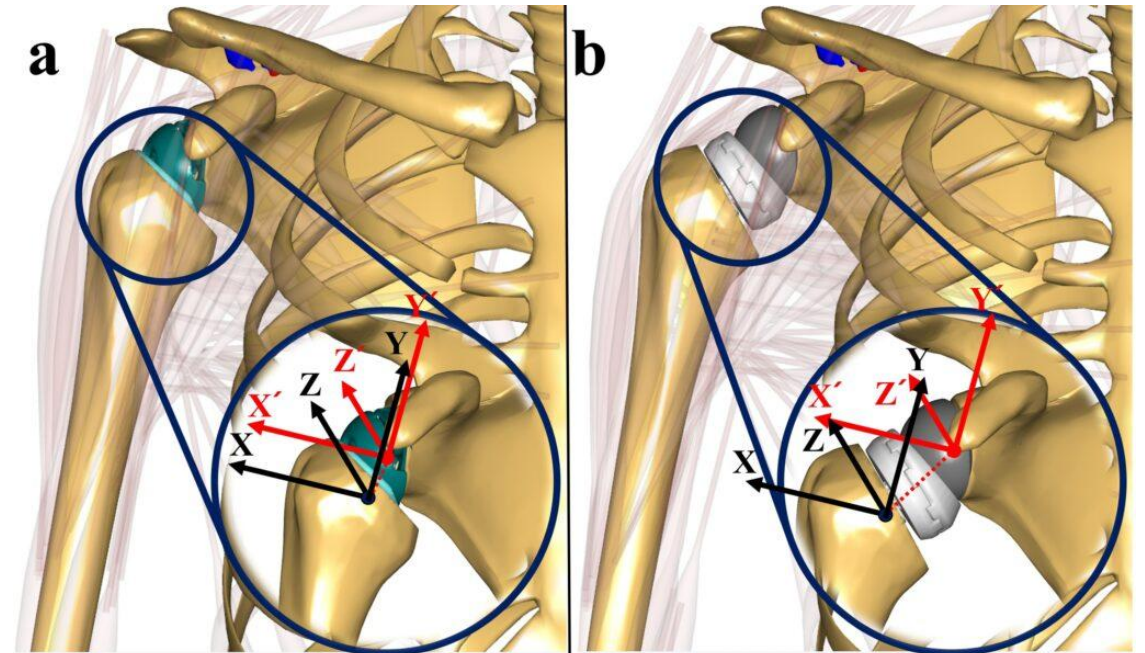


# Subscapularis Integrity and Posterosuperior Cuff Tear Severity Affect Scapular Impingement and Joint Stability in Reverse Total Shoulder Arthroplasty: Medialization vs. Lateralization



The webcast will begin shortly...

# Outline

- Introduction to the AnyBody Modeling System
- Presentation
- Upcoming AnyBody events
- Question and answer session

## Presenter

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## Host

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# Outline

## • Introduction

### BIOMECHANICS

## Do subscapularis integrity and posterosuperior cuff tear severity affect scapular impingement and joint stability during external rotation in lateralized reverse total shoulder arthroplasty?

### Medialization versus lateralization

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152.BJR-2025-0174.R1

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### Aims

The biomechanical effects of varying rotator cuff tear severities on medialized versus lateralized reverse total shoulder arthroplasty (RTSA) remain unclear. This study aimed to compare medialized and lateralized RTSA designs based on subscapularis integrity and the severity of posterosuperior cuff tears.

### Methods

A total of 12 human in vivo experimental datasets were collected during external rotation (ER) from a neutral position to 45° with the elbow fixed at 90° and the palm facing inward. These datasets were used as inputs for musculoskeletal shoulder models of both medialized and lateralized RTSA. Inverse dynamic simulations were conducted under two subscapularis conditions—repaired (all bundles intact) and torn (all bundles torn)—across three stages of posterosuperior cuff tear severity. The scapular notching-related impingement stress, joint subluxation, and muscle-tendon forces were compared between the two RTSA configurations.

### Results

Subscapularis repair in lateralized RTSA led to greater reductions in impingement stress (16.7% to 26.2%,  $p < 0.05$ ) and joint subluxation (27.5% to 58.9%,  $p < 0.001$ ) compared to medialized RTSA (14.1% to 18.6%,  $p < 0.05$  and 14.7% to 22.4%,  $p < 0.001$ , respectively) across all posterosuperior cuff tear severity conditions. Additionally, with subscapularis repair, posterior deltoid increased more markedly with tear severity in lateralized RTSA (from 2.6% to 784.5%, both  $p < 0.001$ ) than in medialized RTSA (from 4.7% to 784.5%, both  $p < 0.001$ ).

### Conclusion

Lateralizing RTSA and repairing the subscapularis can significantly reduce impingement stress, posterior deltoid force, and joint subluxation, supporting the use of a lateralized RTSA design for surgical planning, supporting the use of a lateralized RTSA design to reduce the risk of scapular notching and joint instability.

## Presenter

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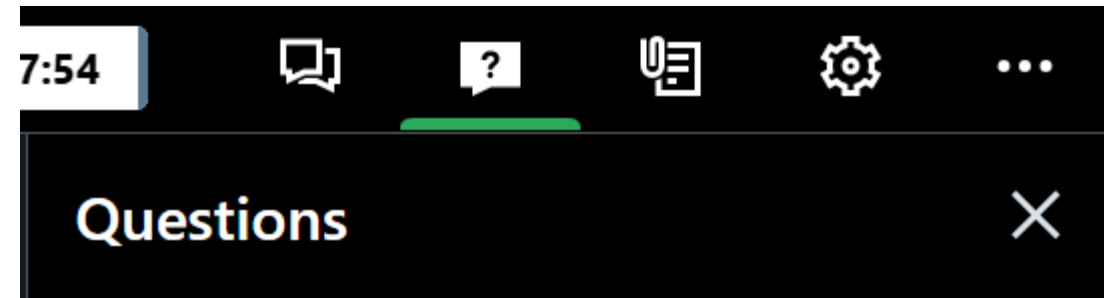


# Control Panel

The Control Panel appears on the **top-right** side of your screen.

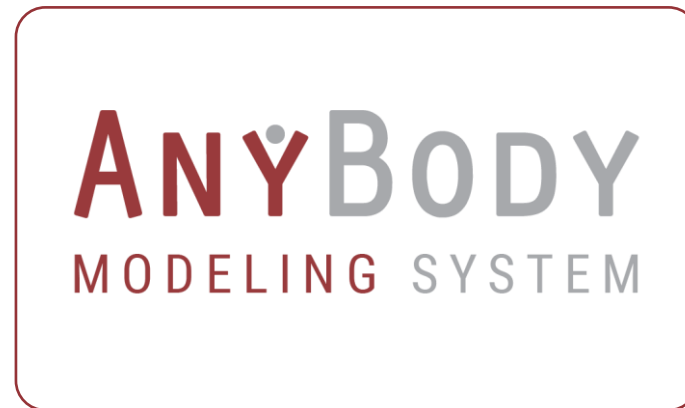
Submit questions and comments via the Questions panel.

*Questions will be addressed at the end of the presentation. If your question is not addressed, we will do so by email.*



# Musculoskeletal simulations

**INPUT** • Motion data



**OUTPUT** • Internal Body Loads

Joint reaction forces

Muscle forces

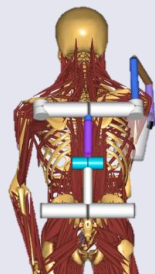
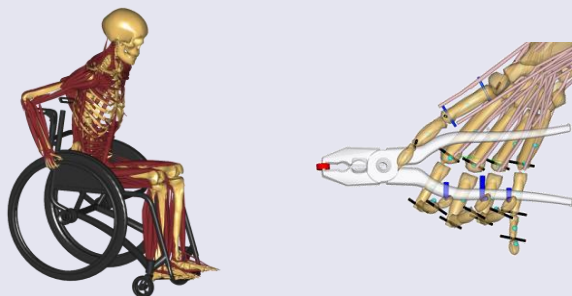
Muscle activity

Metabolic energy + fatigue

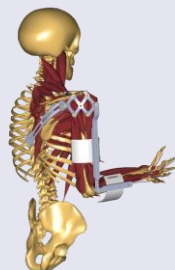


Motion  
analysis

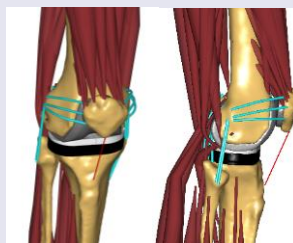
Product design  
and optimization



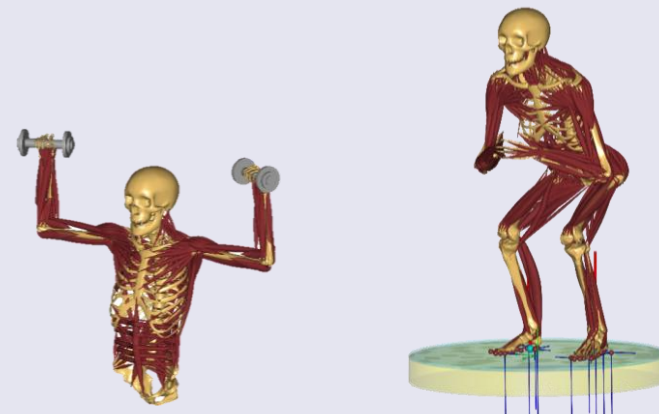
Ergonomics  
with/without  
exoskeletons



