

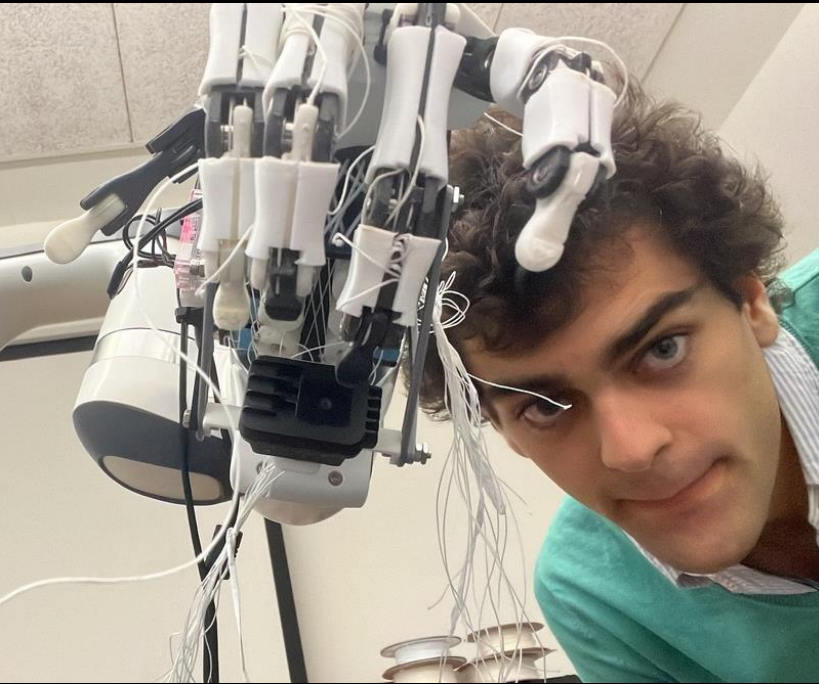


# Design of Robotic Hands Focus & Q&A

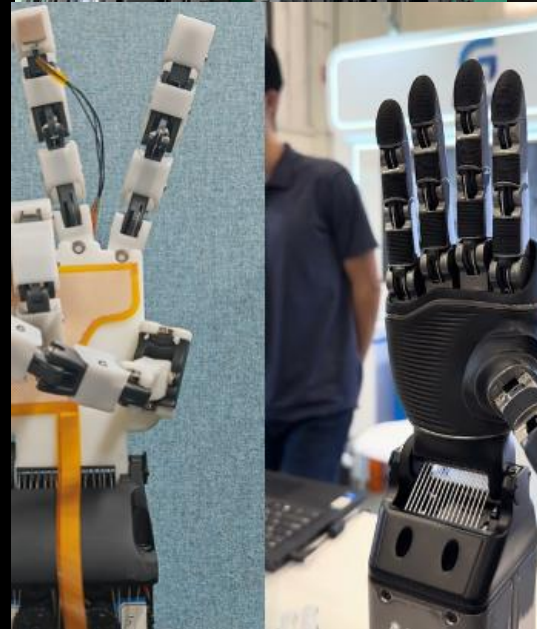
Clemens Christoph  
Founder & CEO, ORCA Dexterity  
September 28, 2026



