Capstone Design: Preparation of the Subtalar Joint in TTC Arthrodesis

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Background: Surgical Procedure

Tibiotalocalcaneal (TTC) arthrodesis = fusion

=

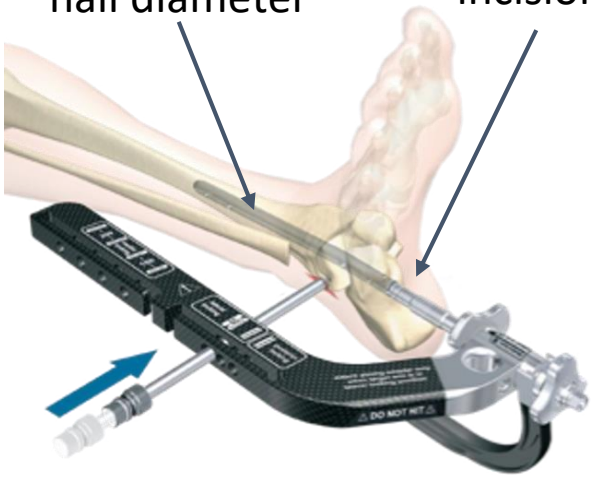
~100mm incision

Joint preparation

+

11-14mm nail diameter

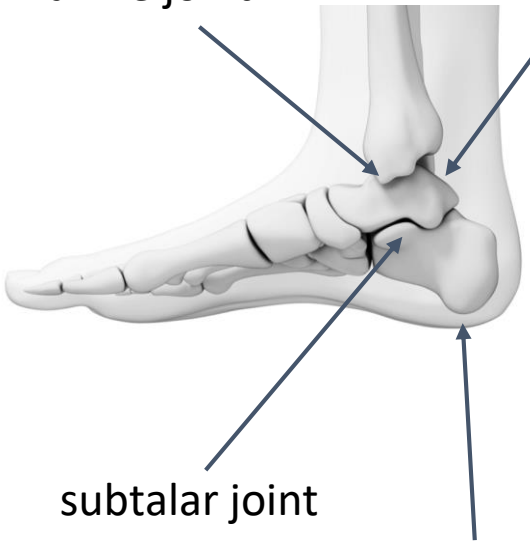
~30mm incision

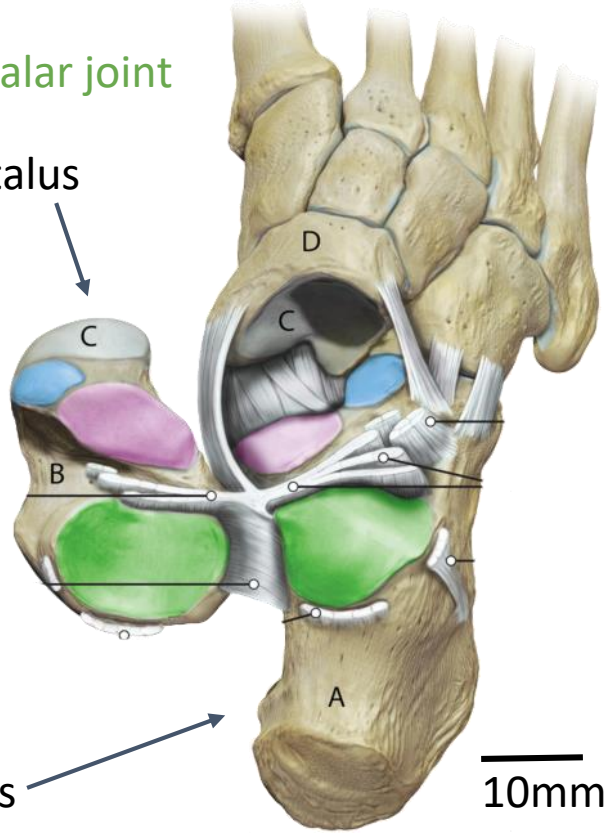


Ankle Fixation

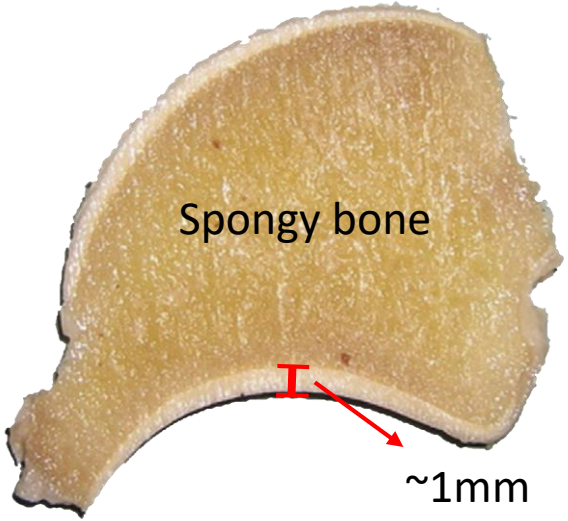
Background: Subtalar Joint Anatomy

Green: subtalar joint

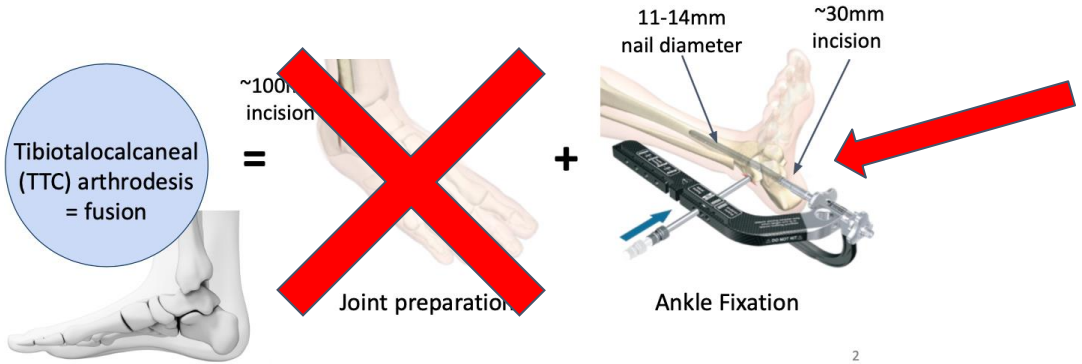




Cross sectional slice of the **talus** bone



