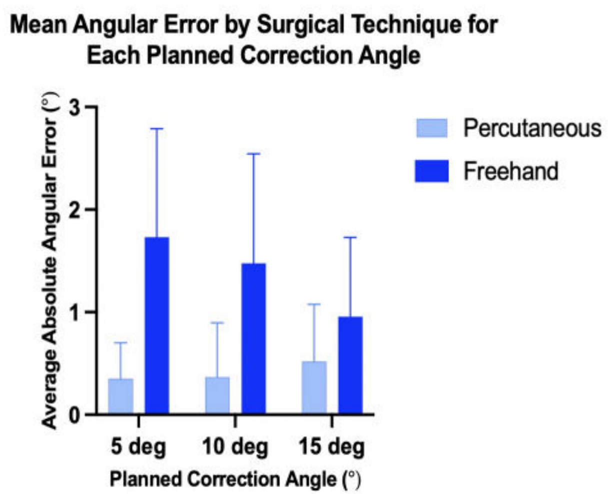


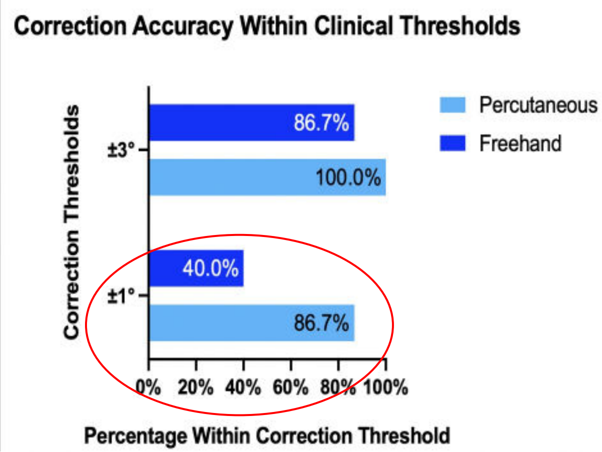
drill passing with 3.5mm drill bit

Results

Guide-assisted technique demonstrated significantly lower absolute angular error compared to freehand (p = 0.002)







Absolute Angular Error	p-value
Surgical Technique	**0.002**
Planned Angle	0.681
Surgical Technique x Planned Angle	0.387

No significant difference in accuracy across the planned correction angles (5°, 10°, and 15°)

86.7% of guide-assisted specimens achieved within ±1° correction compared with 40% of freehand specimens

Discussion & Conclusion

Key Findings

- **Improved Angular Accuracy** with 3D-printed surgical guide compared to freehand technique
- **Greater Correction Precision** under tighter ±1° threshold, achieving clinically acceptable tolerance
- **Consistent Performance** across all target angles of 5°, 10°, and 15°

Implications

- **Improved Feasibility** of minimally invasive osteotomy technique
- **Greater reproducibility** and increased confidence for surgeons performing this technique
- **Potential for improved patient healing outcomes** for patients with wound-healing delays

Future Direction

- **Future iterations** of guide designs for further improvement
- **Evaluate reproducibility** on cadaveric models and additional osteotomy sites across various surgeon experience