ETH zürich



RWR: Dec, 2024

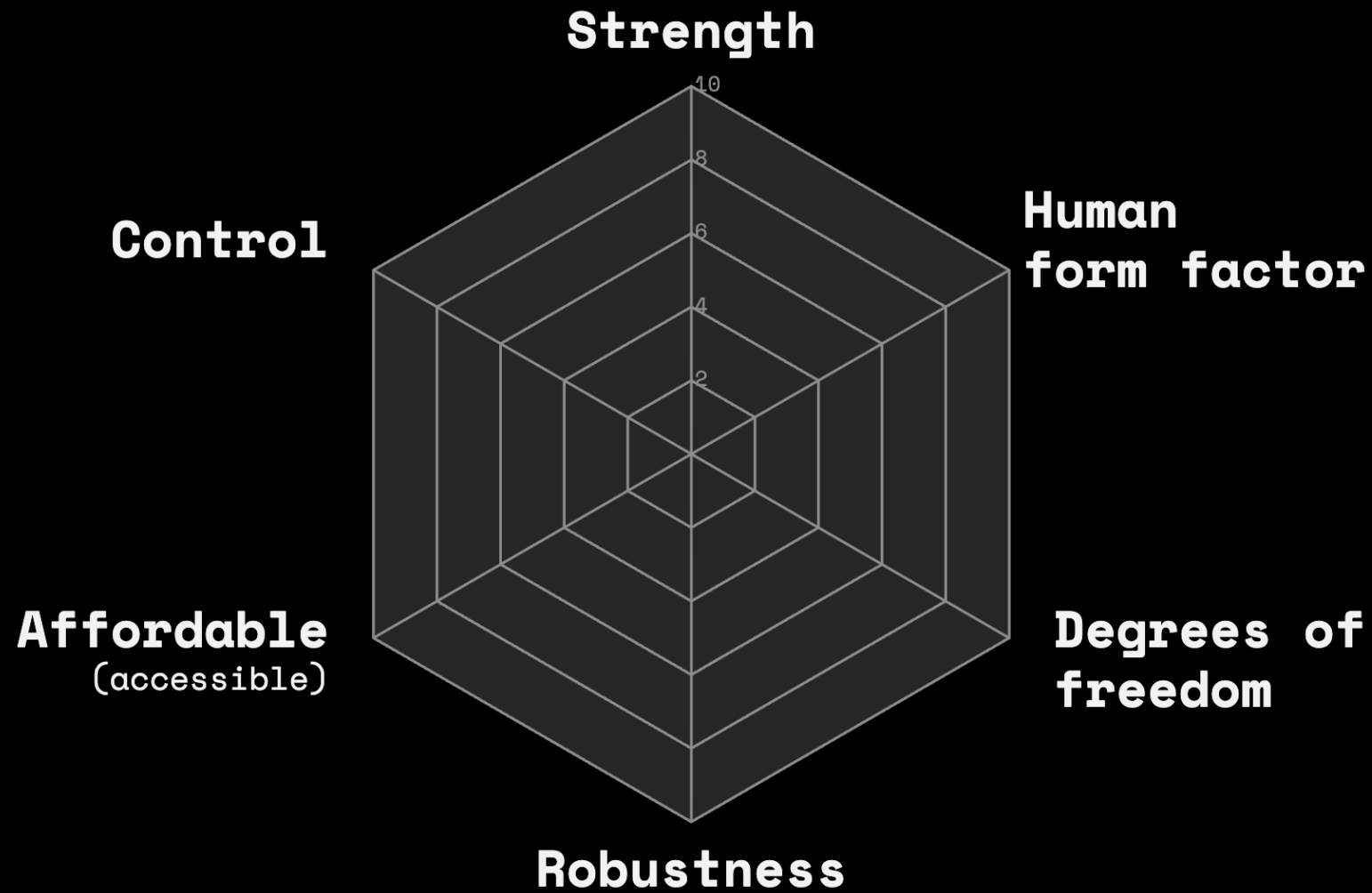


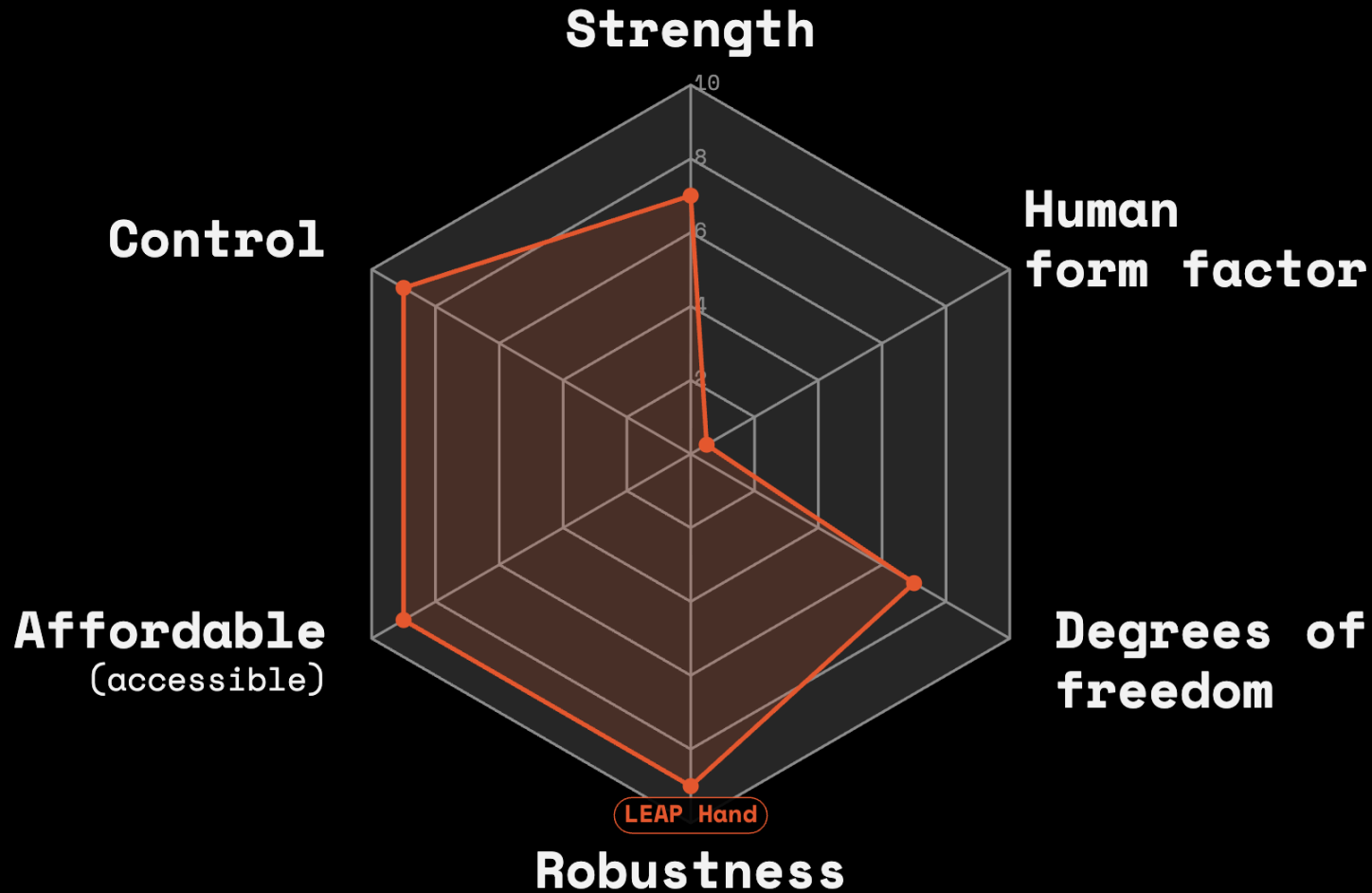
ORCA Dexterity, 2026

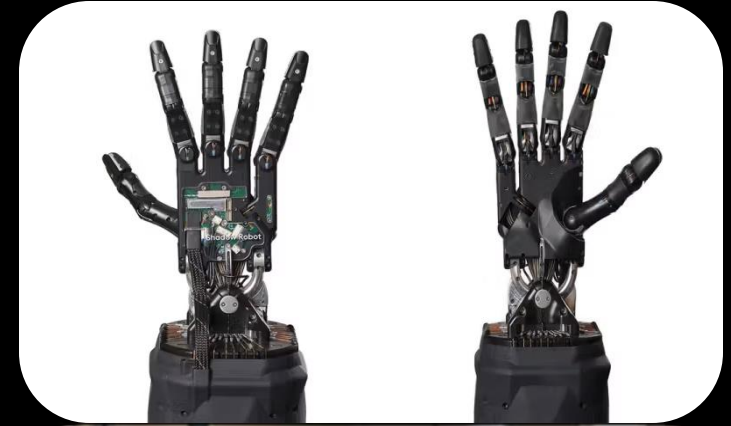
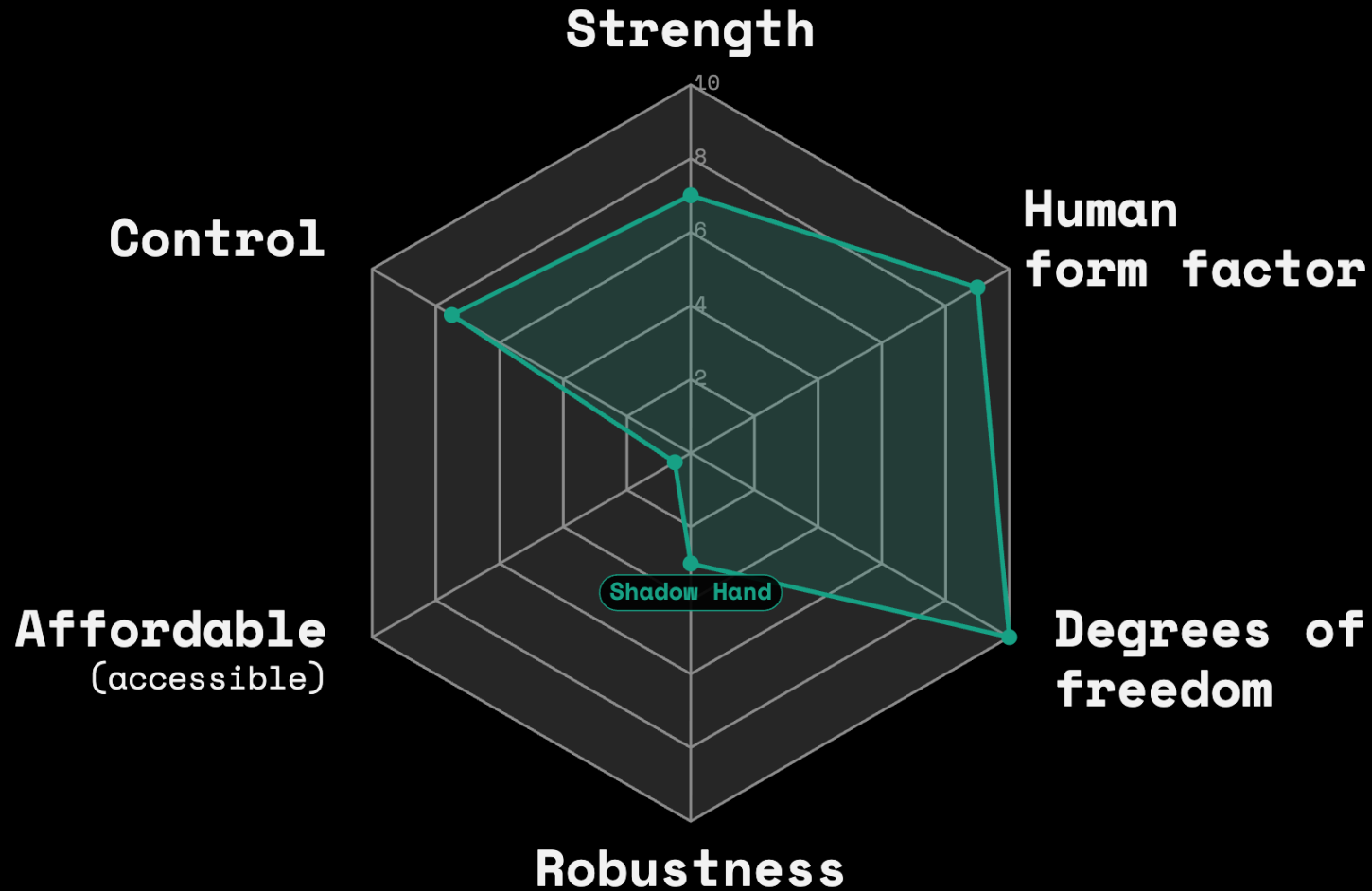
SoftRobotics  
Laboratory