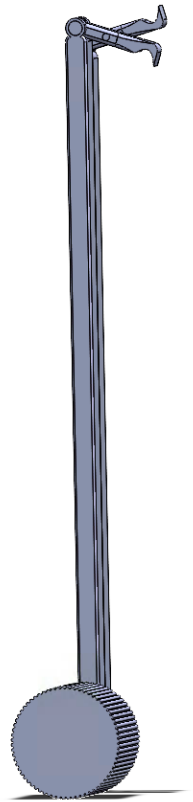
A way to prepare the **subtalar joint** through a **plantar incision** in patients undergoing TTC nailing in a **trauma setting** that improves **bone fusion rates**



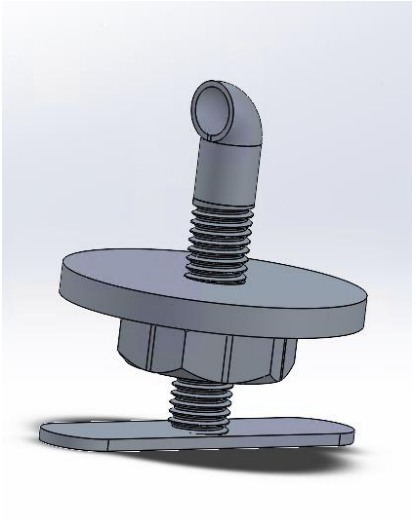
A way to prepare the **subtalar joint** through a **plantar incision** in patients undergoing TTC nailing in a **trauma setting** that improves **bone fusion rates**

- Space & Visualization Constraints
- Cost to Produce <$100 CAD
- Maximize surgeon confidence
- Cartilage and bone disruption
- Minimize surgical time & # of steps
- Compatible with bone graft use