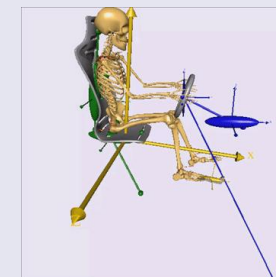
**ANYBODY**  
MODELING SYSTEM



Orthopedics  
and  
Rehabilitation



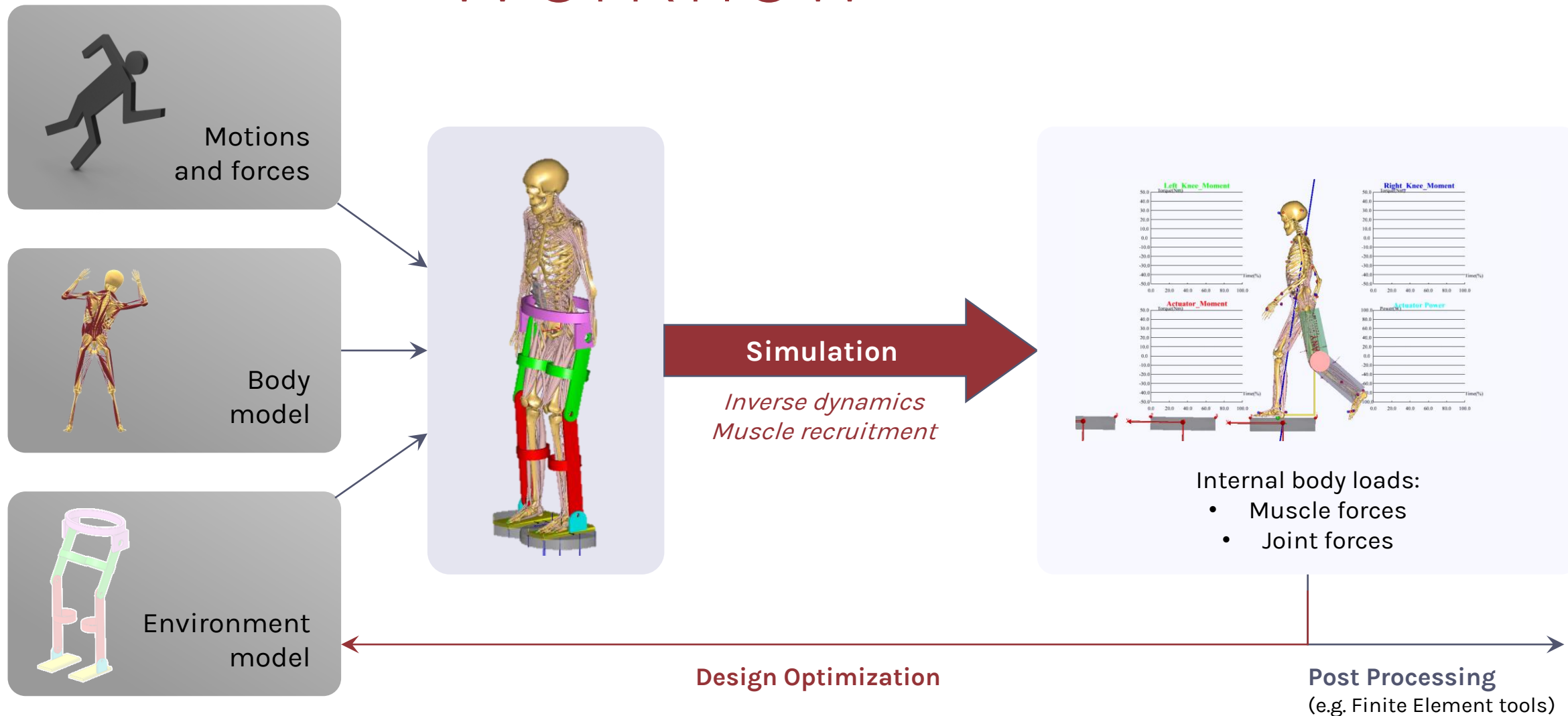
Sports



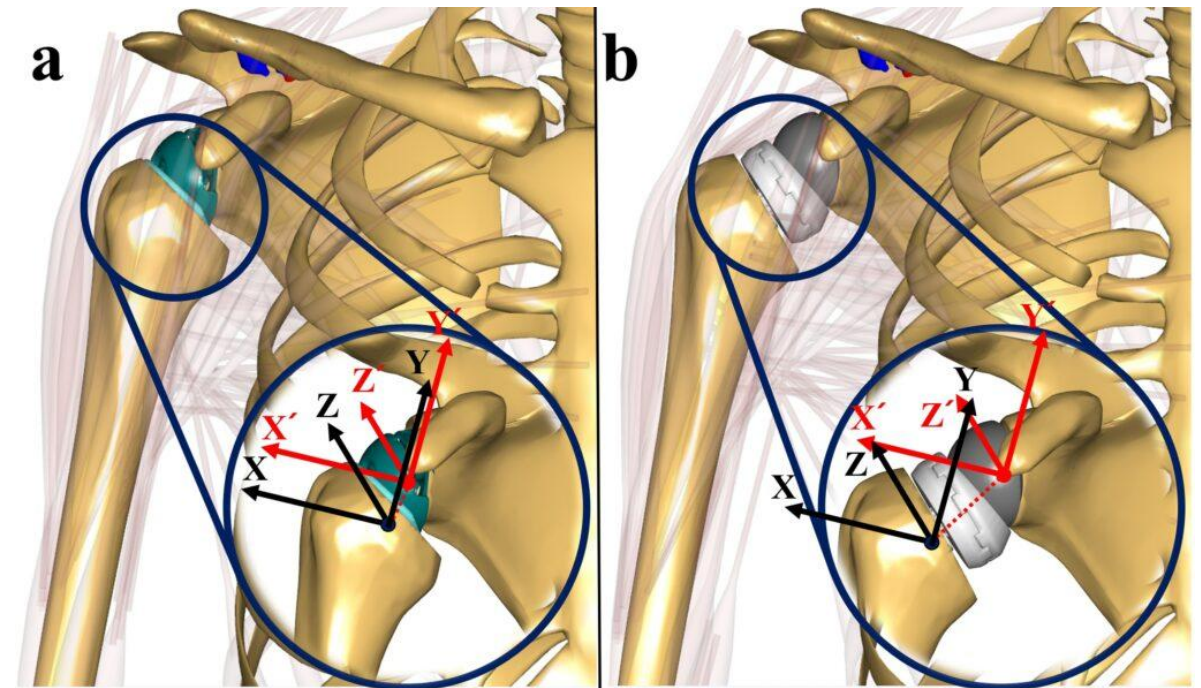
Automotive



# Workflow



# Subscapularis Integrity and Posterosuperior Cuff Tear Severity Affect Scapular Impingement and Joint Stability in Reverse Total Shoulder Arthroplasty: Medialization vs. Lateralization





# Subscapularis Integrity and Posterosuperior Cuff Tear Severity Affect Scapular Impingement and Joint Subluxation in Reverse Total Shoulder Arthroplasty: Medialization vs. Lateralization

*2026. 03. 17.*

*AnyBody Webcast*

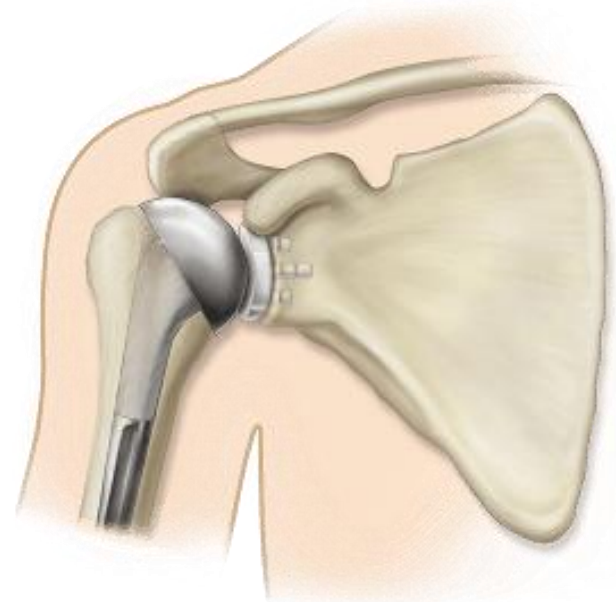
**Donghwan Lee**, Ph.D. Candidate

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Biomechanics and Biomedical Engineering Laboratory

- **Relieving pain** in patients with glenohumeral arthritis (Fig. 1).<sup>1</sup>
- Restoring **shoulder function** for glenohumeral disorders.<sup>1</sup>
- Primarily indicated for chronic arthritis with **intact rotator cuff**.<sup>2</sup>



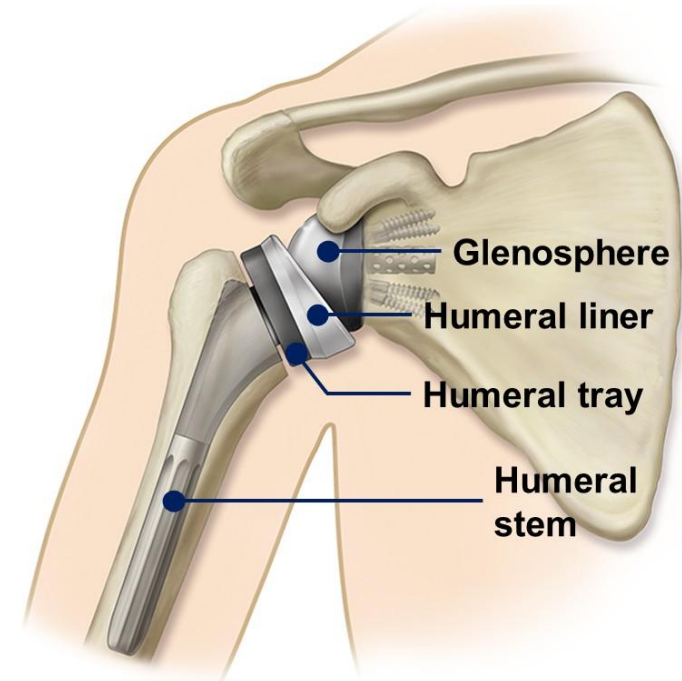
**Fig. 1** Anatomic total shoulder arthroplasty (Exactech Equinox).