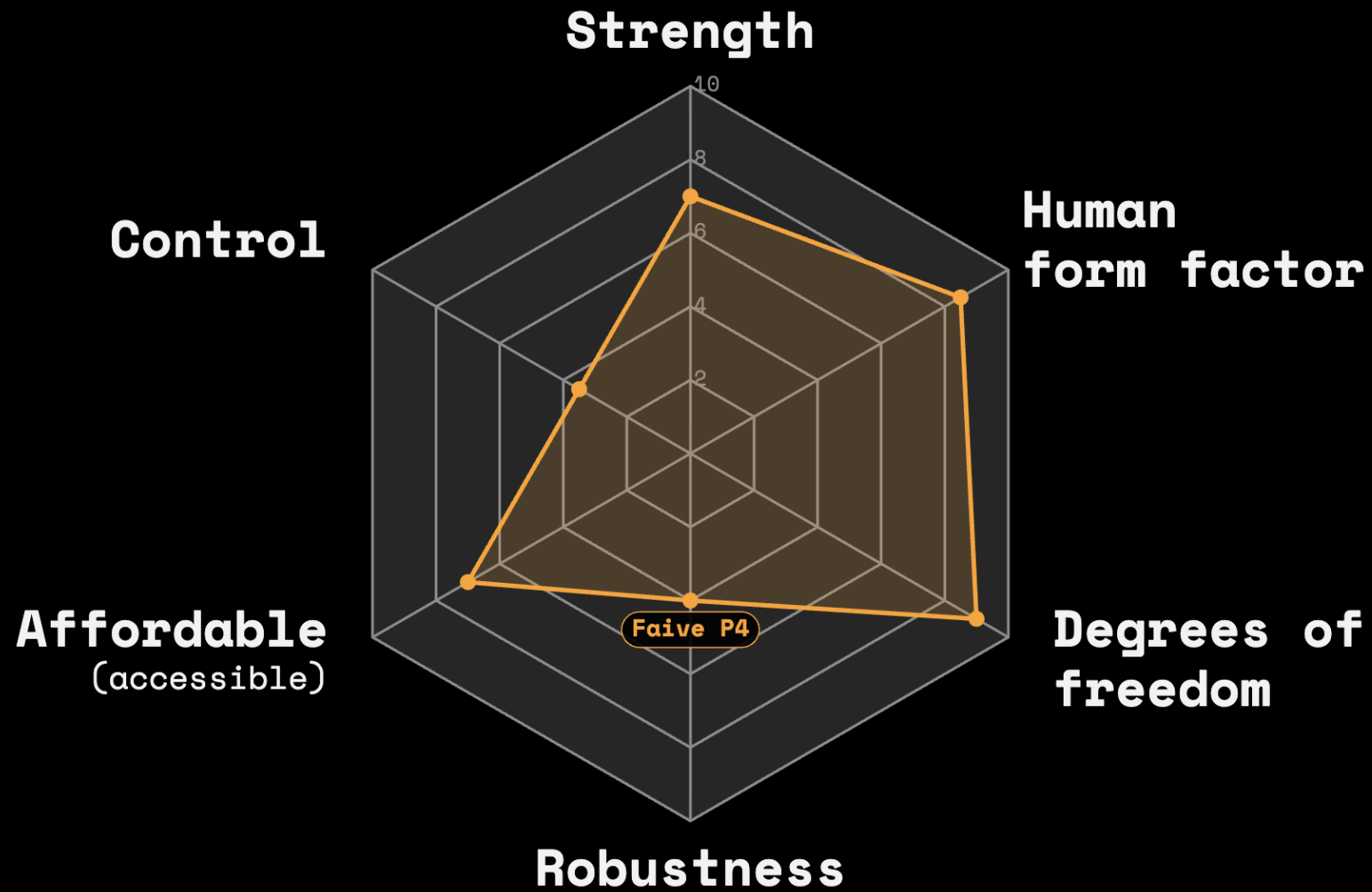
orca

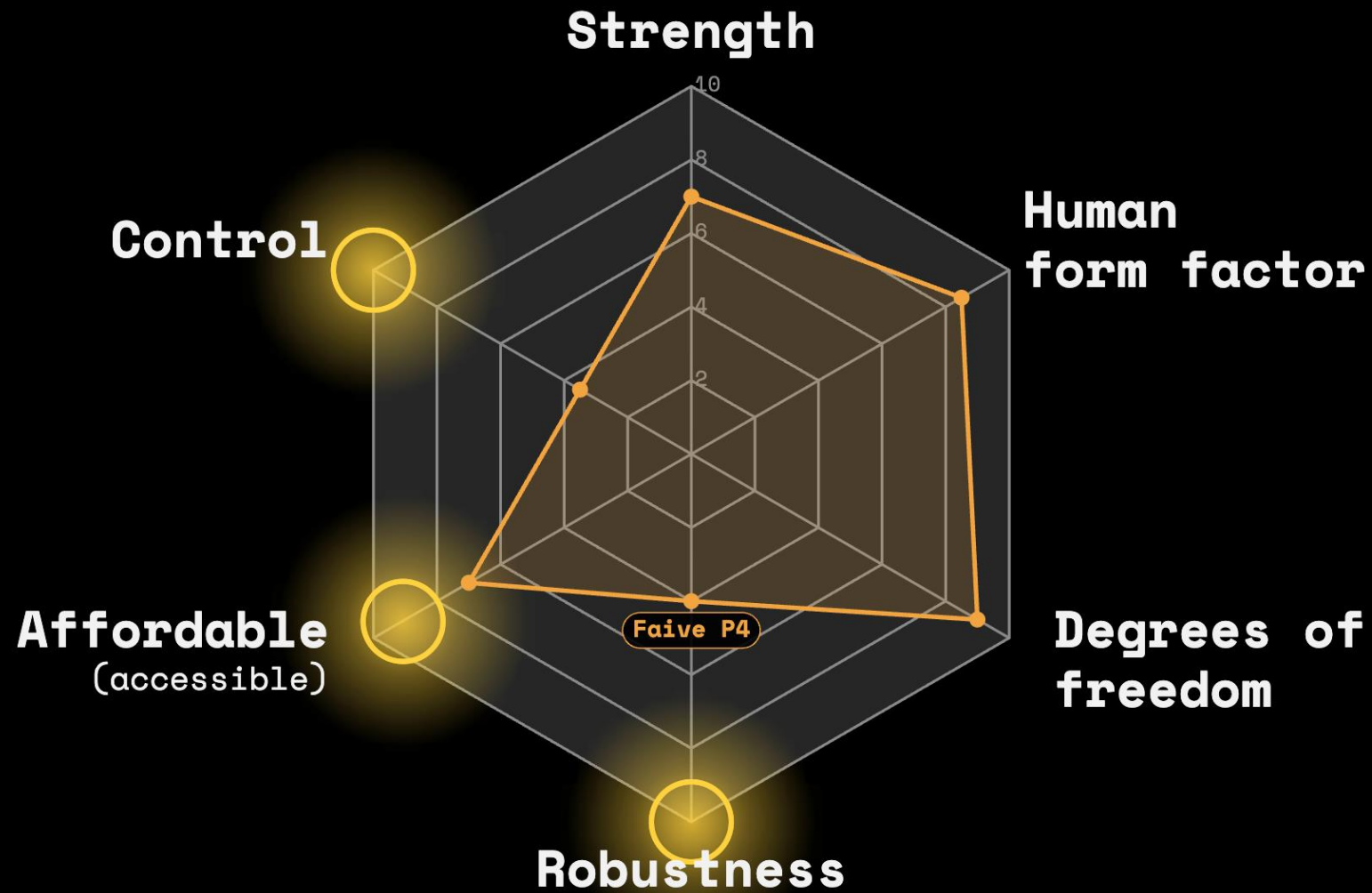


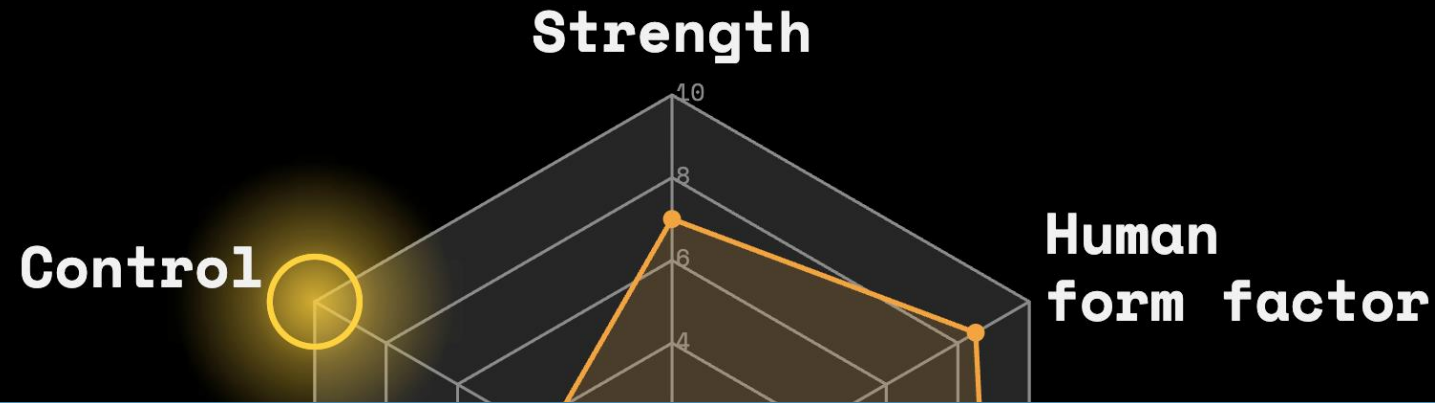




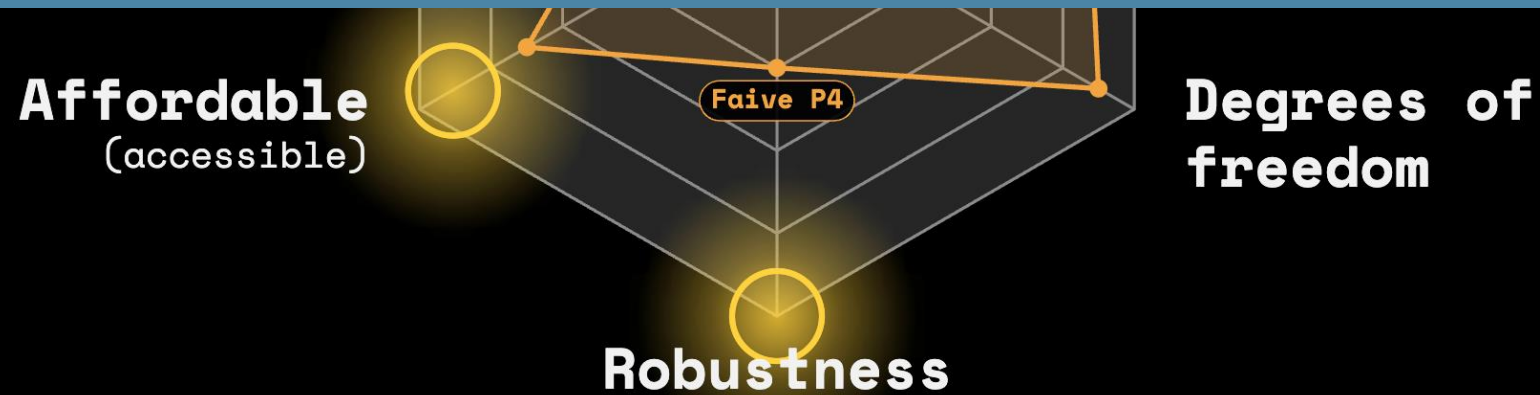








→ **Goal of ORCA Hand**





# Challenge: Human Form Factor + Accessible

Which actuation mechanism?

**Motors at joint?**



# Challenge: Human Form Factor + Accessible

Which actuation mechanism?

Motor + ...?





# Challenge: Human Form Factor + Accessible

Which actuation mechanism?

**Tendon Driven?**



Tendon challenges



- Slack (Creep)
- One way force transmission
- Lifetime
- Controllability
- Wrist/Forearm Space



# Challenge: Human Form Factor + Accessible

Which materials?

**Custom Metal  
Parts?**





# Challenge: Human Form Factor + Accessible

Which materials?

Custom Metal  
Parts





# Challenge: Human Form Factor + Accessible

Which materials?

**3D Printing**

+ off the shelf metal parts



Challenges?



- Tolerances (Repeatability)
- Strength and Durability
- Feature size small
- Soft skin?



- One way force transmission
- Slack (Creep)
- Controllability
- Lifetime
- Strength and Durability (3D Printing)
- Tolerances (Repeatability)



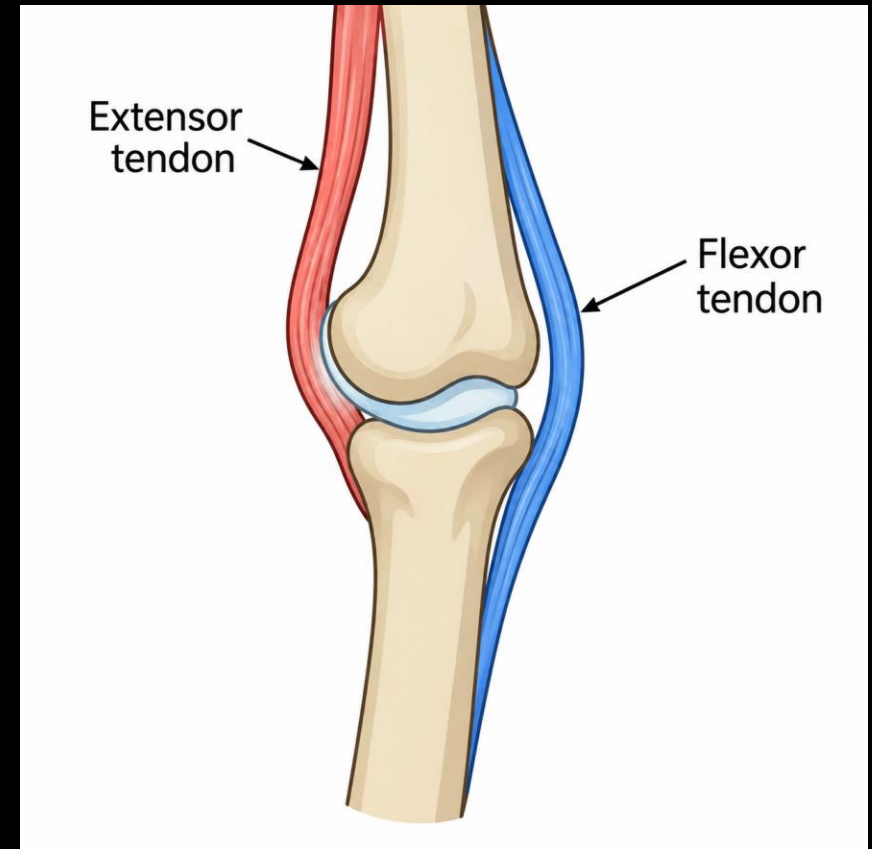
ORCA v2 (2026)

**BoM Cost: \$600**  
(Feetech Motors)



Problem: Tendon can only pull!