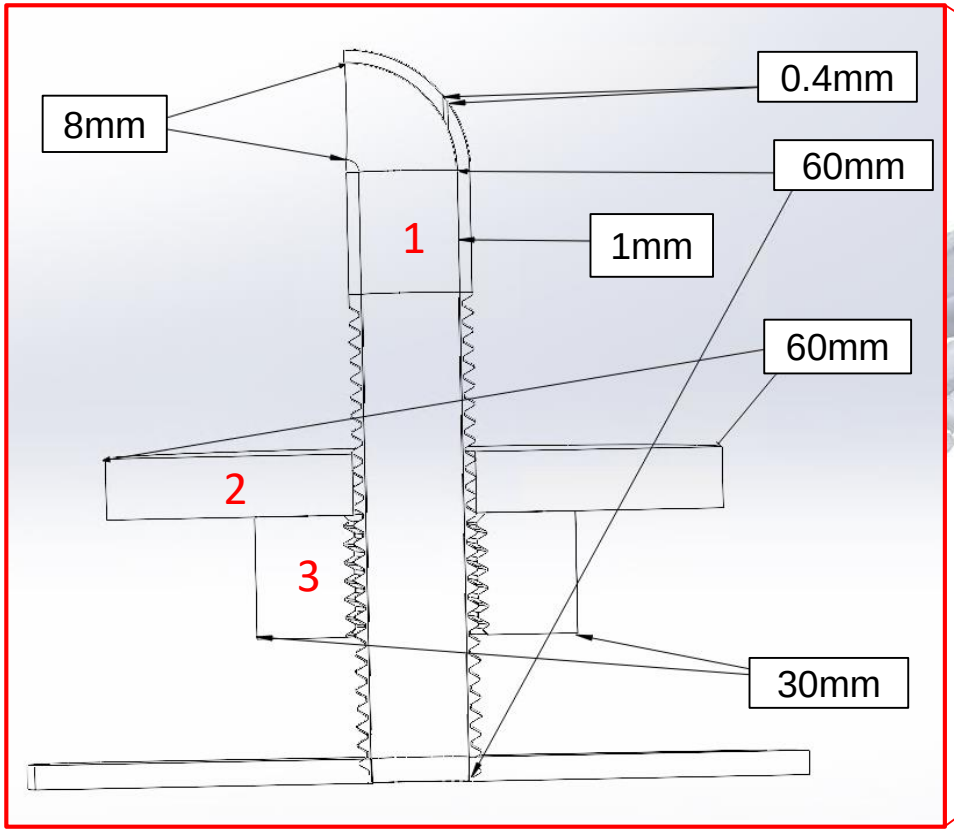
Proposed Solution Overview

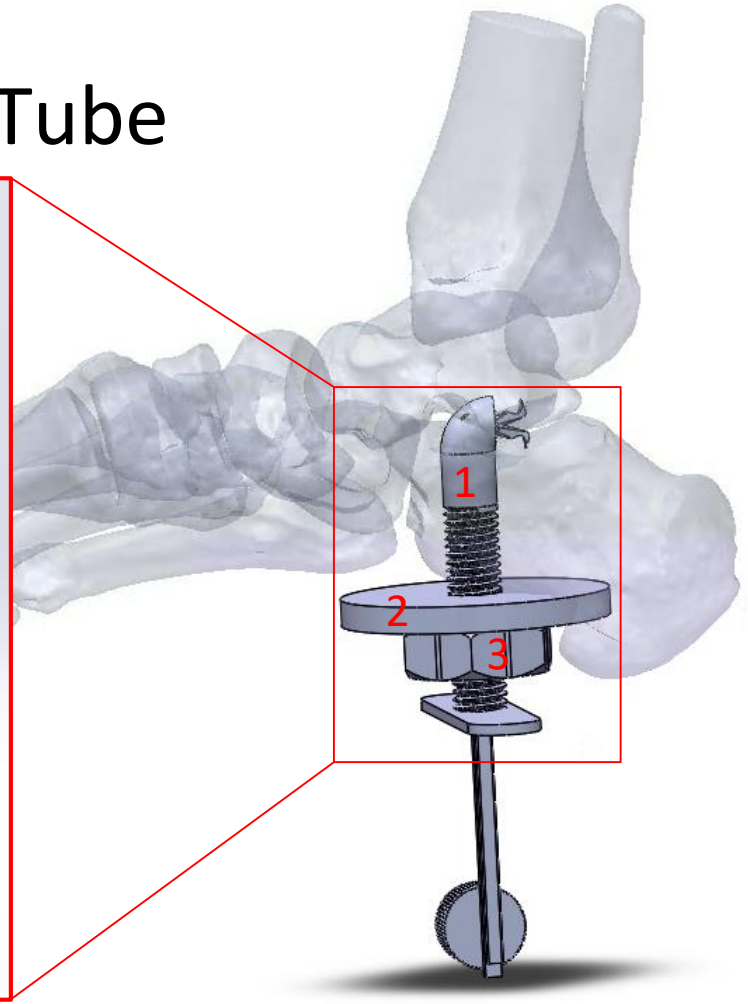


1. Ream Hole
2. Insert Guide tube
3. Adjust guide tube position
4. Insert cutting tool into joint space
5. Expand cutting cool
6. Cut cartilage/ subchondral bone with cutting tool
7. Remove tool
8. Remove cut tissue with suction
9. Repeat 4-8 for subchondral bone
10. Inject bone graft (optional)
11. Remove guide tube
12. Start nail prep