➡ **In anatomic TSA, rotator cuff tears (RCTs) can lead to joint instability due to reduced joint compression.**<sup>2</sup>

[1] Lädermann et al., *J Bone Joint Surg Am.*, 2011

[2] Thomas et al., *J Shoulder Elbow Surg.*, 2018

- The standard treatment for cuff tear arthropathy (Fig. 2).<sup>3</sup>
- Improving **joint stability** compared to anatomic TSA.<sup>4</sup>
- Recruiting **more fibers of the deltoids** to act as abductors.<sup>4</sup>



**Fig. 2** Reverse total shoulder arthroplasty (Exactech Equinox).

➡ However, even in RTSA, **massive RCTs can still increase the risk of joint instability or dislocation.**<sup>5,6</sup>

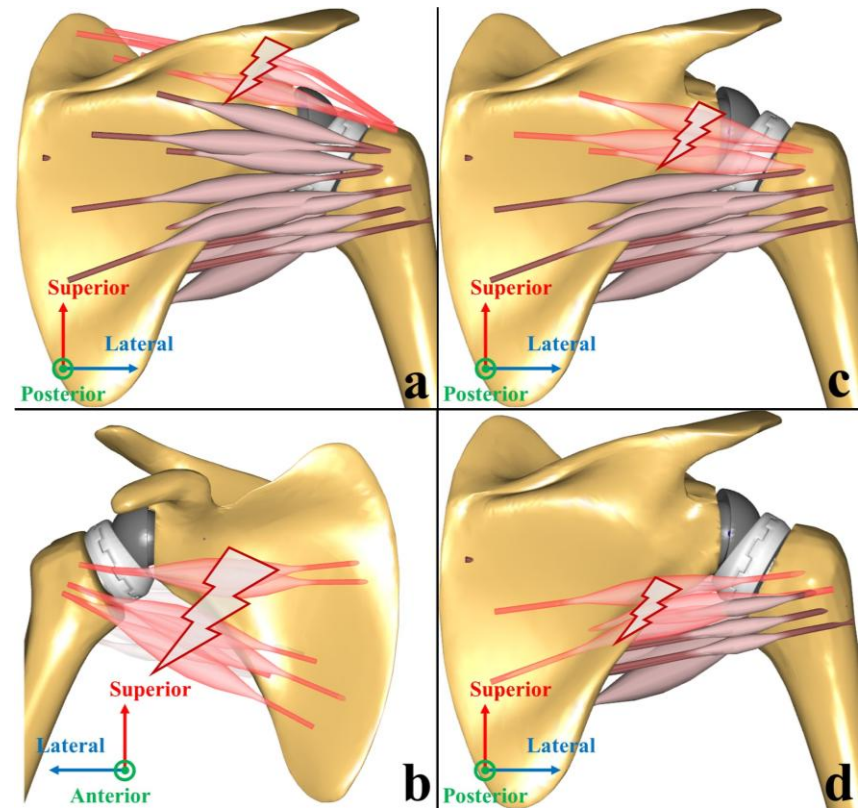
[3] Boileau et al., *J Shoulder Elbow Surg.*, 2006

[5] Wall et al., *J Bone Jt Surg.*, 2007

[4] Boileau et al., *J Shoulder Elbow Surg.*, 2005

[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009

- Varying from **partial- to full-thickness RCTs** (Fig. 3).<sup>1</sup>
- Frequently associated with **RCTs extending supero-posteriorly** rather than supero-anteriorly.<sup>7,8</sup>
- Involving **subscapularis repair or leaving the tear** during RTSA.<sup>6</sup>



**Fig. 3** Cuff conditions: **a** supraspinatus tear, **b** subscapularis tear, **c** partial infraspinatus tear, and **d** complete infraspinatus tear.

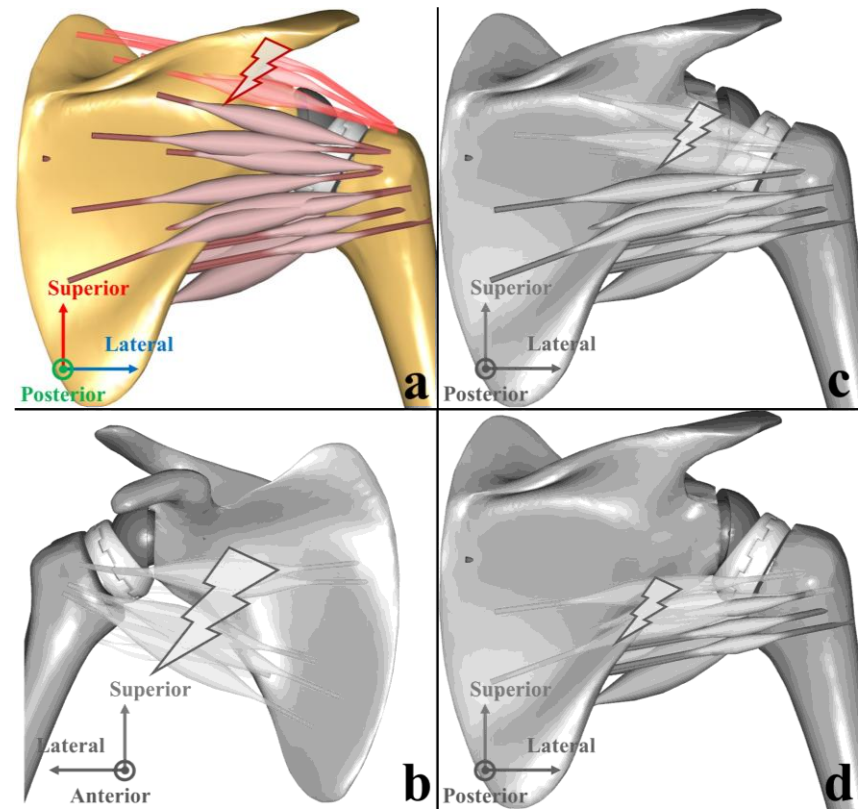
[1] Boileau et al., *J Shoulder Elbow Surg.*, 2006 [7] Gerber et al., *J Bone Jt Surg.*, 2000

[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009 [8] Cofield et al., *J Bone Jt Surg.*, 2001

## 1. Supraspinatus

- **Abductor.**
- **Completely torn** in most RTSA patients (Fig. 3a).<sup>1,6</sup>
- **Often excising** to enhance glenoid exposure.<sup>9</sup>

➔ This tear **increases muscle forces** in the subscapularis and infraspinatus.<sup>10</sup>



**Fig. 3** Cuff conditions: **a** supraspinatus tear, **b** subscapularis tear, **c** partial infraspinatus tear, and **d** complete infraspinatus tear.

[1] Boileau et al., *J Shoulder Elbow Surg.*, 2006

[9] Sirveaux et al., *Orthop Traumatol Surg Res.*, 2010

[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009

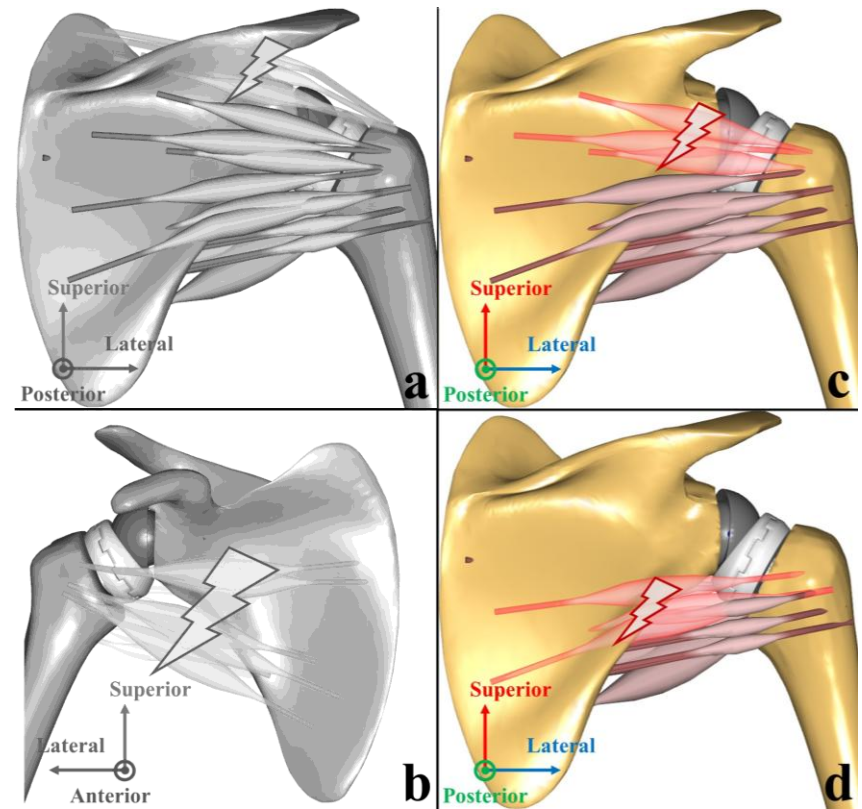
[10] Ackland et al., *J Orthop. Res.*, 2019



## 2. Infrapinatus

- External rotator.
- Partially or completely torn (Fig. 3c and d).<sup>1</sup>
- Providing a **transverse force couple** with the subscapularis.<sup>11</sup>

➡ This tear **reduces joint compression**, potentially leading to joint instability.<sup>11</sup>



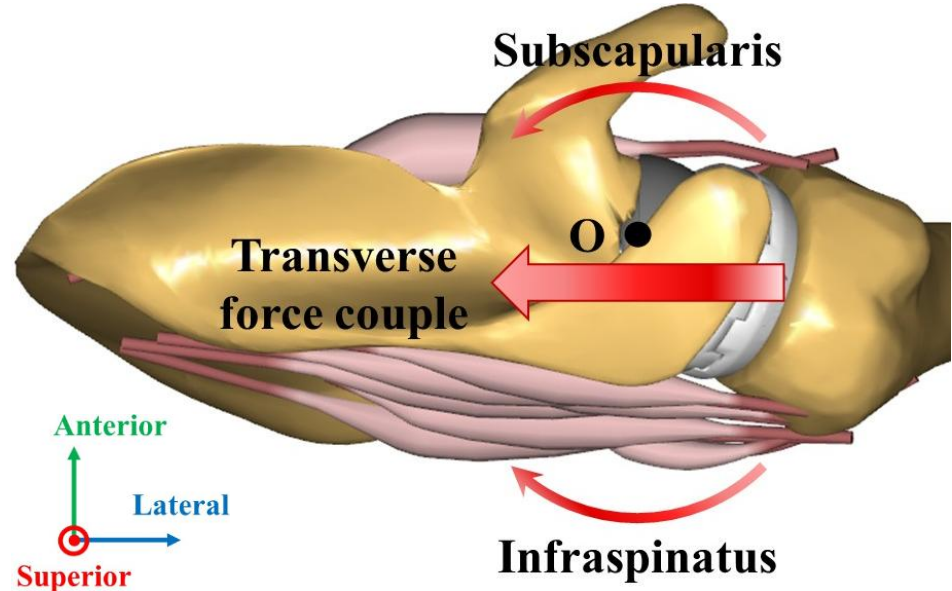
**Fig. 3** Cuff conditions: **a** supraspinatus tear, **b** subscapularis tear, **c** partial infrapinatus tear, and **d** complete infrapinatus tear.