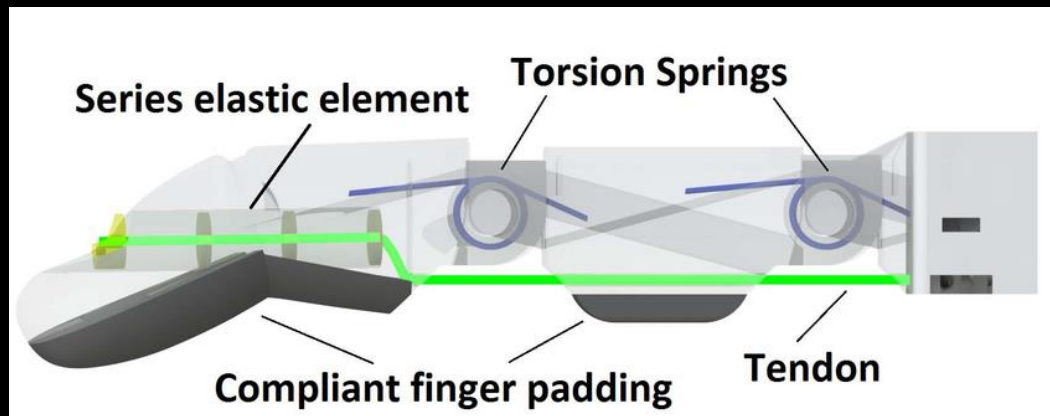
→ **Nature gave us flexors and extensors**



[https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic\\_fig5\\_258022354](https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic_fig5_258022354)



## Option 1: Torsional Spring

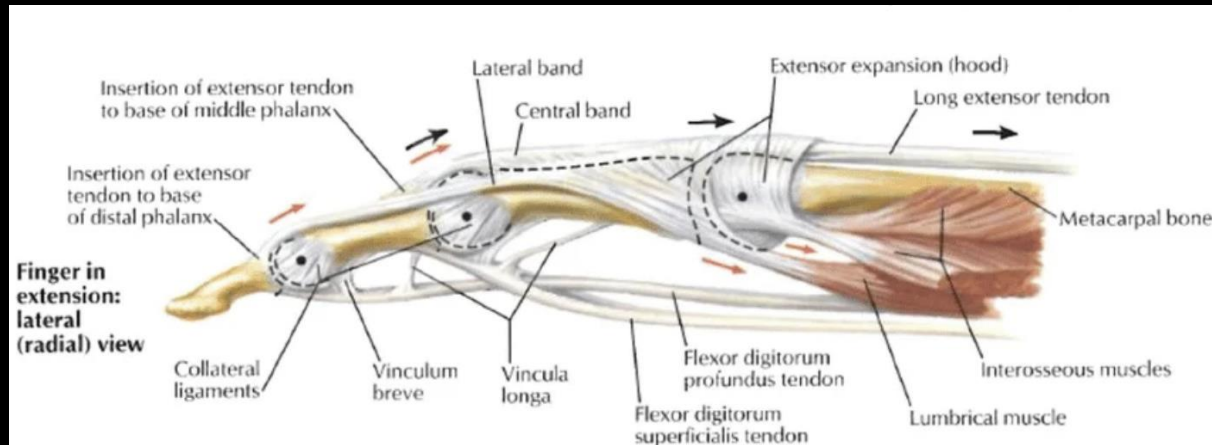


- No extensor forces
- Energy inefficient
- Weird resting positions

[https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic\\_fig5\\_258022354](https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic_fig5_258022354)



## Option 2: Human Inspired

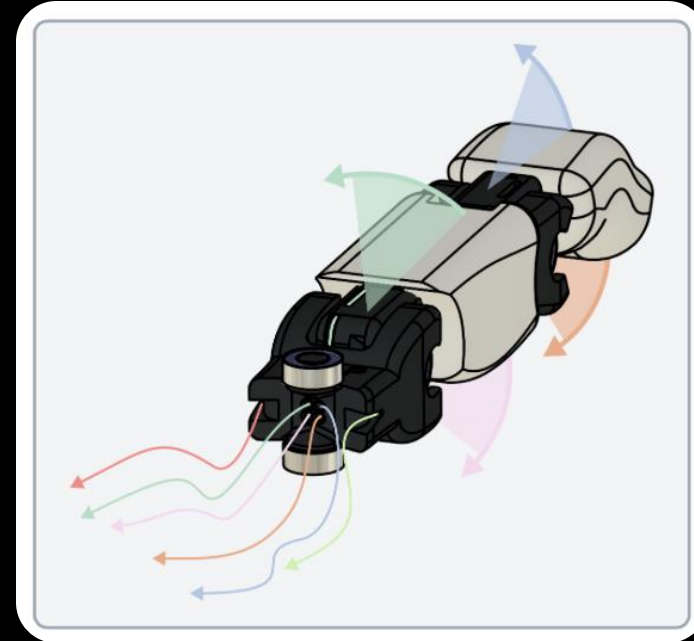
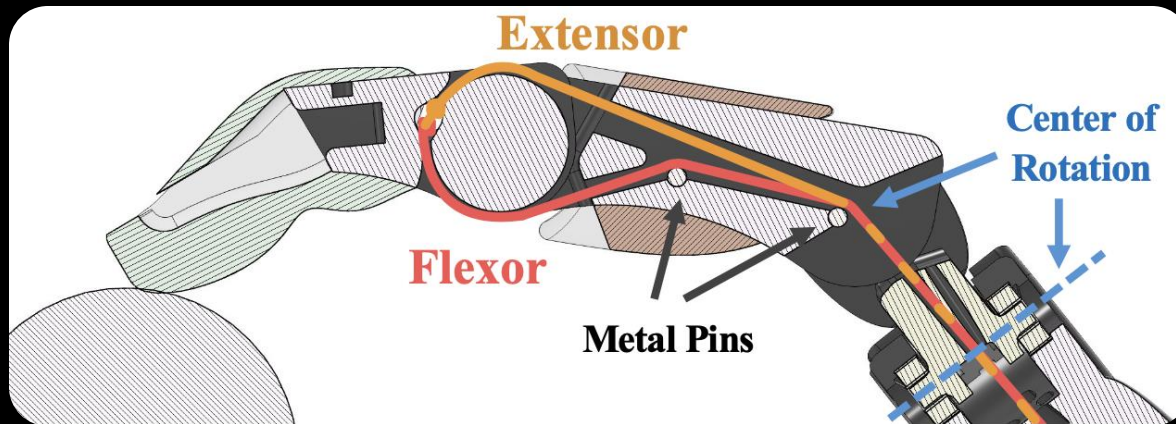


- Good luck with controls
- #Actuators > DoF

[https://www.researchgate.net/figure/Musculotendonal-structure-of-the-human-finger-The-musculotendonal-structure-of-the-human\\_fig1\\_261735584](https://www.researchgate.net/figure/Musculotendonal-structure-of-the-human-finger-The-musculotendonal-structure-of-the-human_fig1_261735584)



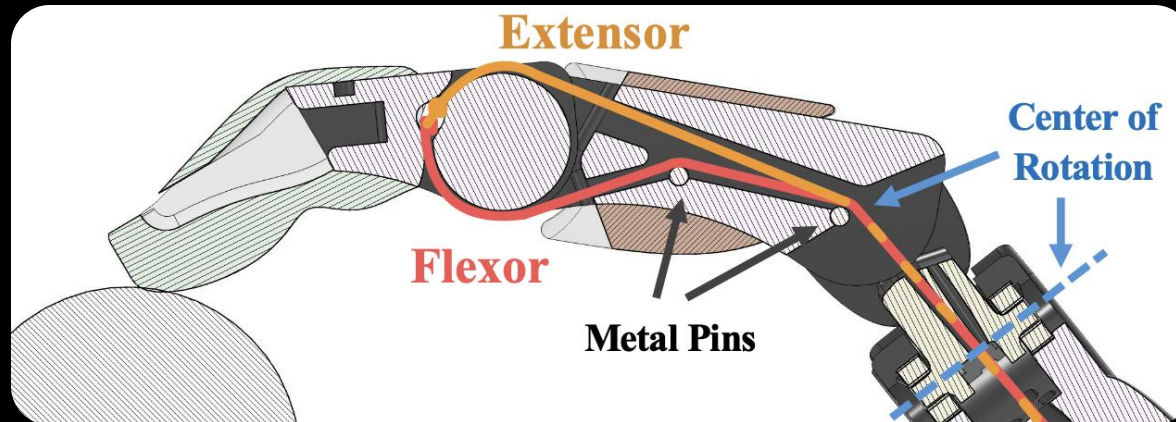
## Option 3: Full Antagonistic



[https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic\\_fig5\\_258022354](https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic_fig5_258022354)



# One-Way Force Transmission

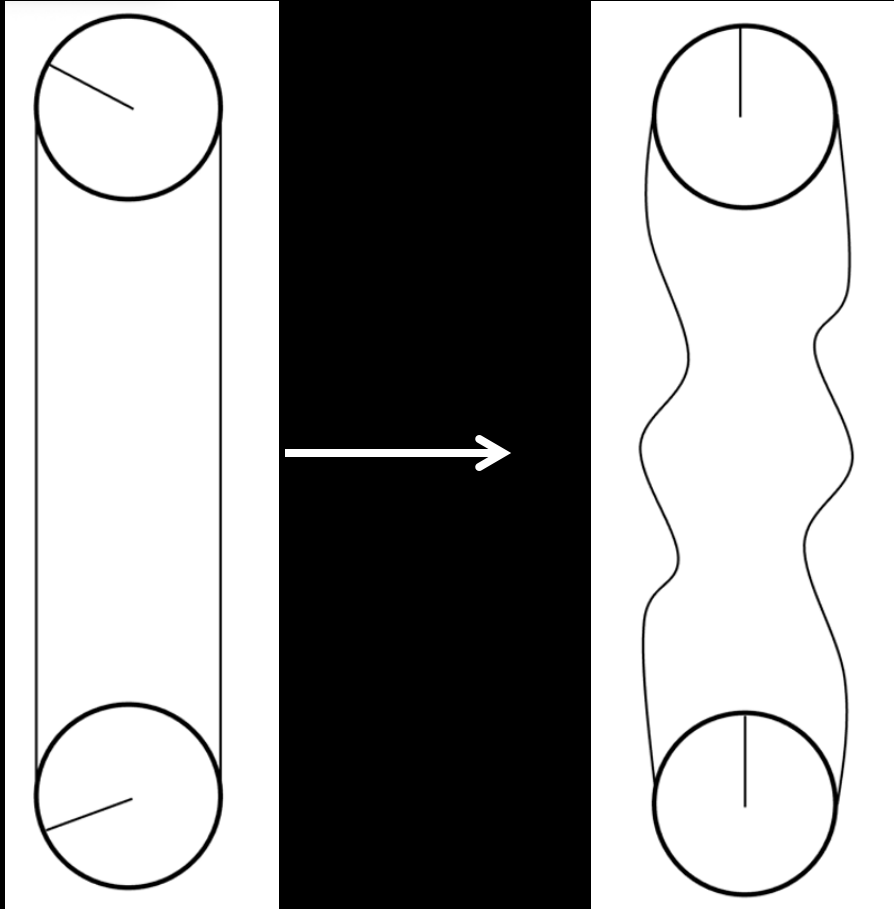


→ Only controllable if:  $l_{\text{flexor}} + l_{\text{extensor}} \neq \text{const}$