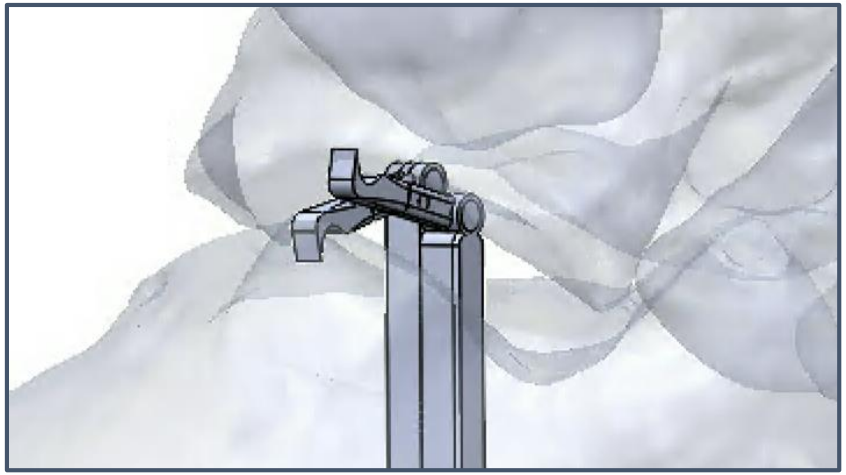


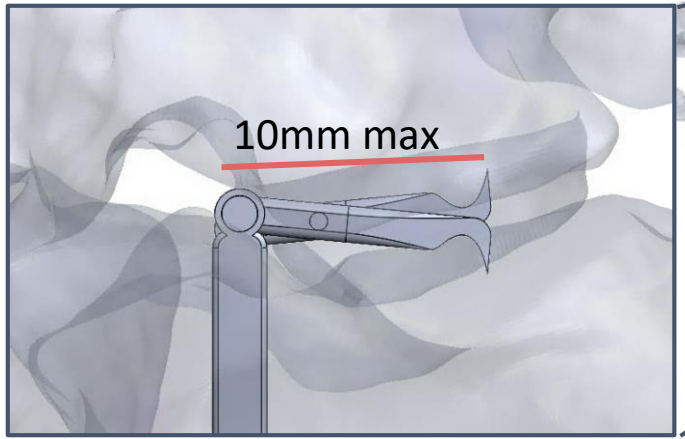
Proposed Solution: Guide Tube

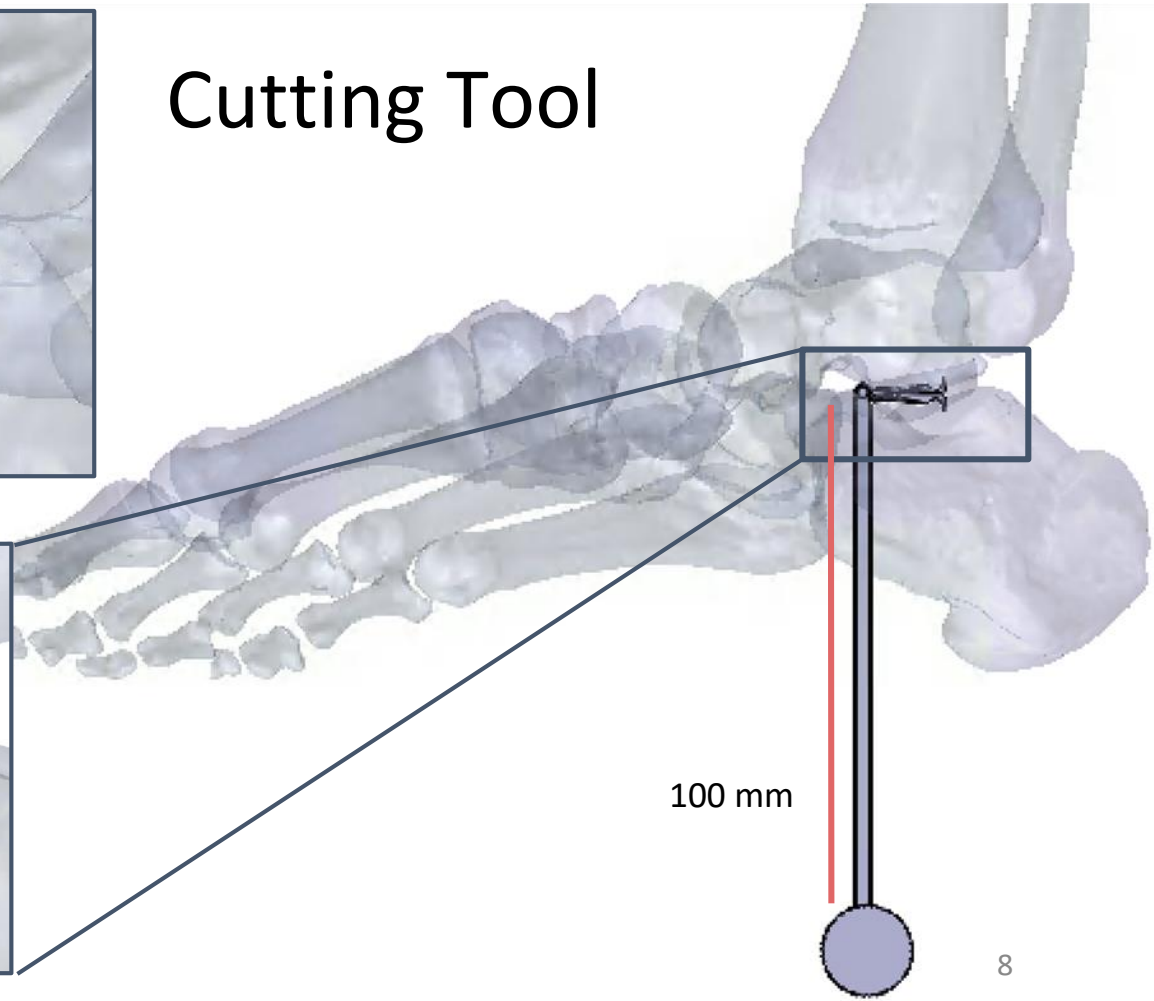




Cutting Tool