[1] Boileau et al., *J Shoulder Elbow Surg.*, 2006

[11] Lee et al., *Ann Biomed Eng.*, 2026

## 3. Subscapularis

- Internal rotator.
- Being **repaired** after tenotomy or left **torn**.<sup>6</sup>
- Providing the **transverse force couple** with the infraspinatus (Fig. 4).<sup>11</sup>



**Fig. 4** Illustration of a transverse force couple between the subscapularis and infraspinatus.

➡ **Various outcomes following subscapularis repair have been reported to **depend on implant designs**.**

[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009

[11] Lee et al., *Ann Biomed Eng.*, 2026

## 1. Medialized RTSA

- Non-offset from the glenoid surface (**medial glenoid**).
- Humeral inlay configuration (**medial humerus**).
- More prone to **dislocation** than lateralized RTSA.<sup>12</sup>

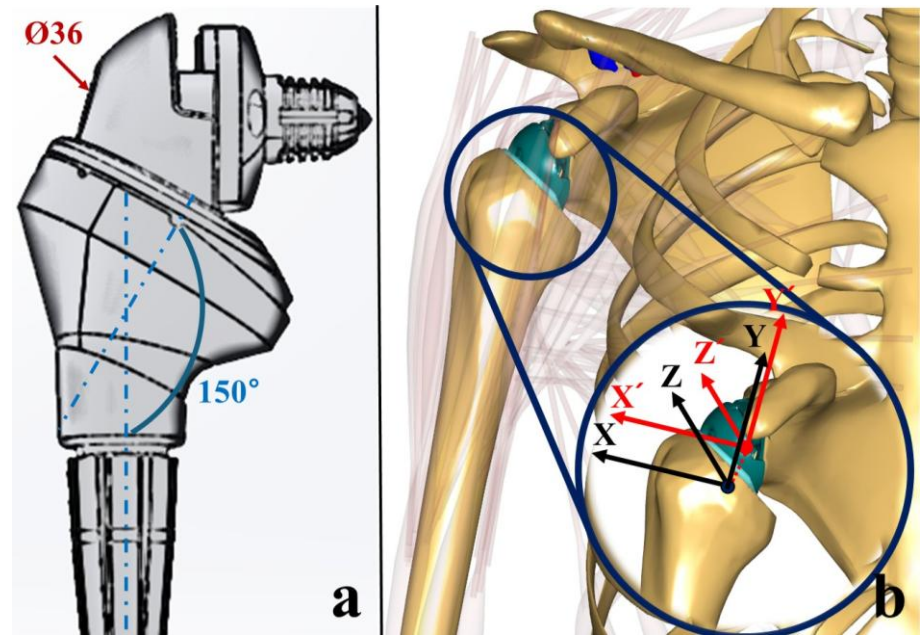


Fig. 5 Illustration of medialized reverse total shoulder arthroplasty.

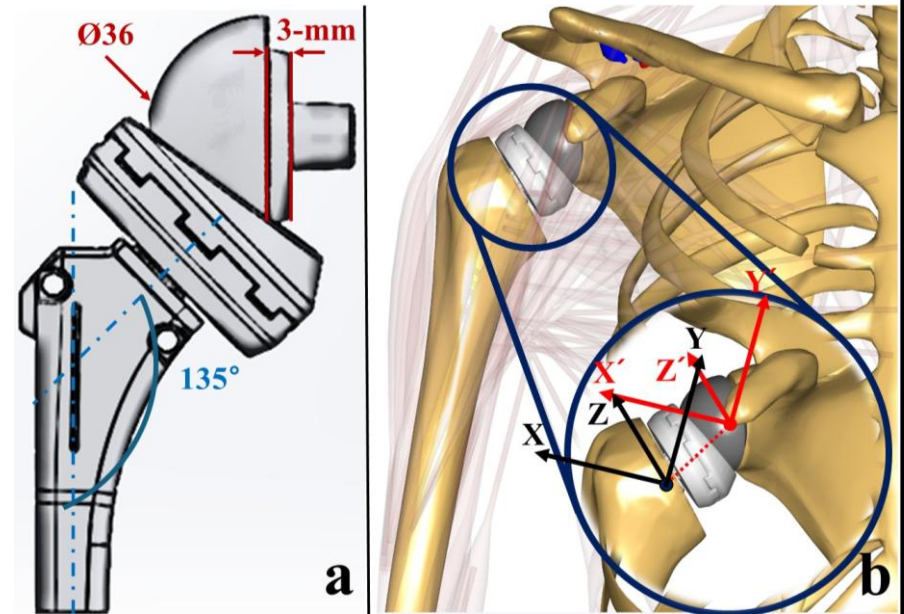
➡ In medialized RTSA, subscapularis repair can **reduce the risk of joint instability or dislocation**.<sup>6,12</sup>

[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009

[12] De Fine et al., *Arch Orthop Trauma Surg.*, 2022

## 2. Lateralized RTSA

- Lateral offset from glenoid surface (**lateral glenoid**).
- Humeral onlay configuration (**lateral humerus**).
- Improving **joint stability** by enhancing the compression.<sup>12</sup>



**Fig. 6** Illustration of lateralized reverse total shoulder arthroplasty.

➡ However, in lateralized RTSA, **the effects of subscapularis repair remain controversial.**<sup>12–15</sup>

[12] De Fine et al., *Arch Orthop Trauma Surg.*, 2022

[14] Caceres et al., *Iowa Orthop J.*, 2019

[13] Franceschetti et al., *Int Orthop.*, 2019

[15] Johnson et al., *J Shoulder Elbow Surg.*, 2021



1. Why is **the effect debated** in lateralized RTSA?

➤ **Pros:** reduced **impingement** and **subluxation** (Fig. 7).<sup>14,15</sup>

➤ **Cons:** no significant effect on **stability** or **dislocation**.<sup>12,13</sup>

2. Did prior studies account for the integrity of the remaining cuff (e.g., **infraspinatus**)?

➡ The influence of subscapularis repair across RCT severities remains unclear in **both medialized and lateralized RTSA**.

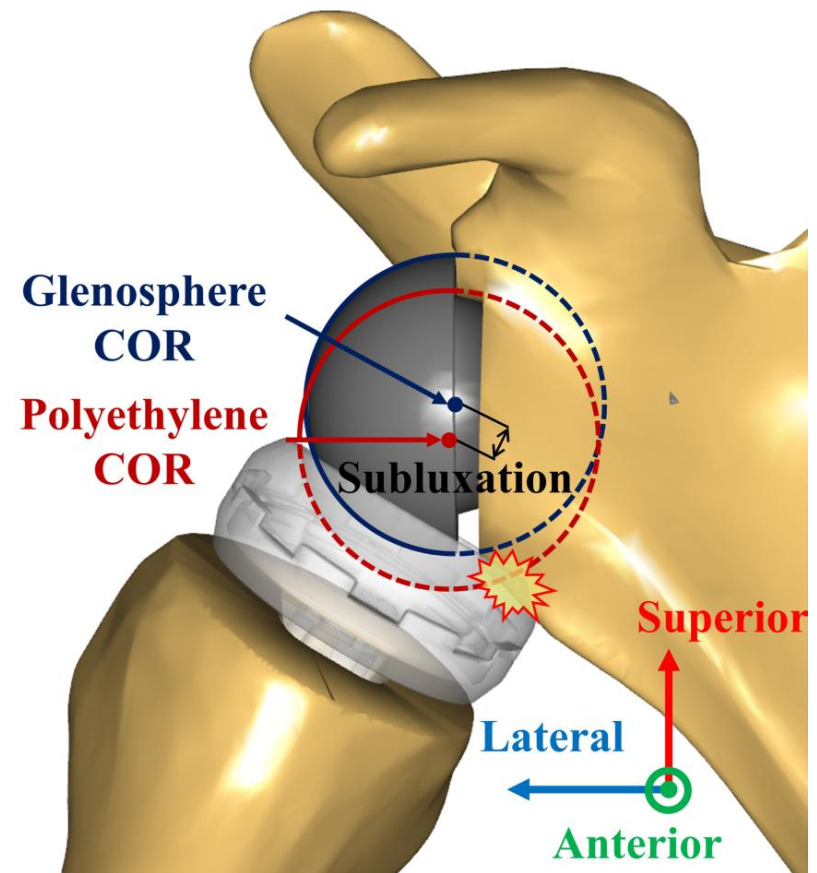


Fig. 7 Impingement and subluxation.