[https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic\\_fig5\\_258022354](https://www.researchgate.net/figure/index-finger-cross-section-view-of-the-NU-Hand-showing-tendon-routing-series-elastic_fig5_258022354)



## Slack in the system



Three causes:

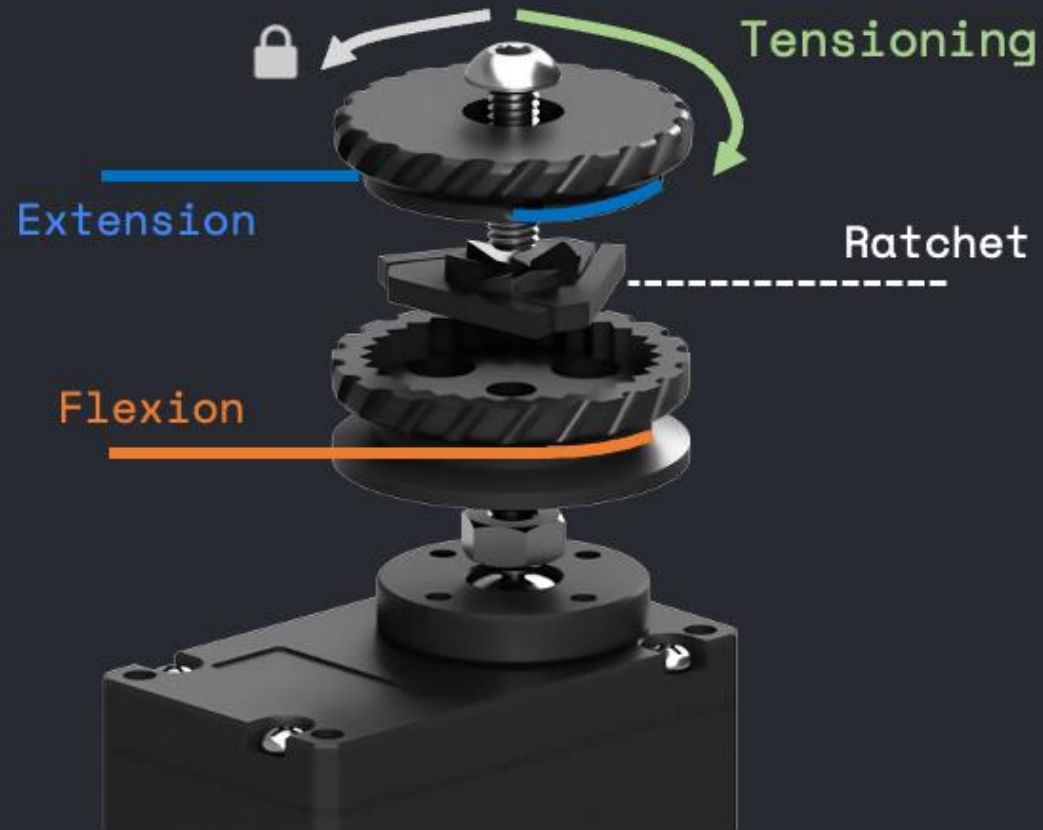
Tendon longer (creep)

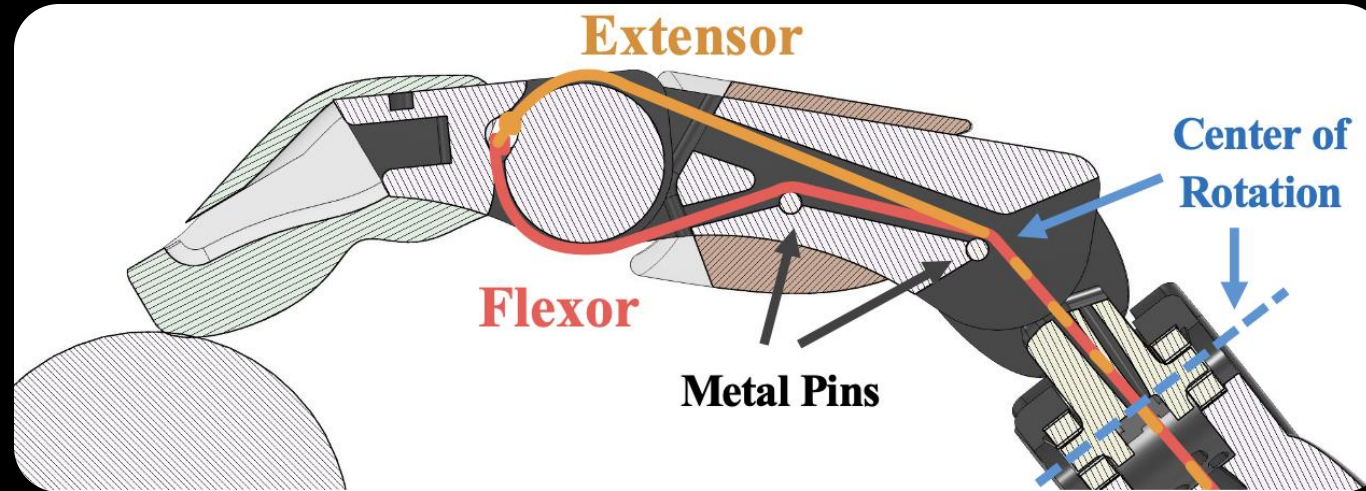
Tendon path shorter (Degradation of the path)

Incorrect Assembly



# Slack in the system Solution: Ratchet Spool

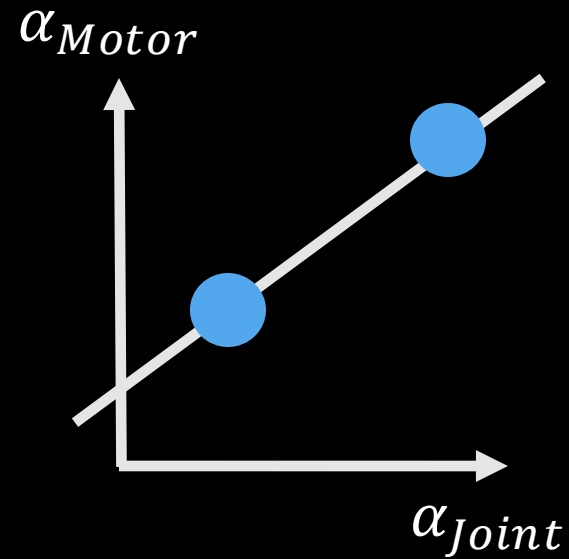
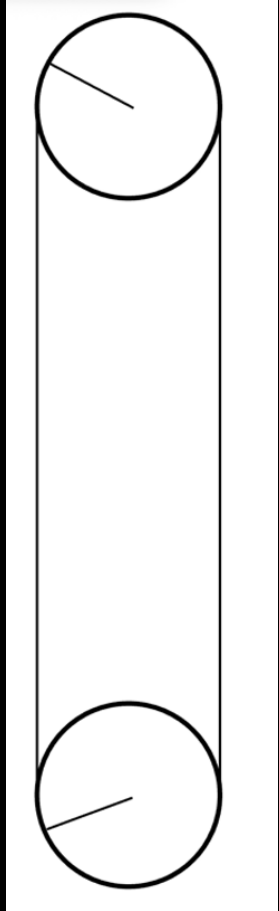




→ Will only work if:  $l_{\text{flexor}} + l_{\text{extensor}} = \text{const}$



# Controllability



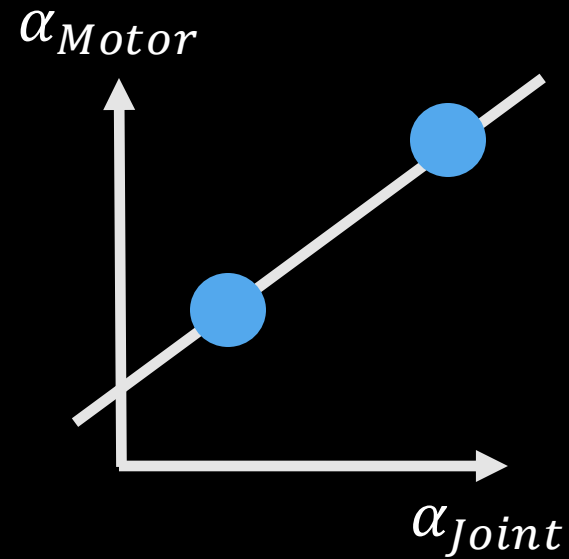
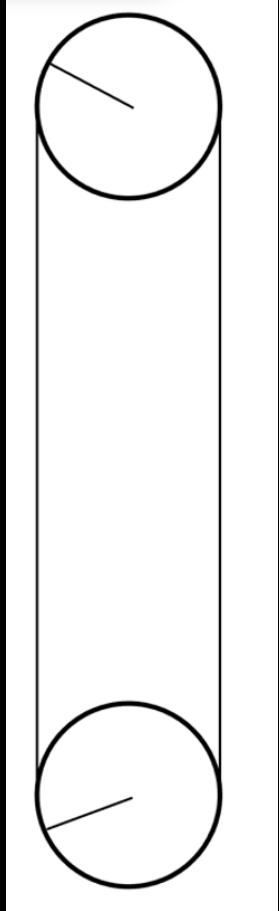
Given desired joint angle  $\theta_j$ , motor position  $m_j$  is calculated as:

$$m_j = m_j^{min} + \rho_j(\theta_j - \theta_j^{min})$$

→ holds for every joint



# Controllability

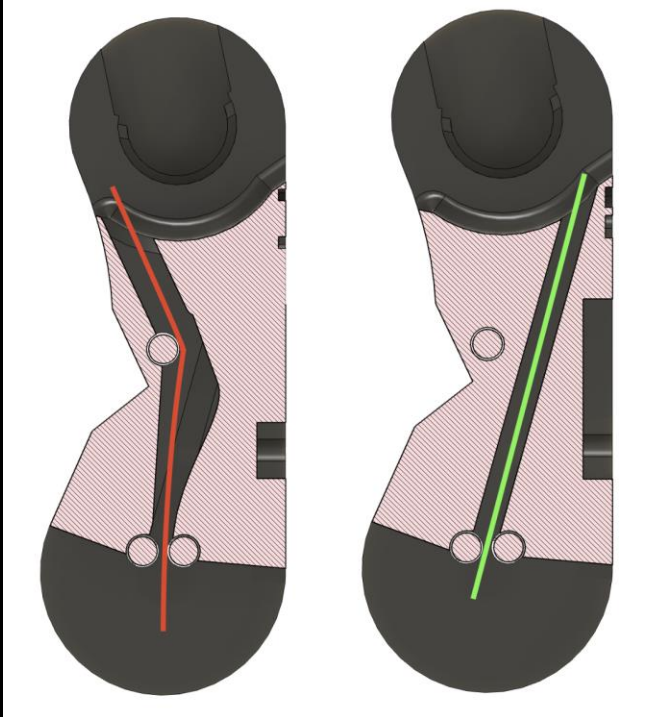


→ holds for every joint

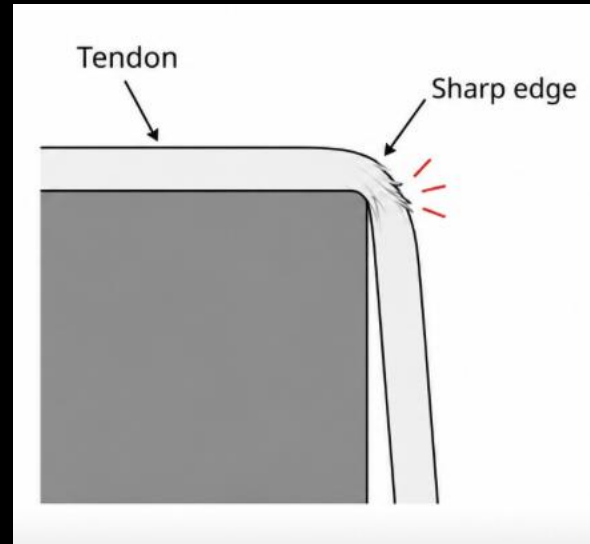


# Lifetime

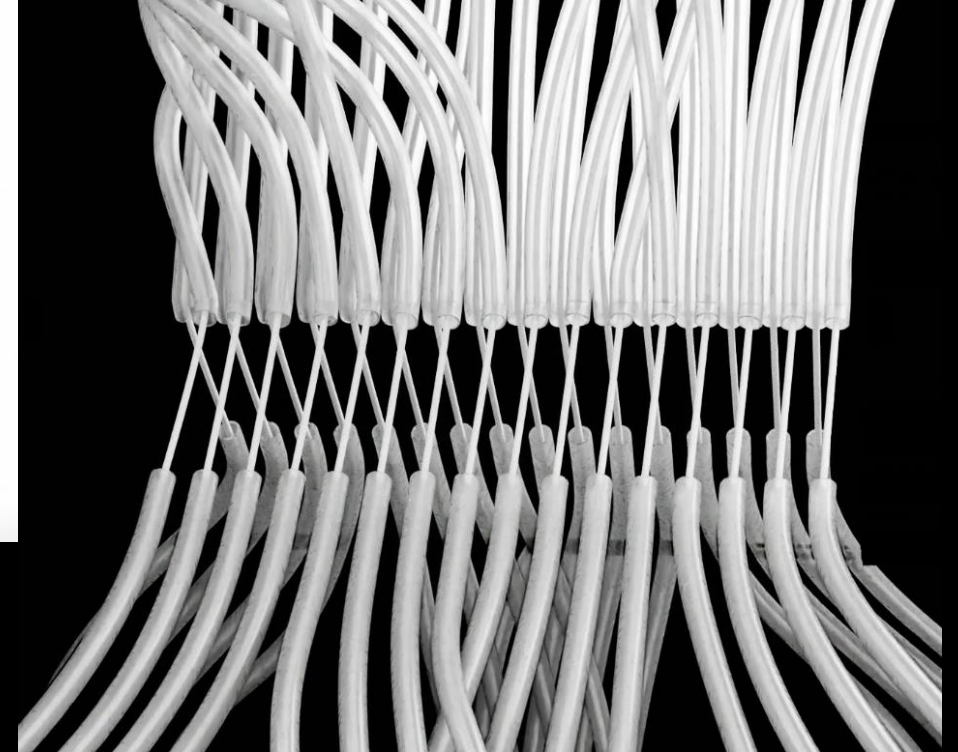
## metal pins



## Avoid sharp edges



## Teflon tubes

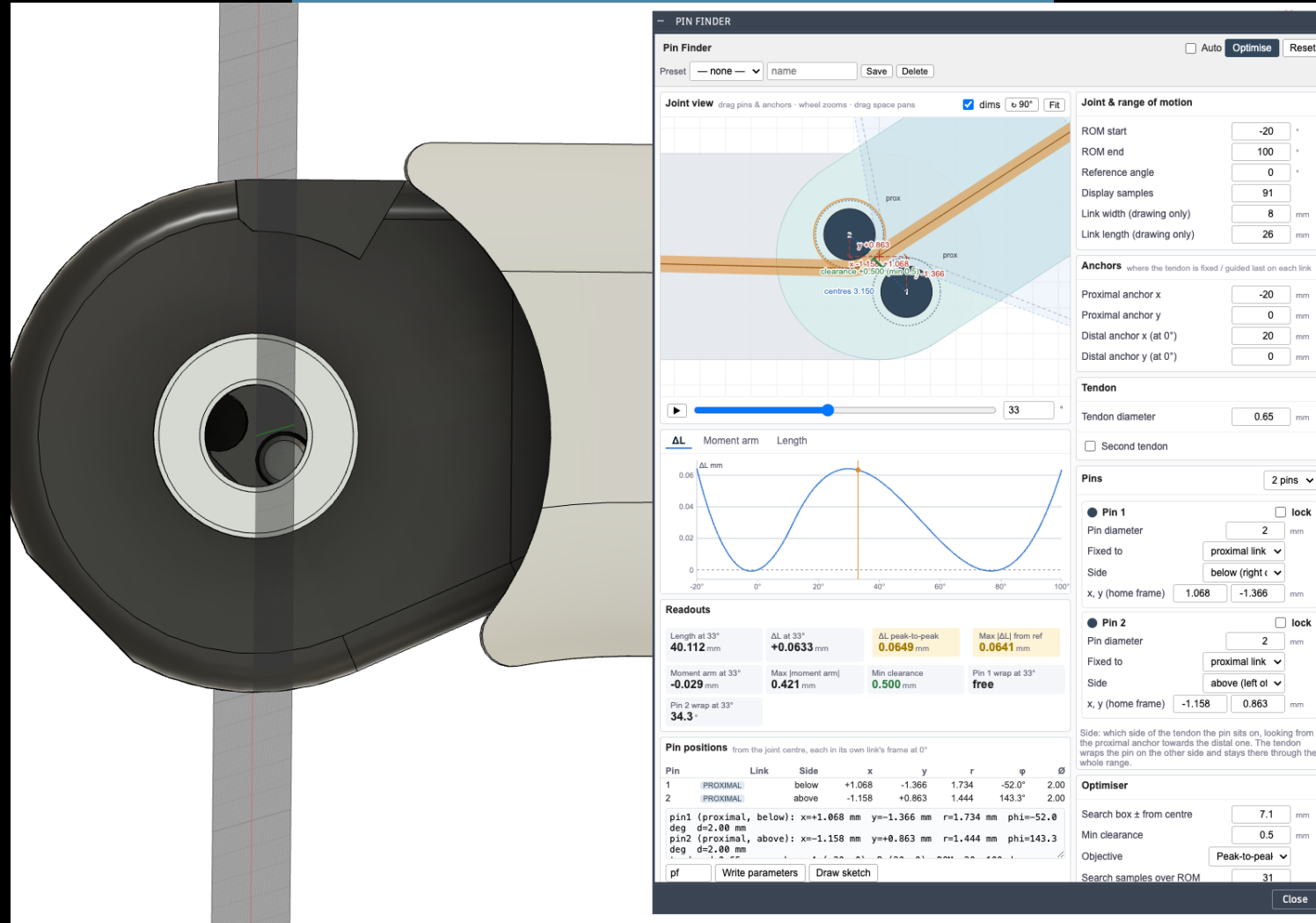


→ tendon should not touch any PLA



## Lifetime

Example:  
Pin Finder





- One way force transmission
- Slack (Creep)
- Controllability
- Lifetime
- Strength and Durability (3D Printing)
- Tolerances (Repeatability)



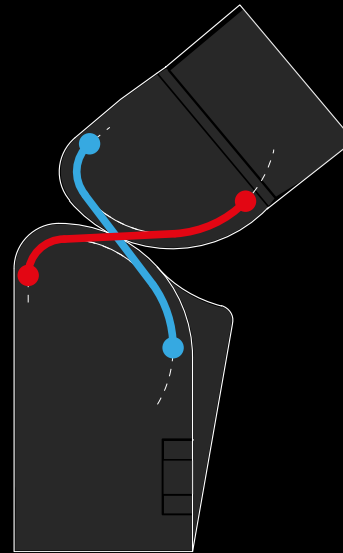
ORCA v2 (2026)

**BoM Cost: \$600**  
(Feetech Motors)



## Joint Design

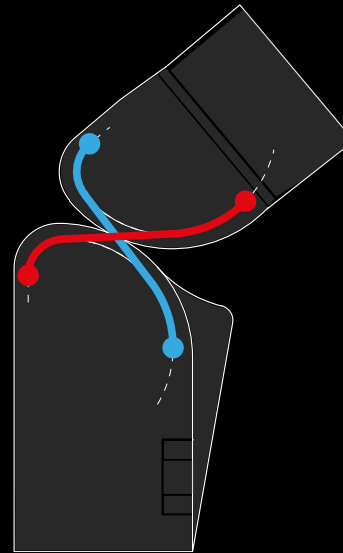
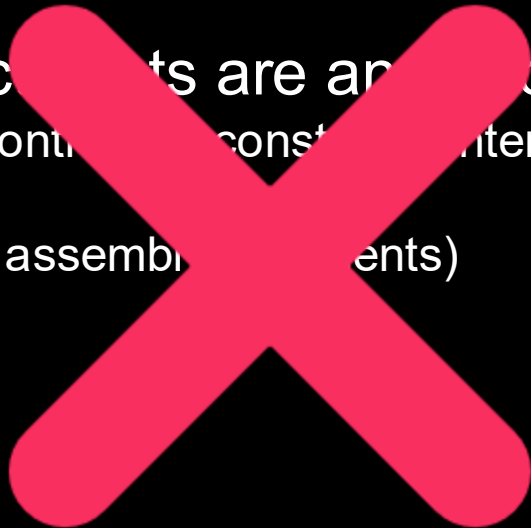
- Problem: PLA joints break easily
- Rolling contact joints are an option
  - Hard to control (no constant center of rotation)
  - Complex assembly (ligaments)