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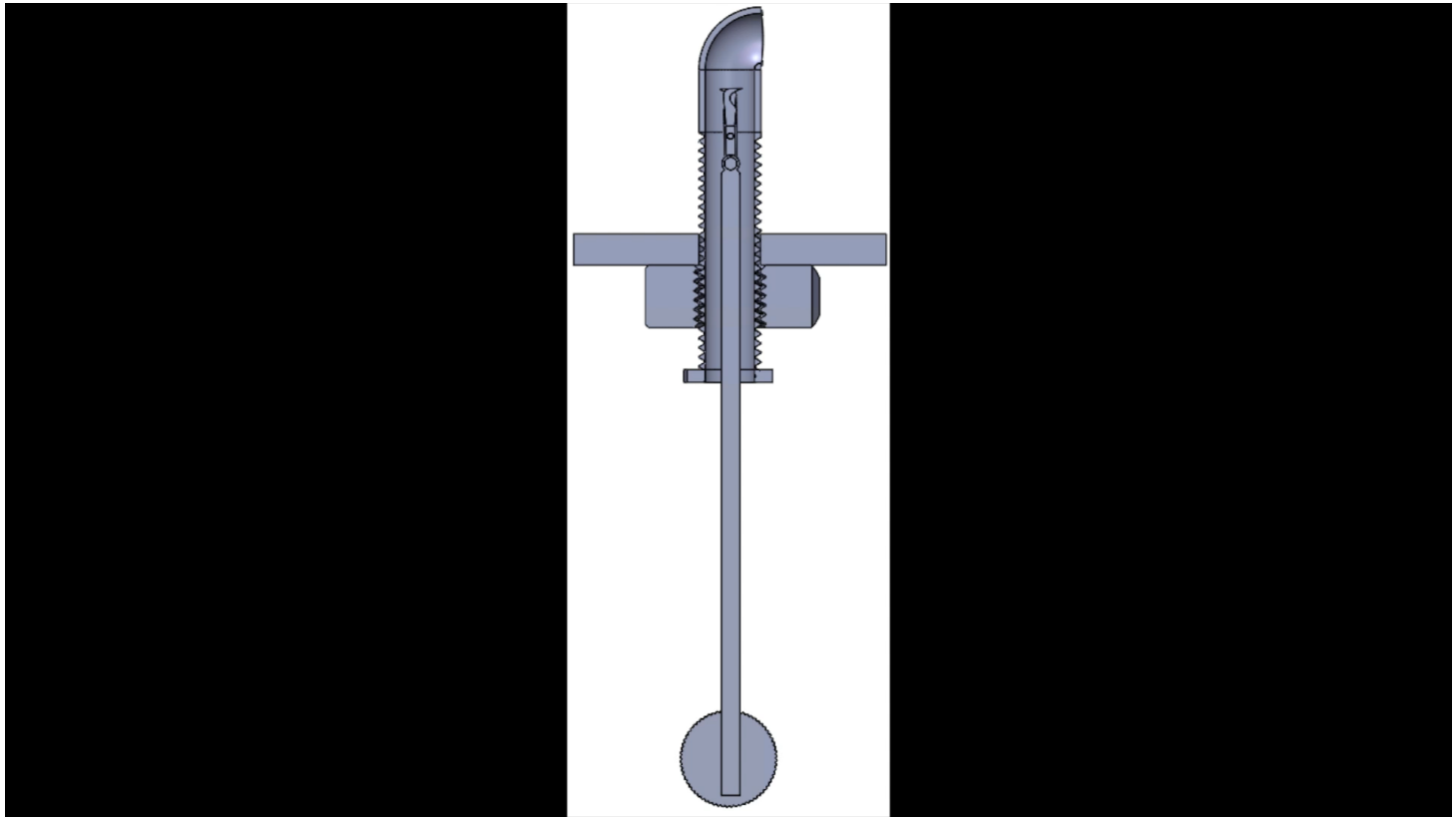


Proposed Solution: Materials and Cost

Materials

Martensitic 400-series **stainless steel** with blade made of **tungsten carbide**.