[12] De Fine et al., *Arch Orthop Trauma Surg.*, 2022

[14] Caceres et al., *Iowa Orthop J.*, 2019

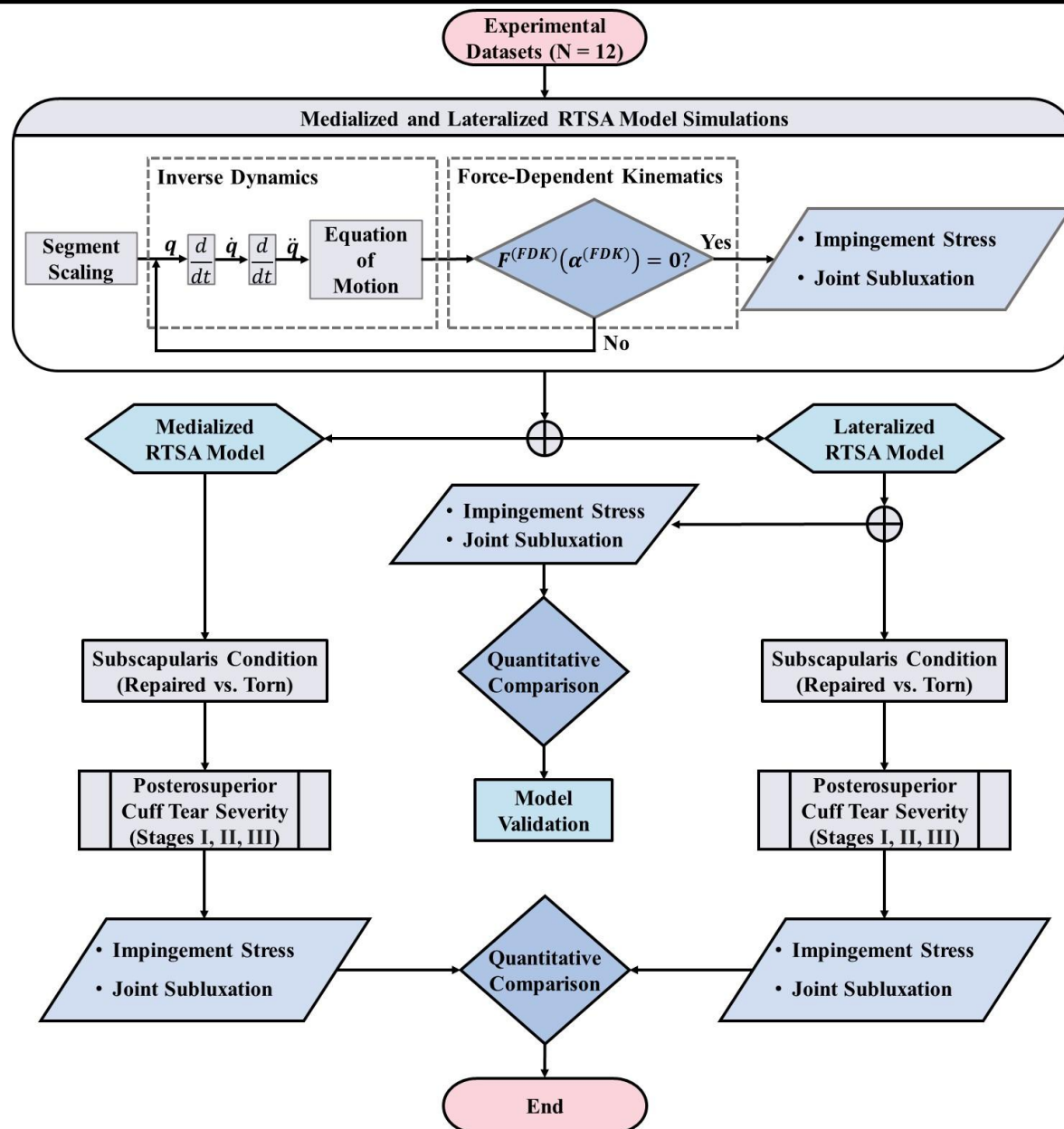
[13] Franceschetti et al., *Int Orthop.*, 2019

[15] Johnson et al., *J Shoulder Elbow Surg.*, 2021



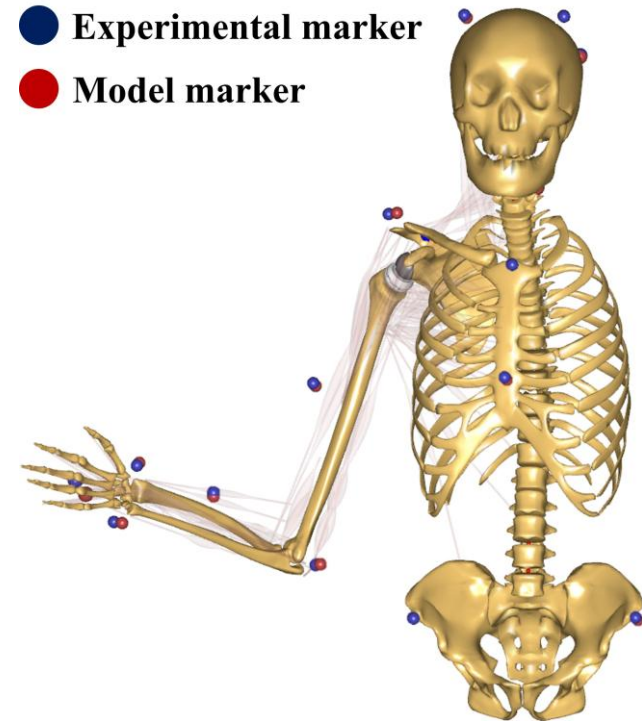
## *Purpose of the study*

To compare **the effects of medialized and lateralized RTSA on impingement stress and joint subluxation**, based on subscapularis integrity and RCT severity.



- **Experimental Protocol**

- **Twelve males** (age:  $24.7 \pm 2.3$  years, weight:  $76.8 \pm 7.9$  kg, height:  $174.7 \pm 6.1$  cm).
- Marker placements<sup>16</sup>: clavicle, head, humerus, right hand, scapula, and thorax (Fig. 22).
- **45° of external rotation (ER)** from the neutral position (Fig. 8).



**Fig. 8** External rotation.

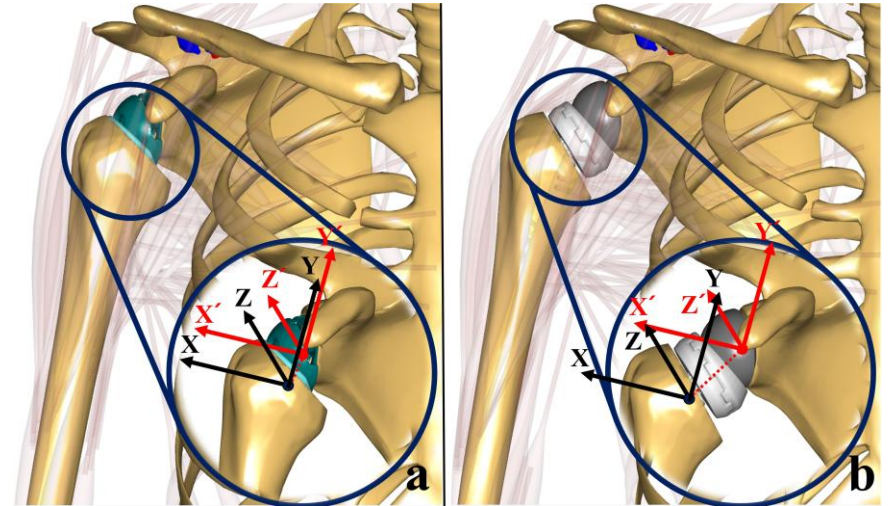
[16] Lee et al., *Front Bioeng Biotechnol.*, 2023

- **Musculoskeletal Modeling**

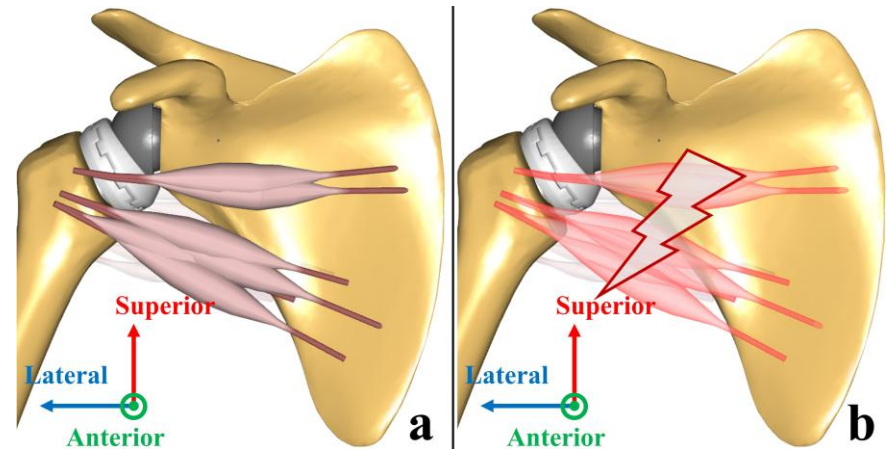
- **Medialized RTSA model**  
(Lima Corp., Italy) (Fig. 9a).

- **Lateralized RTSA model**  
(Corentec Co., Ltd.,  
Republic of Korea) (Fig. 9b).

- **Subscapularis-repaired**  
and **subscapularis-torn**  
models (Fig. 10a and b).



**Fig. 9a** medialized and **b** lateralized RTSA models.



**Fig. 10a** subscapularis-repaired and **b** subscapularis-torn models.

- ***Musculoskeletal Modeling***

- **Impingement stress** between the **posteroinferior scapular neck** (cortical bone) and the **humeral liner** (polyethylene insert), as follows:

$$F_i = P_v \times V_i \quad \dots (1)$$

$$V_i = A_i \times d_i \quad \dots (2)$$

$$P_v = \left( \frac{(1 + \nu_1)(1 - 2\nu_1)h_1}{(1 - \nu_1)E_1} + \frac{(1 + \nu_2)(1 - 2\nu_2)h_2}{(1 - \nu_2)E_2} \right)^{-1} \quad \dots (3)$$