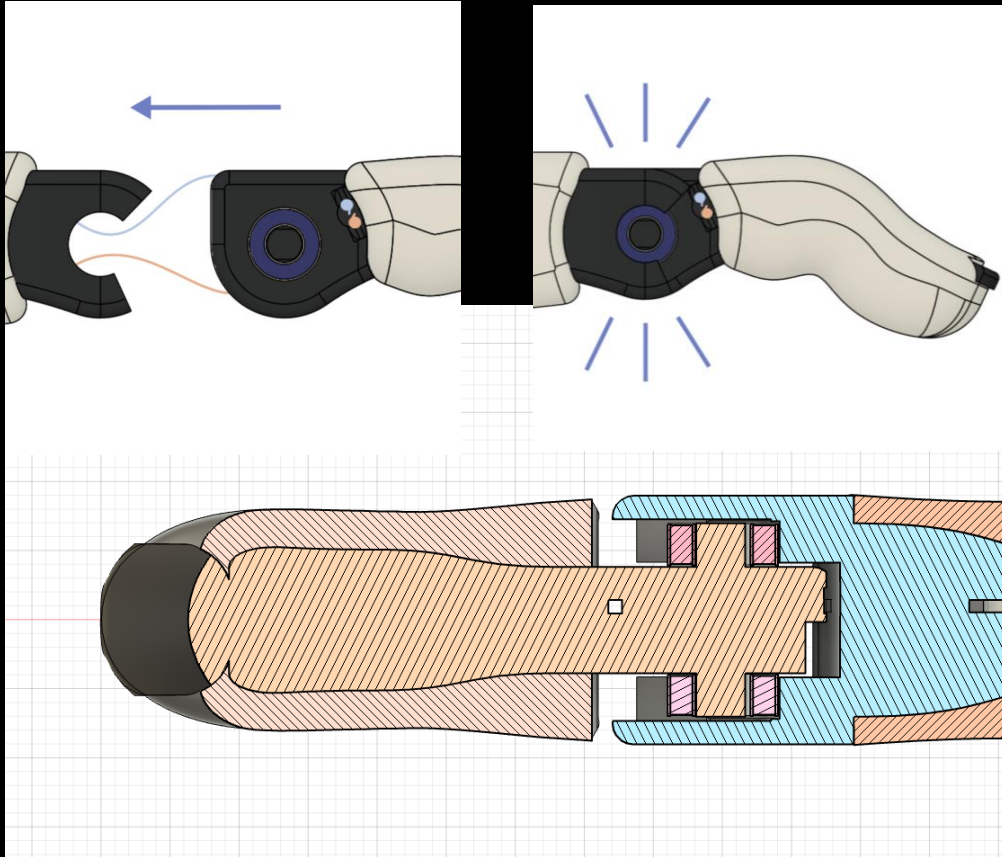




## Joint Design

- Problem: PLA joints break easily
- Rolling contact joints are an option
  - Hard to control (constant center of rotation)
  - Complex assembly (multiple parts)





## Popping joint

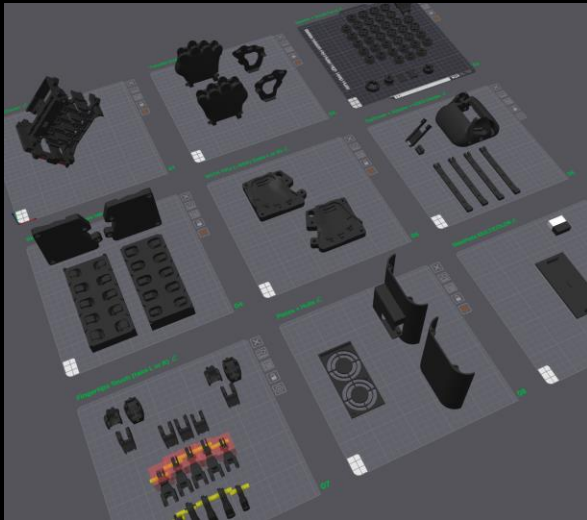
- Does not break (elastic enclosure)
- Simple control
- Easy assembly
- Good axial alignment
- Allows going through CoR



# Tolerances (Repeatability)

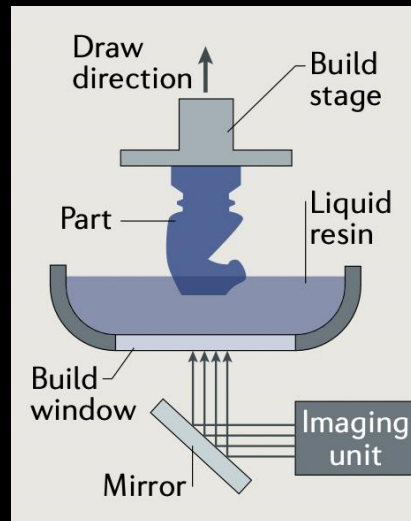
## FDM

- tolerance:  $\sim \pm 0.2\text{--}0.5$  mm
- Print orientation matters!