Costs

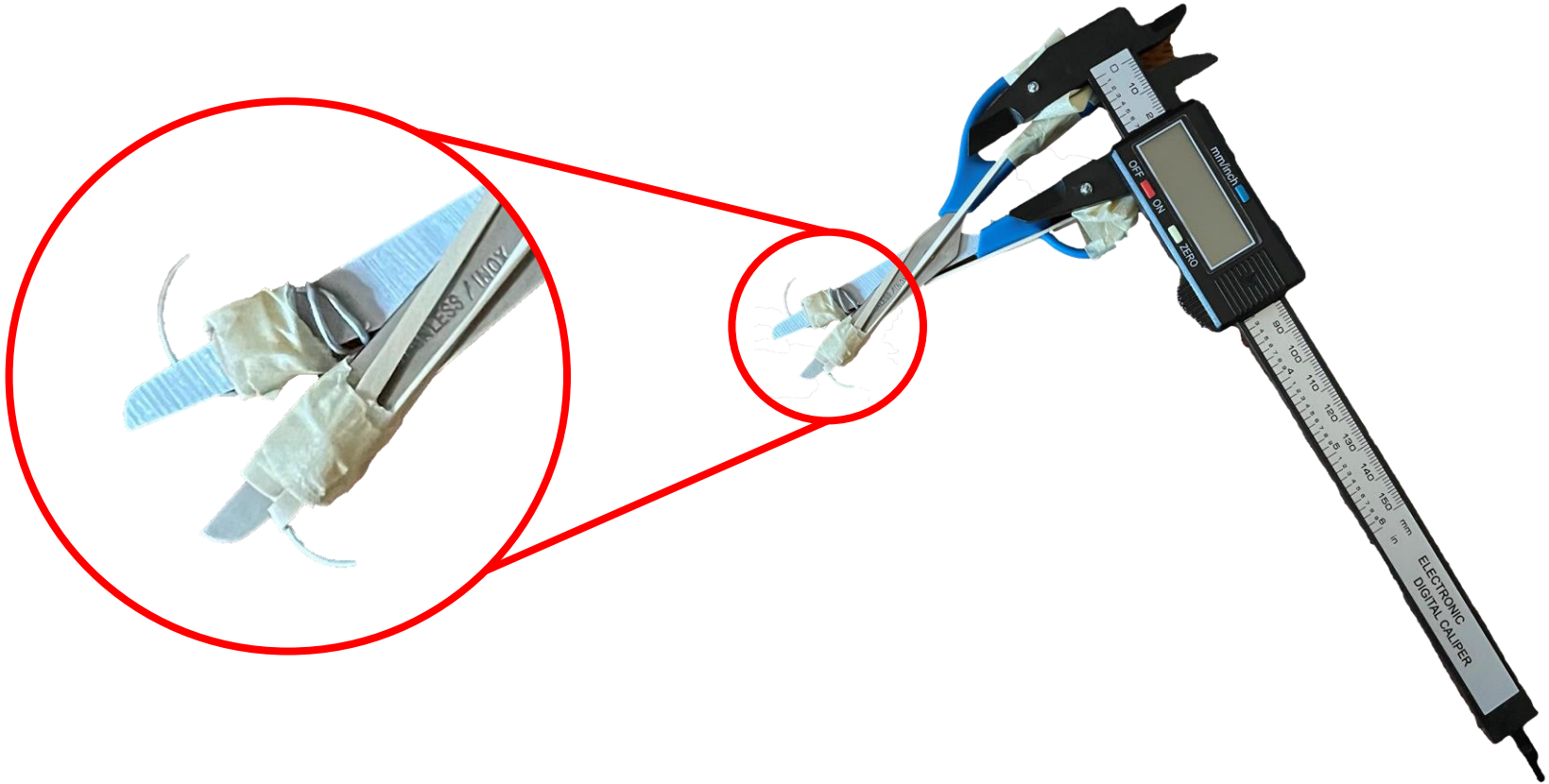
1mm-thick 400-series stainless steel: **USD $0.815/lb**. (current mkt value).

Tungsten carbide: **USD $9-12.00/lb**. (approx. mkt value).

Manufacturing: ~ **USD $30.00/tool**.