$$\sigma_i = \frac{F_i}{A_i} \quad \dots (4)$$

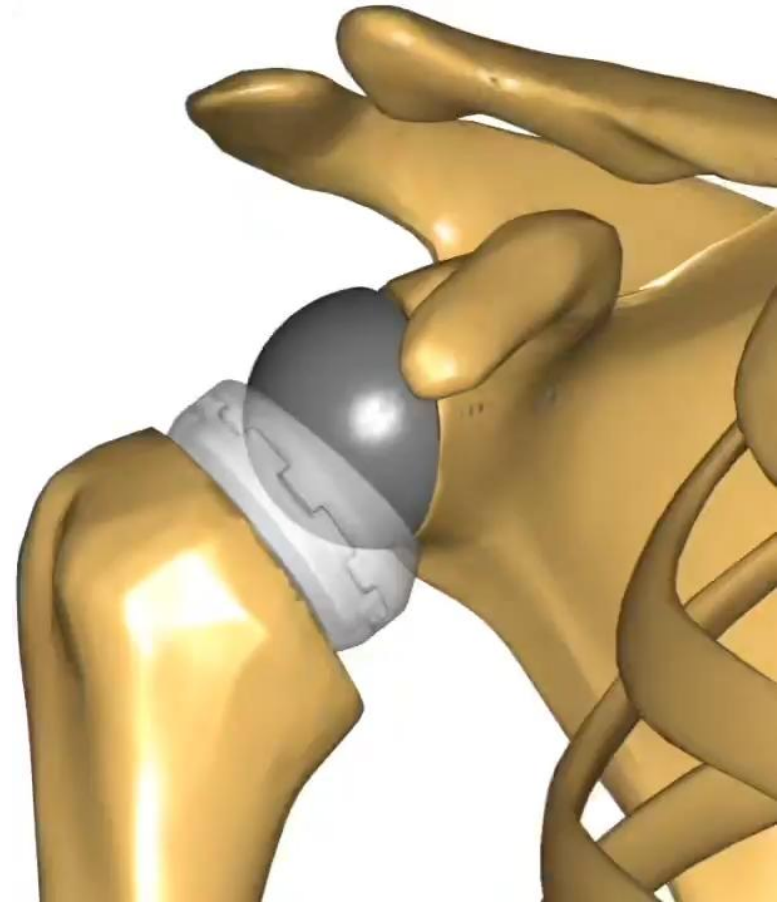
where  $F_i$  is the impingement force at the  $i$ -th vertex;  $P_v$  is the contact pressure module;  $V_i$  is the penetration volume;  $A_i$ ;  $\sigma_i$  is the impingement stress. The pressure module was calculated as  $3.55e^{11}$  N/m<sup>3</sup> in medialized RTSA and  $3.93e^{11}$  N/m<sup>3</sup> in lateralized RTSA [17].

[17] Lee et al., *Bone Joint Res.*, 2026



- ***Musculoskeletal Modeling***

- **Scapular notching-related impingement stress (MPa):** obtained by dividing the contact force by contact area.
- **Joint subluxation<sup>18</sup> (mm):** quantified as the sum of the square roots of the three-dimensional joint translations between the CORs of the glenosphere and humeral liner.

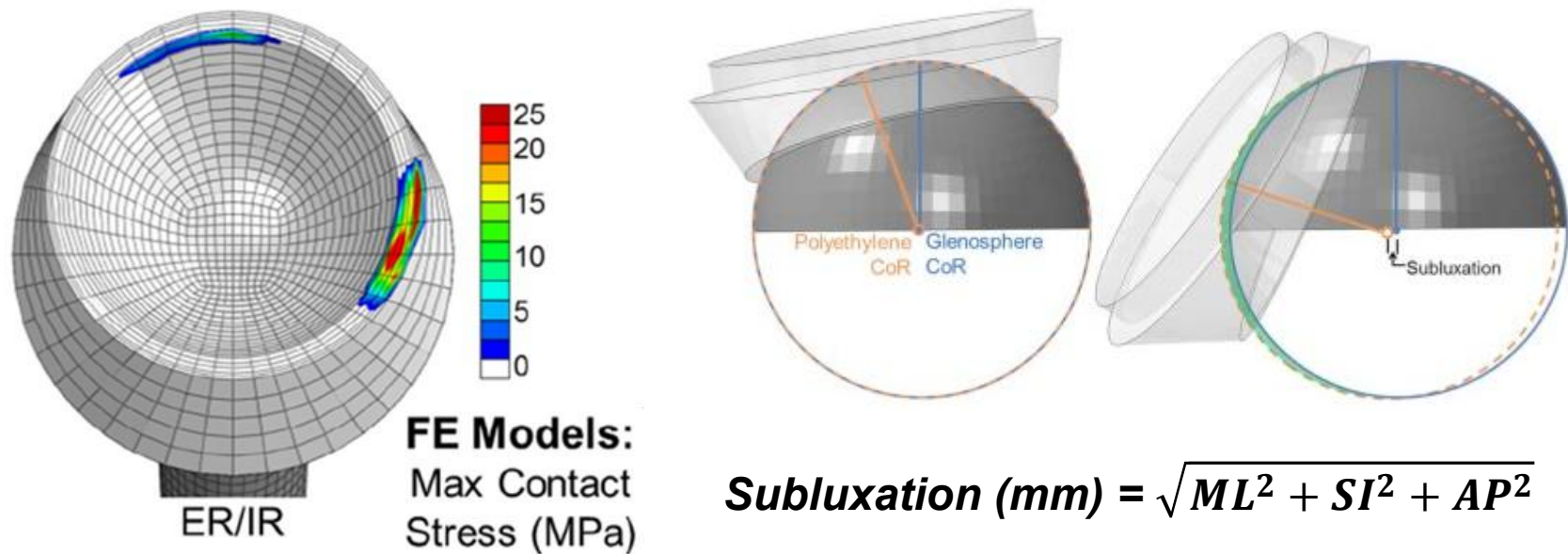


**Fig. 7** Impingement and joint subluxation.

[18] Permeswaran et al., *J Shoulder Elbow Surg.*, 2017

## • Model Validation

- Comparing **impingement stress** and **joint subluxation** against results from a validated finite element model.<sup>18</sup>

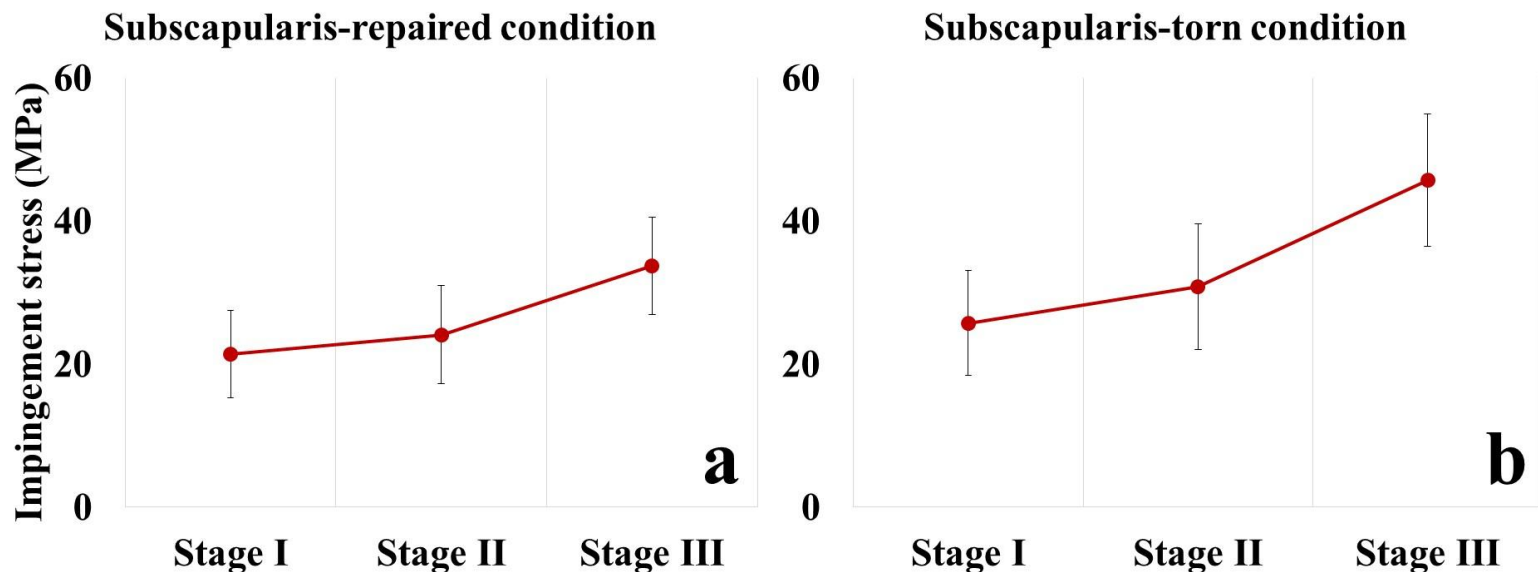


**Fig. 11** Impingement stress and joint subluxation at 45° of external rotation from a previously validated finite element model (Wright Tornier, USA) [18].

[18] Permeswaran et al., *J Shoulder Elbow Surg.*, 2017

## • *Model Validation (Results)*

- The predicted range of peak impingement stress (**21.4 to 45.7 MPa**) (Fig. 12).
- A previously reported value of **25 MPa** [18].

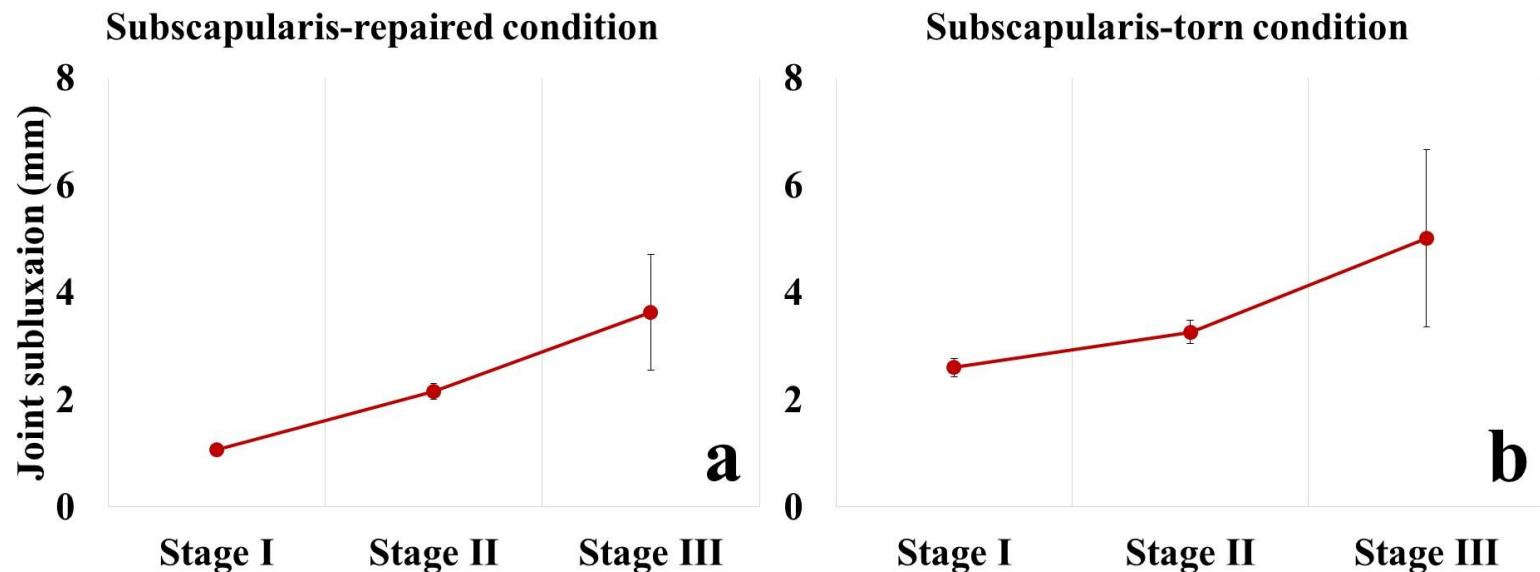


**Fig. 12** Peak impingement stress under **a** subscapularis-repaired and **b** subscapularis-torn conditions, based on the three stages of posterosuperior cuff tear severity.