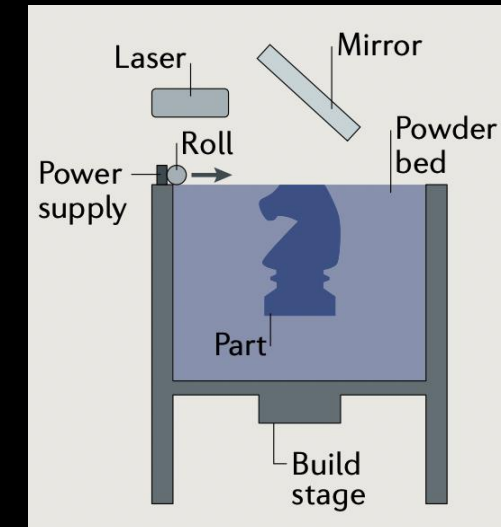
## SLA

- tolerance:  $\sim \pm 0.1$  mm
- Brittle



## SLS

- tolerance:  $\sim \pm 0.3$  mm
- Strong and tough
- Limited wall thickness



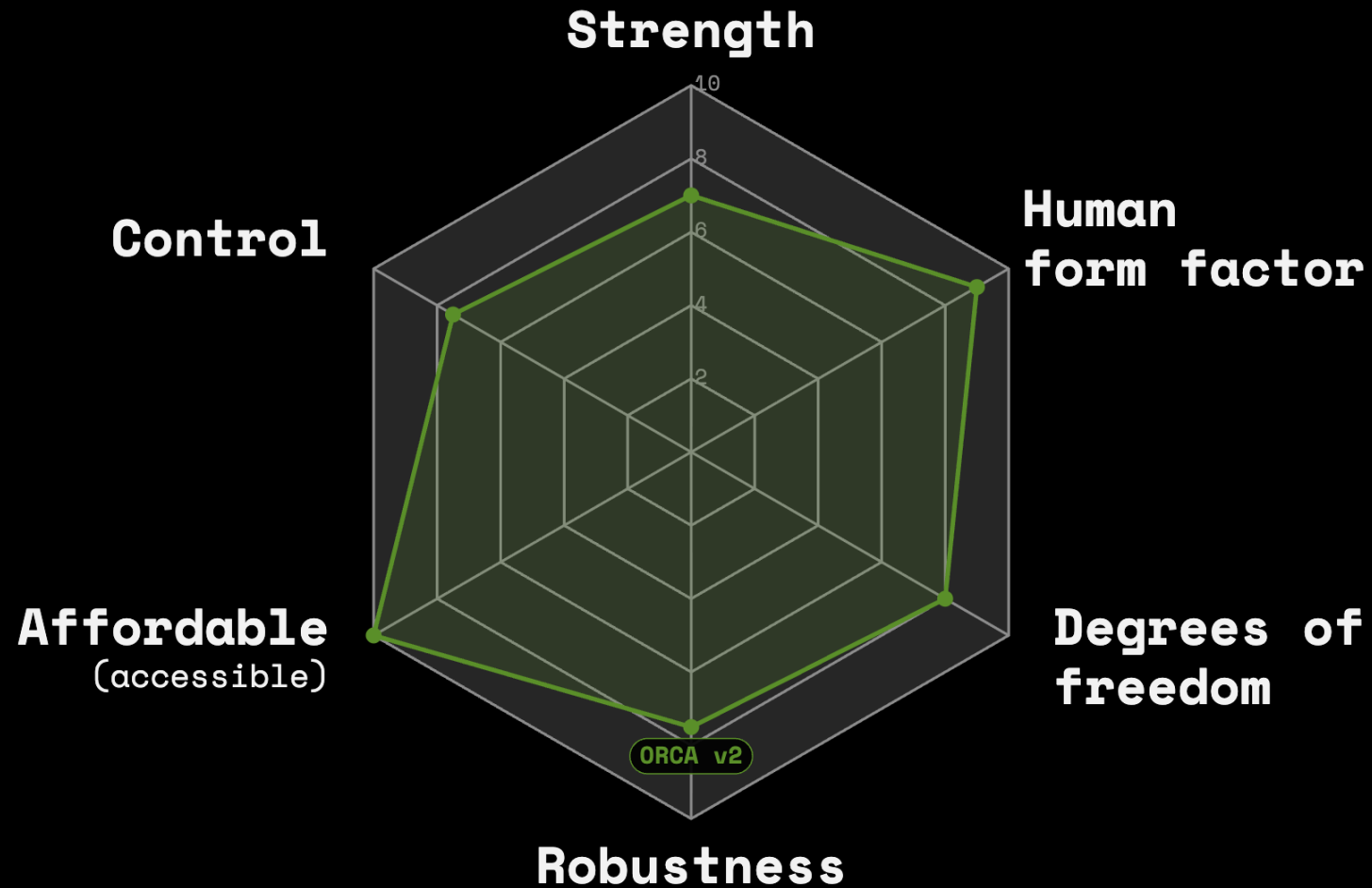


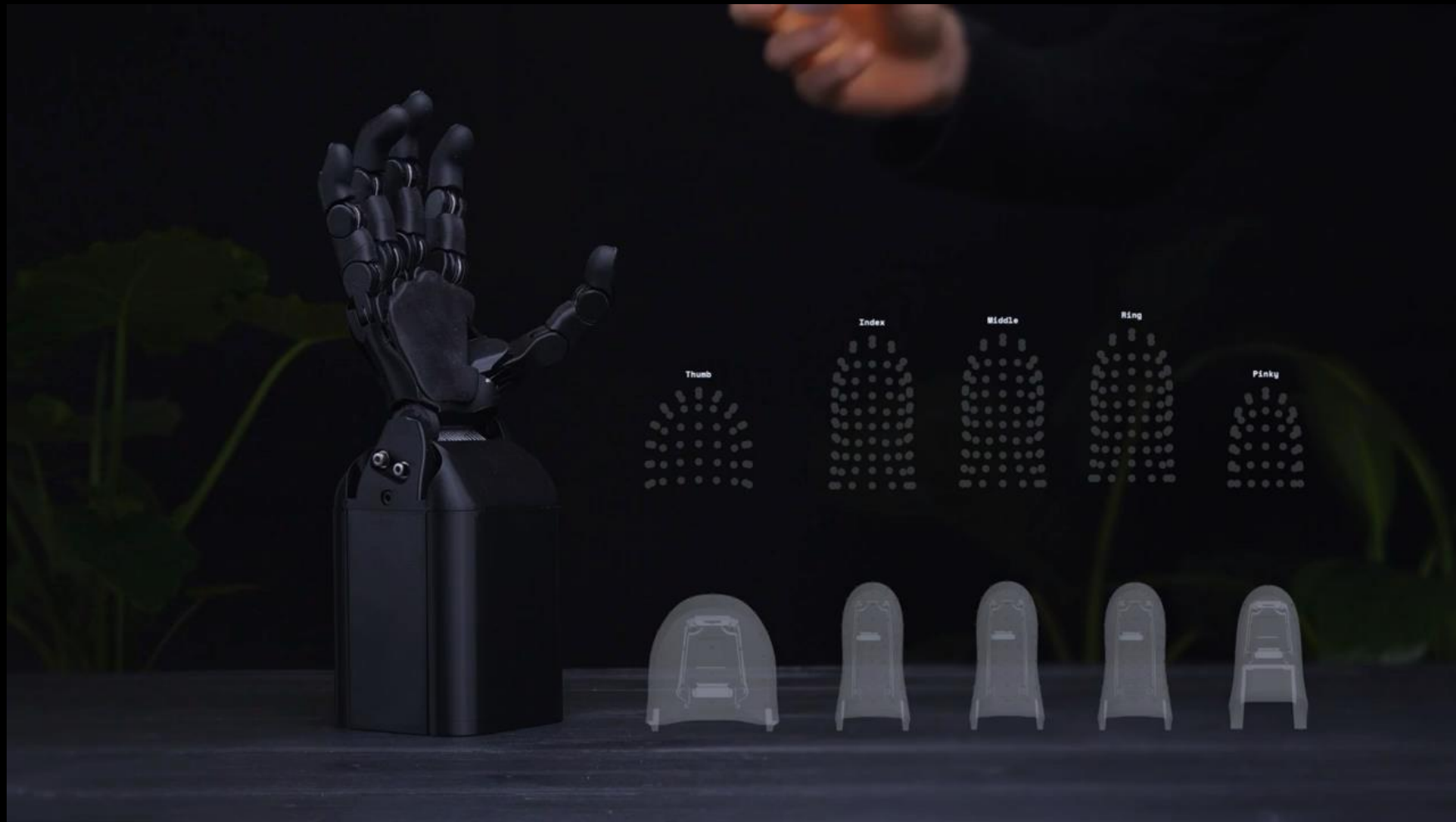
- Strength and Durability
- One way force transmission
- Slack (Creep)
- Lifetime
- Controllability
- Tolerances (Repeatability)



ORCA v2 (2026)

**BoM Cost: \$600**  
(Feetech Motors)

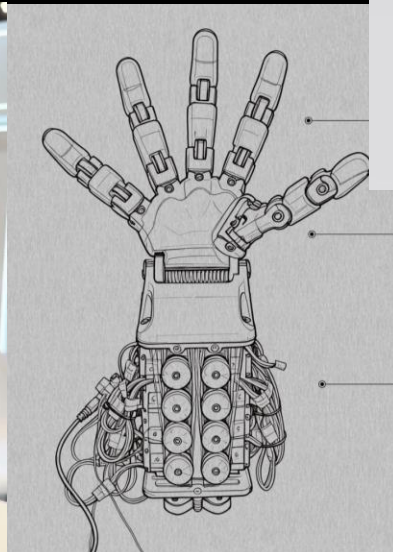




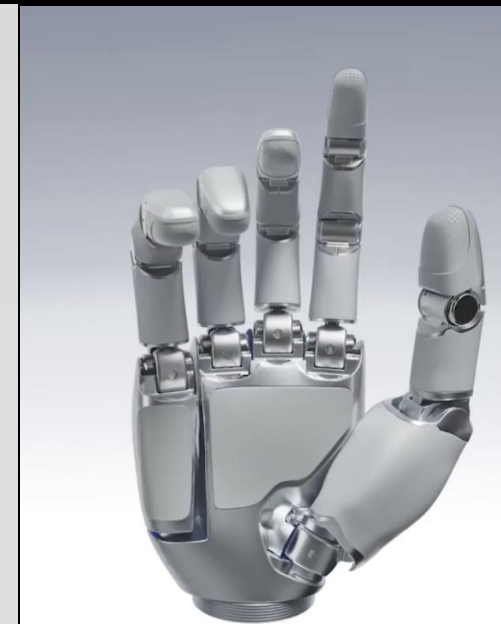


LinkerBot L30

DexHand021E



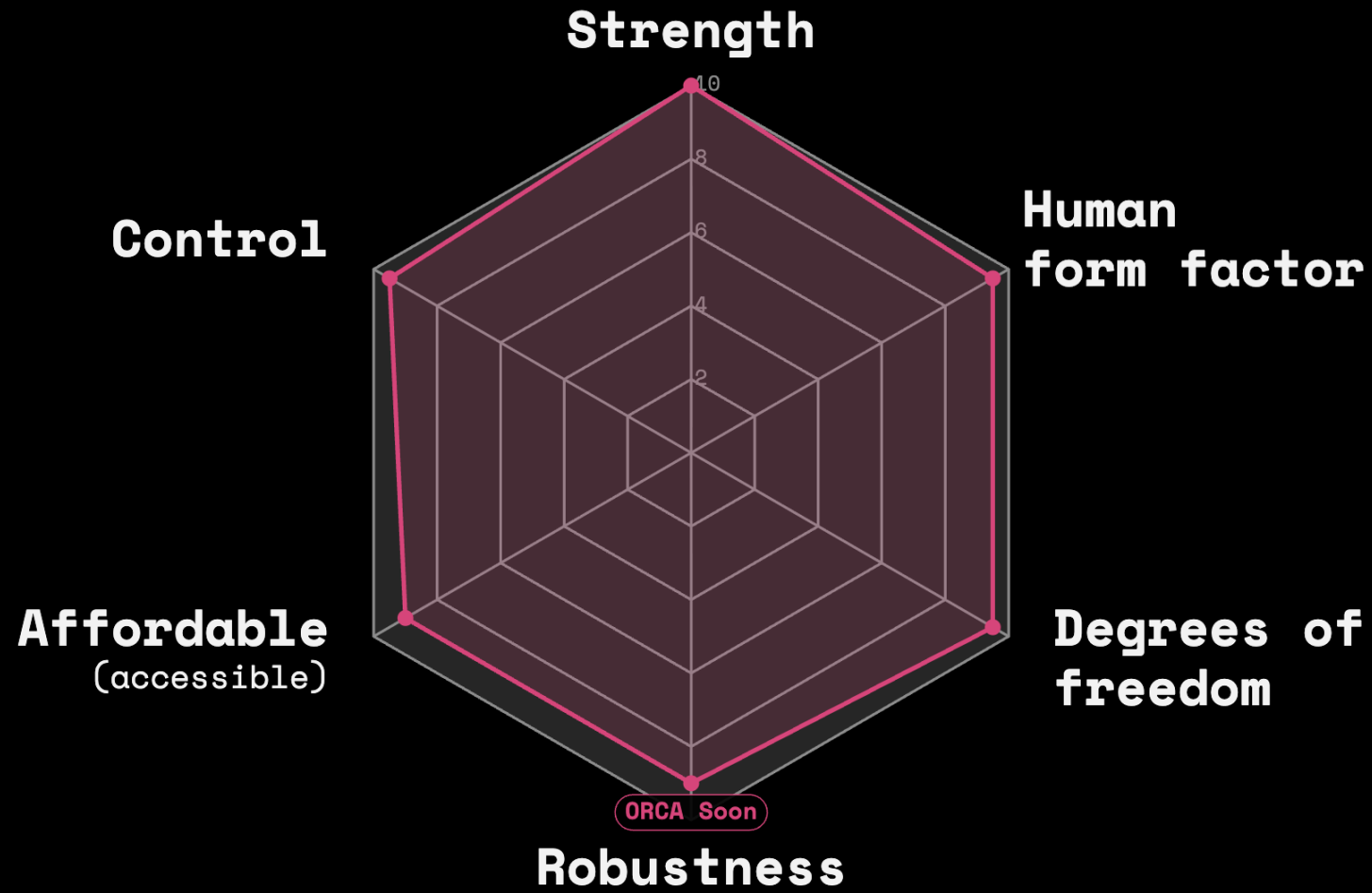
Xynova, hybrid



Sharpa



Wuji Tech





[clemens@orcahand.com](mailto:clemens@orcahand.com)

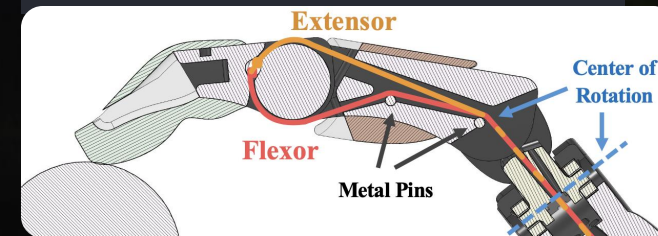
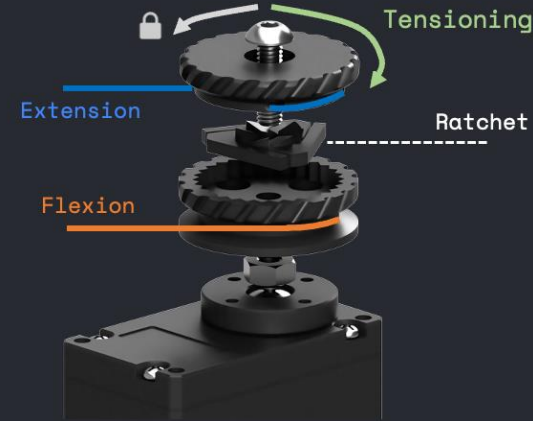




# Design of Robotic Hands

## Q&A

Clemens Christoph  
Founder & CEO, ORCA Dexterity  
September 28, 2026



- Strength and Durability
- One way force transmission
- Slack (Creep)
- Lifetime
- Controllability
- Tolerances (Repeatability)