Total cost: ~ **CAD $40.60/tool**

Low fidelity Prototyping

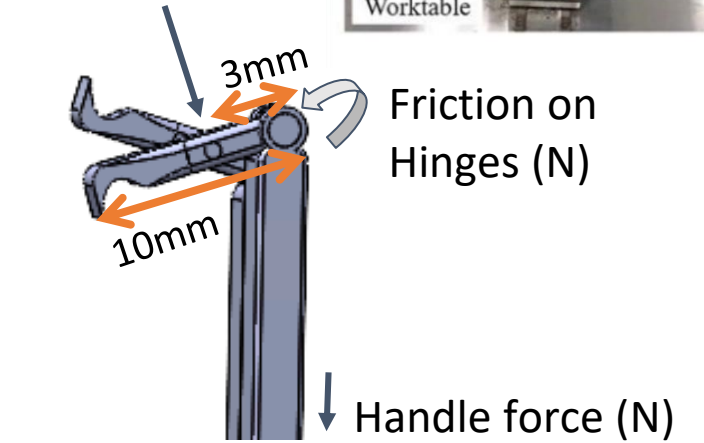


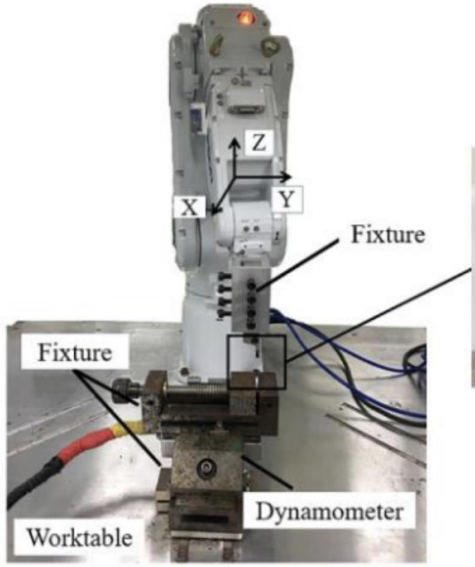
Force Calculations

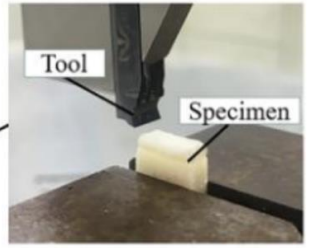
Friction on hinges	**6.18×10^{-9} N**

Max blade force required to cut cartilage	**27.6 N**

Handle force	**9.17 N**
Force on pin	**3.93 N**

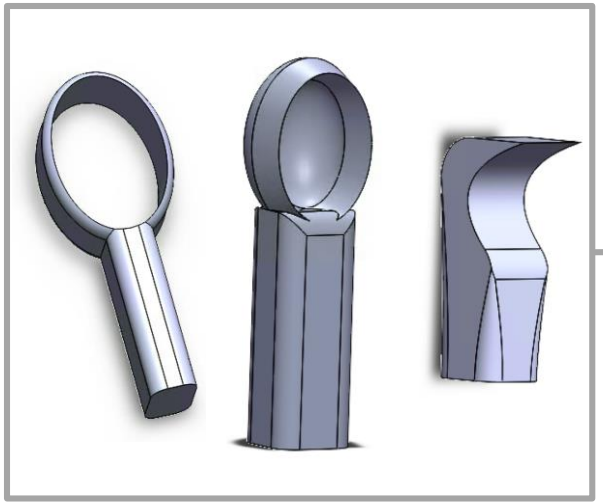






Experimental setup for measuring cartilage cutting force

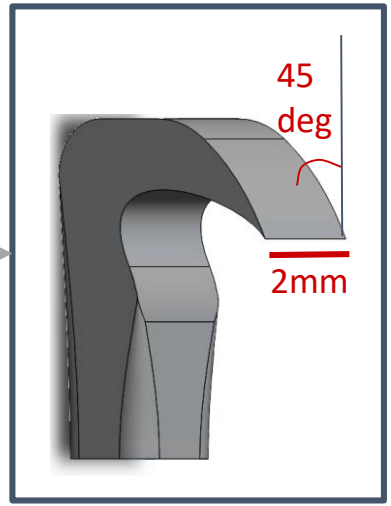
Blade Selection



Open curette

Closed curette

Anterior lesion curette



Modified anterior lesion curette

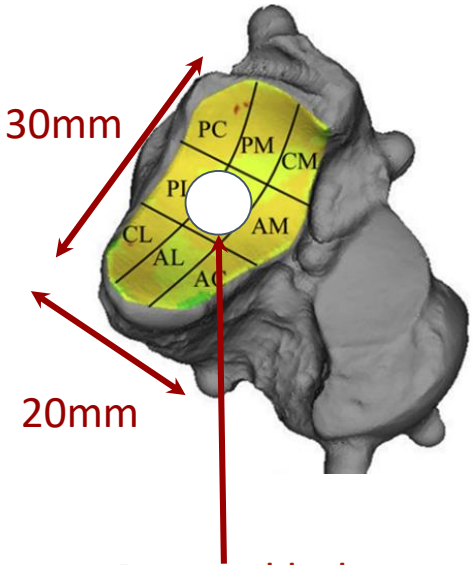
Force (N)	15		50	
Length to fixed end (mm)	5	10	5	10
Max Stress (N/m^2)	$6x10^7$		$2x10^8$	
Max Displace-ment (μm)	1.7	5.7	2.7	9.1