[18] Permeswaran et al., *J Shoulder Elbow Surg.*, 2017

## • *Model Validation (Results)*

- The predicted range of peak joint subluxation (**1.1 to 5.0 mm**) (Fig. 13).
- A previously reported value of **7.6 mm** [18].

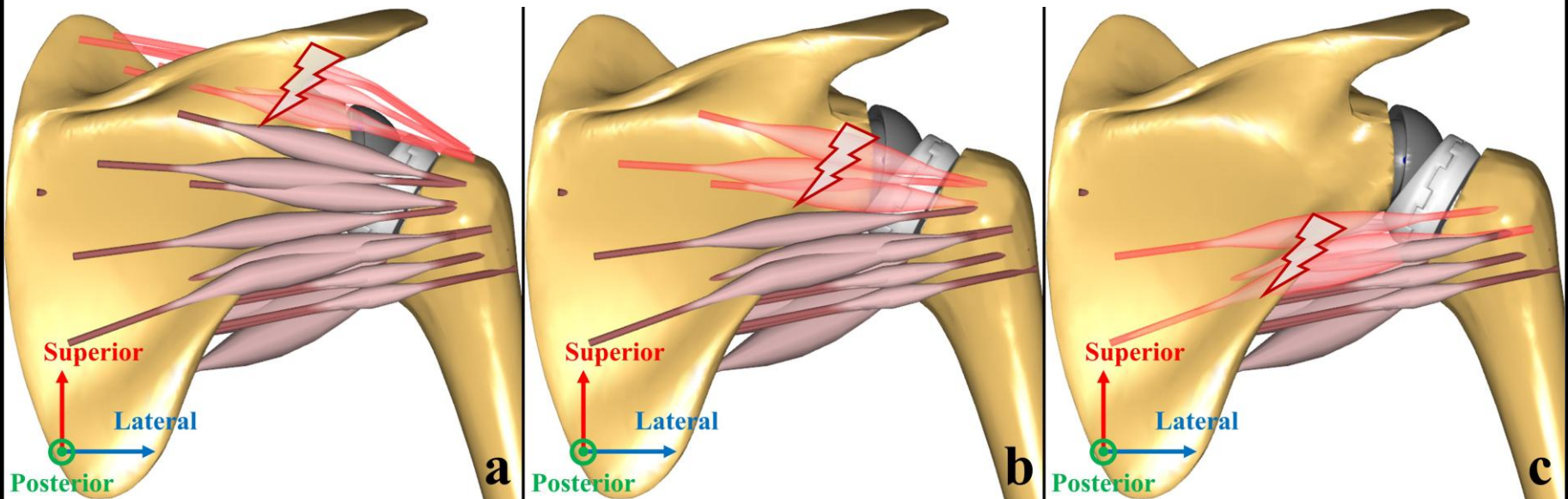


**Fig. 13** Peak joint subluxation under **a** subscapularis-repaired and **b** subscapularis-torn conditions, based on the three stages of posterosuperior cuff tear severity.

[18] Permeswaran et al., *J Shoulder Elbow Surg.*, 2017

- **Simulations**

- The **medialized** and **lateralized RTSA models** under **subscapularis-repaired** and **subscapularis-torn** conditions.
- **Three stages of posterosuperior cuff tear severity** (Fig. 14).



**Fig. 14a** Stage I: isolated supraspinatus bundle tears, **b** Stage II: Stage I + superior bundle tears of the infraspinatus, and **c** Stage III: complete posterosuperior cuff tears.



- **Statistical Analysis**

- A three-way ANOVA to assess the effects of **RTSA design** (medialized vs. lateralized), **subscapularis condition** (repaired vs. torn), and **cuff tear severity** (Stages I to III).
- Post hoc paired t-tests with false discovery rate correction for **peak impingement stress** and **peak subluxation**, significance level = 0.05.



**Fig. 7** Impingement and joint subluxation.

## • RTSA Design (Medialized vs. Lateralized)

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

- The peak **impingement stress** and **joint subluxation** were consistently higher in **medialized RTSA** than in lateralized RTSA across **all conditions**.

## • *Subscapularis Condition (Repaired vs. Torn)<sup>d</sup>*

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

- Subscapularis repair in Stages I to III significantly reduced peak impingement stress by **14.1 to 18.6% in medialized RTSA** and by **16.7 to 26.2% in lateralized RTSA**.

## • *Subscapularis Condition (Repaired vs. Torn)<sup>d</sup>*

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

- The same repair stages also significantly decreased peak joint subluxation by **14.7 to 22.4% in medialized RTSA** and by **27.5 to 58.9% in lateralized RTSA**.

## • Cuff Tear Severity (Stages I to III)<sup>a</sup> (I vs. II), <sup>b</sup> (II vs. III), <sup>c</sup> (I vs. III)

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

- Relative to Stage I, peak impingement stress in **medialized RTSA** significantly increased by **19.7%** and **16.7%** in **Stage II**, and by **55.6%** and **59.9%** in **Stage III**, in subscapularis-repaired and -torn conditions, respectively.



## • Cuff Tear Severity (Stages I to III)<sup>a</sup> (I vs. II), <sup>b</sup> (II vs. III), <sup>c</sup> (I vs. III)

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

➤ In lateralized RTSA, corresponding increases were **12.5%** and **19.9%** in Stage II, and **57.4%** and **77.8%** in Stage III.

## • Cuff Tear Severity (Stages I to III)<sup>a</sup> (I vs. II), <sup>b</sup> (II vs. III), <sup>c</sup> (I vs. III)

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

- Compared to Stage I, peak joint subluxation in **medialized RTSA** significantly increased by **11.7% and 18.4% in Stage II**, and by **62.0% and 56.0% in Stage III**, under the repaired and torn conditions, respectively.

## • Cuff Tear Severity (Stages I to III)<sup>a</sup> (I vs. II), <sup>b</sup> (II vs. III), <sup>c</sup> (I vs. III)

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

➤ In lateralized RTSA, increases were 101.0% and 25.5% in Stage II, and 239.5% and 92.6% in Stage III.

## • Interaction Effects

**Table 1** Comparison of peak impingement stress and joint subluxation.

Variable	Subscapularis Condition	Stage	Medialized RTSA	Lateralized RTSA	P-value
Impingement stress (MPa)	Repaired	I	42.0 ± 7.9	21.4 ± 6.1	< 0.001
		II	50.3 ± 9.8 <sup>a</sup>	24.1 ± 6.9 <sup>a</sup>	< 0.001
		III	65.3 ± 12.0 <sup>b, c</sup>	33.7 ± 6.8 <sup>b, c</sup>	< 0.001
	Torn	I	50.2 ± 9.7 <sup>d</sup>	25.7 ± 7.3 <sup>d</sup>	< 0.001
		II	58.6 ± 11.3 <sup>a, d</sup>	30.9 ± 8.8 <sup>a, d</sup>	< 0.001
		III	80.2 ± 14.6 <sup>b, c, d</sup>	45.7 ± 9.3 <sup>b, c, d</sup>	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5 <sup>a</sup>	2.1 ± 0.1 <sup>a</sup>	< 0.001
		III	9.7 ± 1.2 <sup>b, c</sup>	3.6 ± 1.1 <sup>b, c</sup>	< 0.001
	Torn	I	7.2 ± 0.5 <sup>d</sup>	2.6 ± 0.2 <sup>d</sup>	< 0.001
		II	8.6 ± 0.6 <sup>a, d</sup>	3.3 ± 0.2 <sup>a, d</sup>	< 0.001
		III	11.3 ± 0.8 <sup>b, c, d</sup>	5.0 ± 1.7 <sup>b, c, d</sup>	< 0.001

- Significant interactions were observed between **RTSA design** and **cuff tear severity** for peak **impingement stress** ( $P = 0.027$ ) and **joint subluxation** ( $P < 0.001$ ).

- ***Impingement and Subluxation***

- **Lateralized RTSA** more effectively reduces the **impingement stress** and **subluxation** during ER.
- **Subscapularis repair** further enhances these benefits in **lateralized RTSA**, across **all RCT conditions**.
- **Joint instability** is commonly associated with **impingement** and arises from an **unbalanced force couple** due to **anterior or posterior cuff deficiency**.<sup>19,20</sup>
- ➡ These findings support **lateralized RTSA with subscapularis repair as an effective strategy** for mitigating impingement and improving joint stability.

[19] Boileau, *Orthop Traumatol Surg Res.*, 2016

[20] Macken et al., *Bone Joint J.*, 2023



- ***Conclusion***

- **Lateralization and subscapularis repair in RTSA** can mitigate impingement and improve joint stability in patients with **posterosuperior cuff deficiencies**.