Tungsten carbide yield strength: 3.35 - 5.30 $x10^8$ N/m^2

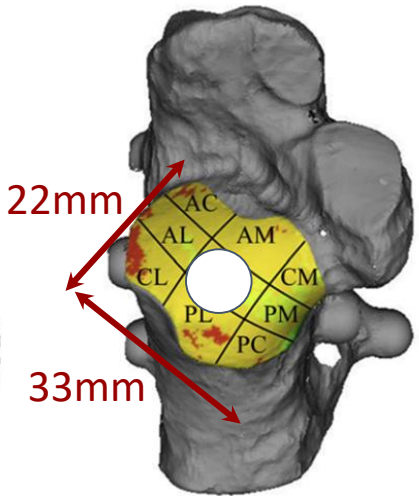
Factor of Safety: 2.5-8

Surface Area Calculations

Underside of talus



Top of calcaneus



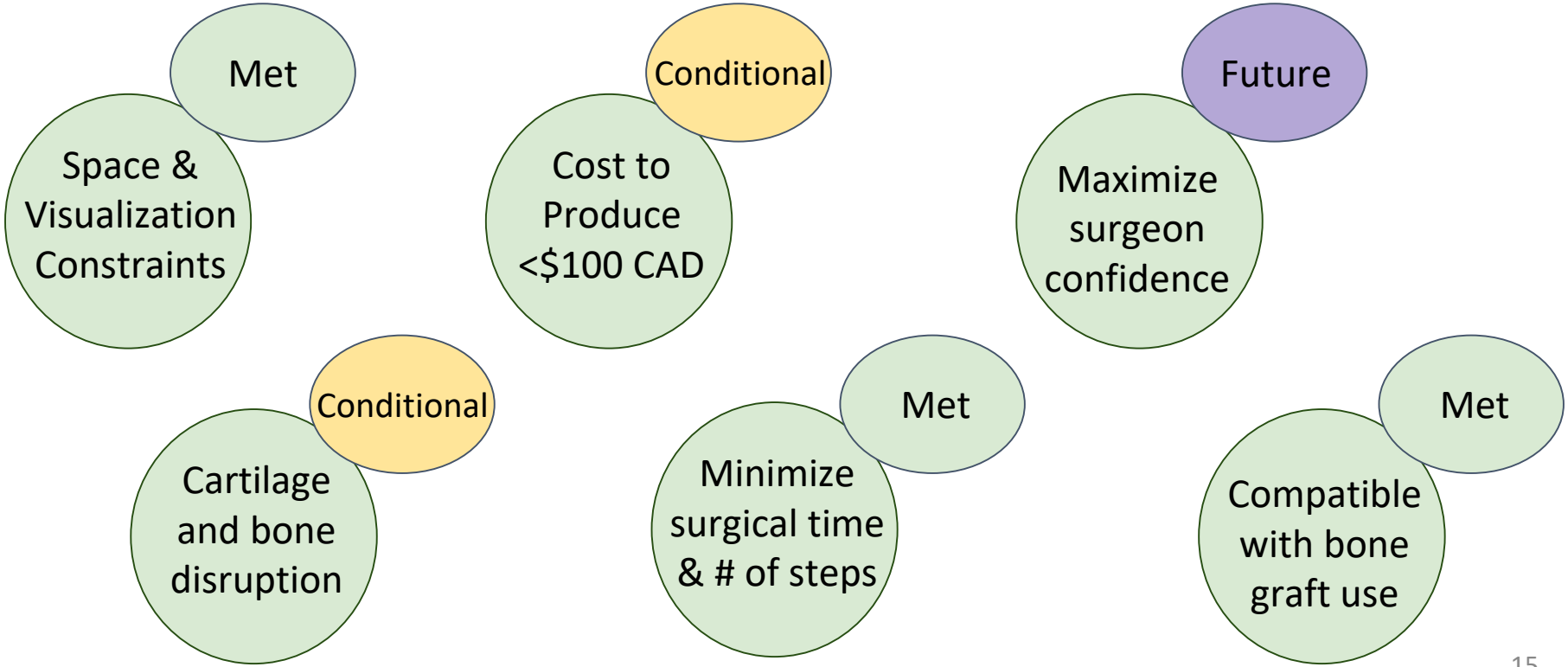
1 *Talus Area*: 600 mm²
Calcaneus Area: **726 mm²**

2 With scrapes of size 2mm x 10mm x 1mm:

SA scraped (%)	# of scrapes required
25%	7.5
50%	16.5

~5 minutes

Summary, Design Successes and Failures



Next Steps

- Make a higher-fidelity prototype
  - Give to surgeons, test forces and cartilage scraping
- Gather more feedback from surgeons
- Evaluate subtalar fusion rates

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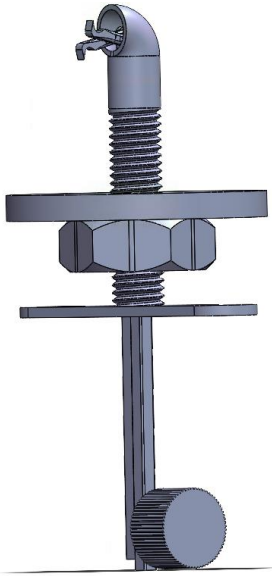

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