- ***Clinical Implication***

- These findings can inform **surgical decisions** regarding **implant design** and **subscapularis repair** to reduce the **risk of scapular impingement** and **joint subluxation**.

# Upcoming Events: ORS & WCB



**Donghwan Lee**

PhD Candidate (**Aug 2026**)

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[www.linkedin.com/in/donghwanlee0513](https://www.linkedin.com/in/donghwanlee0513)



***Poster #: 606 (Shoulder and Elbow)***

***Time: March 28 (Saturday), 6:30–7:15 PM***



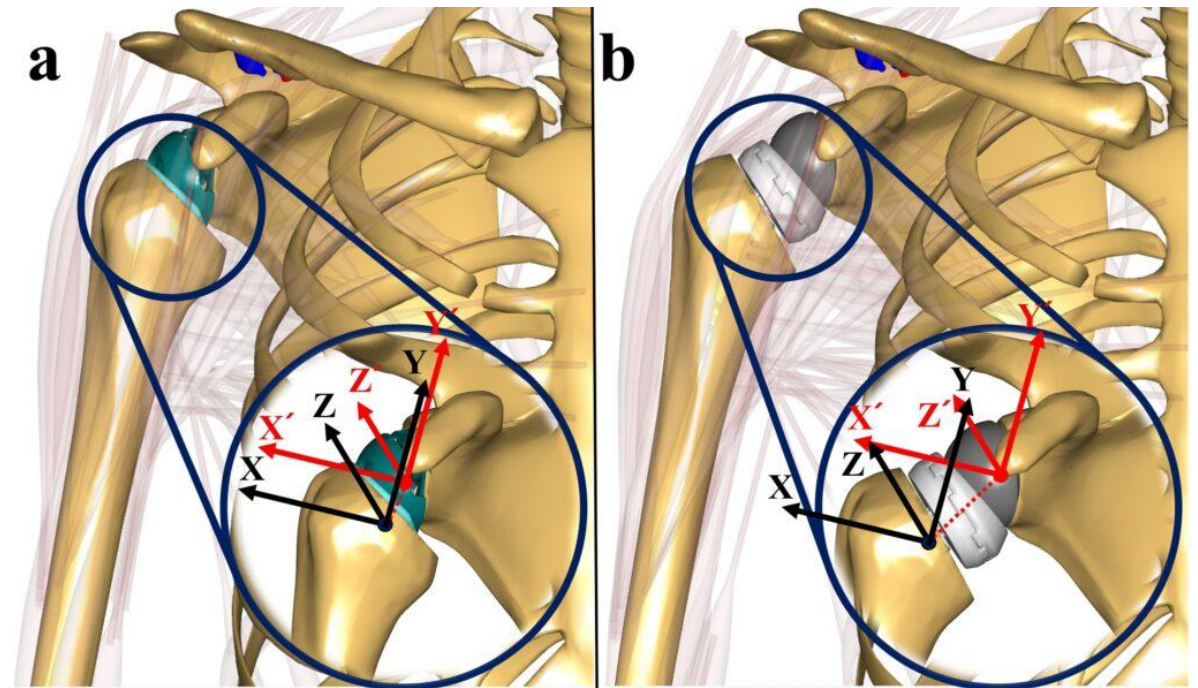
## **10<sup>th</sup> World Congress of Biomechanics**

**JULY 11 – 15, 2026 | VANCOUVER, CANADA**

***Poster #: 1476 (Orthopaedic Biomechanics)***

***Time: July 14 (Tuesday), 10:30–11:30 AM***

# Subscapularis Integrity and Posterosuperior Cuff Tear Severity Affect Scapular Impingement and Joint Stability in Reverse Total Shoulder Arthroplasty: Medialization vs. Lateralization



# Resources

- [www.anybodytech.com](http://www.anybodytech.com)
  - Events, Webcast library, Publication list, ...
- [www.anyscript.org](http://www.anyscript.org)
  - Wiki, Blog, Repositories, Forum
- **Events**
  - ORS 2026 (Orthopaedic Research Society)
    - March 27 – 31, 2026; Charlotte, North Carolina, USA
  - WCB 2026 (10<sup>th</sup> World Congress of Biomechanics)
    - July 11 – 15, 2026; Vancouver Canada

## Welcome to AnyScript.org

An open community for users of the AnyBody Modeling System and a

ORS 2026 – The annual meeting of the Orthopaedic Research Society


**Date:** March 27 – 31, 2026


**Location:** Charlotte, North Carolina

Let's meet at 2026 ORS annual meeting in Charlotte, North Carolina! Stop by the AnyBody Technology booth and let's talk musculoskeletal modeling and simulations.


If you want to book a dedicated meeting time, please reach out to us prior to the conference.

- Read more about the conference at the official website [here](#).






**Forum**



**GitHub Repositories**



**Model documentation**

WCB 2026 – 10th World Congress of Biomechanics


**Date:** July 11 – 15, 2026

**Location:** Vancouver, Canada

Let's meet at 2026 WCB Congress of Biomechanics in Vancouver, Canada! Stop by the AnyBody Technology booth and let's talk musculoskeletal modeling and simulations.

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webcasts

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### Publication list

Resources / Publication list

**Industry**

sports exoskeleton work place ergonomics orthopedics defense aerospace automotive consumer products furniture

**Research area**

gait methods validation animal sensitivity analysis rehab seating fea AnyBody Tech selected

**Body part**

knee lower extremity foot spine upper extremity hand shoulder hip mandible wrist trunk elbow ankle leg

**NEW**

**Year 1271 Publications**

2026	Li Y, Liu J, Zhang B, Zhang F, Tian Z, Zhang J. (2026). "Biomechanical analysis of femoral stress response during squatting: A combined multibody dynamics and finite element approach". J. Orthop., vol. 73, pp. 198-205. [ DOI, WWW ]	NEW orthopedics leg
2026	Lunn DE, De Pieri E, Chapman GJ, Lund ME, Ferguson SJ, Redmond AC. (2026). "Motion capture dataset of 137 post-operative total hip replacement patients performing activities of daily living". Sci. Data. [ DOI, WWW ]	NEW orthopedics hip gait
2026	Ma J, Ye B, Zhang B, He Z, Liu G, Sheng C, Zhu H, Meng G. (2026). "Impact of exercise-induced fatigue on the risk of stress fractures in the tibia during smash landing in female badminton players". Sci. Rep., [ DOI, WWW ]	NEW orthopedics sports fea
2026	Liew BX, Hu J, Altai Z, Soliman A, Gao L, McDonnell S, Guo W, Maas S, Cortes N. (2026). "Ranking hip and knee joint contact forces during high-impact activities in high-functioning adults after hip or knee arthroplasty". medRxiv. [ DOI ]	NEW orthopedics hip lower extremity
2026	Zhang L, Zhu M, Jiang S, Jiang B. (2026). "Design and evaluation of a passive knee-ankle exoskeleton for walking and squatting: a musculoskeletal simulation study". Med. Biol. Eng. Comput., [ DOI, WWW ]	NEW exoskeleton ankle lower extremity gait
2026	Gregory T, Mohajer N. (2026). "Design and model-based evaluation of a novel assistive neck exoskeleton system for aircrews safety". Proc Inst Mech Eng Part C, [ DOI ]	NEW aerospace defense
2026	Lee D, Jung S, Shin CS, Oh JH. (2026). "Do subscapularis integrity and posterosuperior cuff tear severity affect scapular impingement and joint stability during external rotation in lateralized reverse total shoulder arthroplasty?". Bone Joint Res., vol. 2026, pp. 2. [ DOI ]	NEW orthopedics shoulder
2026	Lee D, Oh JH, Lee J, Jung S, Kim N, Kim N, Shin CS. (2026). "Effect of Level of Posterosuperior Cuff Tear Severity on Joint Contact Mechanics in Reverse Total Shoulder Arthroplasty: A Simulation Study". Ann. Biomed. Eng., [ DOI ]	NEW orthopedics shoulder
2026	Klooster LT, Tzanetis P, Janssen D, Bitter T, Wolterink JM. (2026). "Neural network surrogates for musculoskeletal models: An application to implant alignment in total knee arthroplasty". J. Biomech., pp. 113214. [ DOI, WWW ]	NEW orthopedics knee methods
2026	Fontana C, Laiola N, Naddeo A, Califano R. (2026). "Musculoskeletal and ergonomic demands of the pumping maneuver in Laser-class sailing: An integrated biomechanical analysis". Preprints. [ DOI, WWW ]	NEW

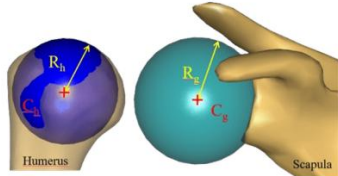
Publications list

### Webcast library

Resources / Webcast library

All Aerospace All use cases Animal Assistive devices Automotive Consumer Ergonomics Exoskeletons

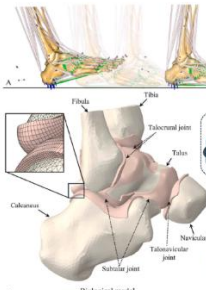
Product presentations Sports Universities Workplace ergonomics



16. January 2026

**Sphere-on-Sphere model: shoulder model including humeral head translation**

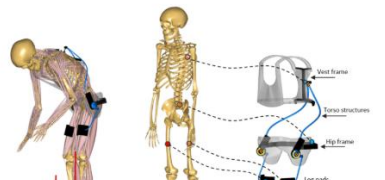
Margaux Peixoto, PhD Candidate at École de Technologie Supérieure Montreal

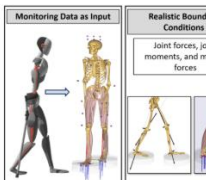


18. December 2025

**Evaluation of a uni-implant during gait musculoskeletal ar element modelling**

Sami Al Shweiki, MSc in Biomedical Engineering, Khalifa University





Webcasts list



# Questions

## Meet us

- Send email to [sales@anybodytech.com](mailto:sales@anybodytech.com)

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## Presentation questions

- Send email to [dsc@anybodytech.com](mailto:dsc@anybodytech.com)

Thank you for your  
attention!

