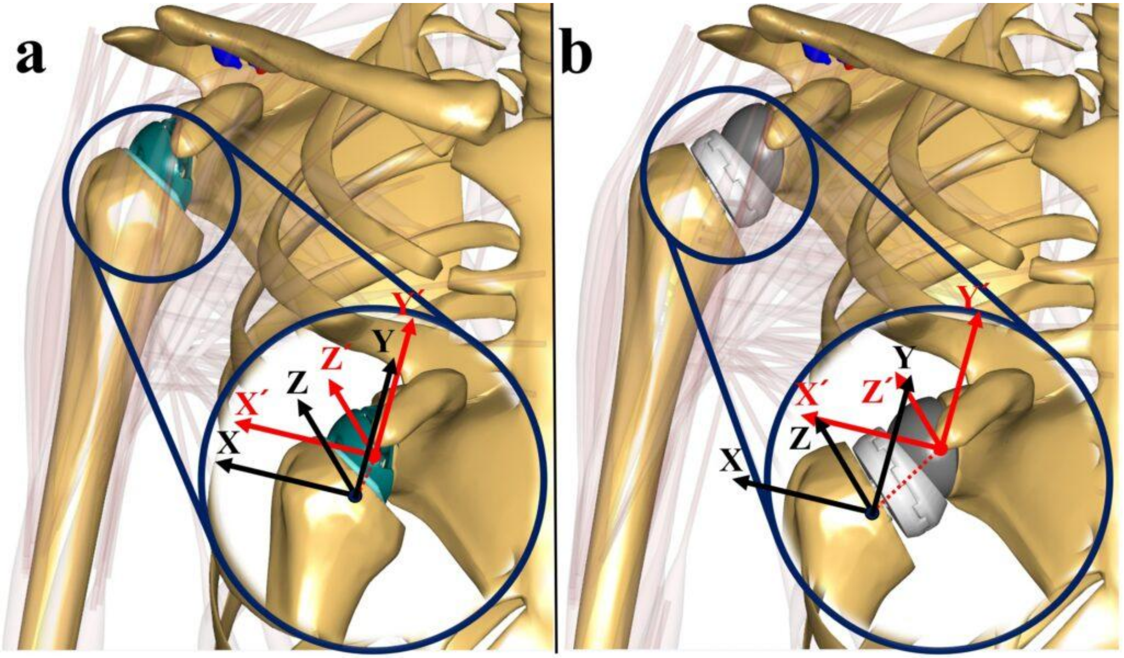
AnyBody Technology

March 17, 2026

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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Outli

- Intr … ystem

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

@BoneJointRes

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Cite this article: Bone Joint Res 2026;15(2):135–147.

DOI: 10.1302/2046-3758.152.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 conditions. Additionally, with subscapularis repair, posterior deltoi… increased more markedly with tear severity in lateralized RTSA (from 2.6% ($p = 0.007$) … ($p < 0.001$)) than in medialized RTSA (from 4.7% to 784.5%, both $p < 0.001$).

Conclusion
Lateralizing RTSA and repairing the subscapularis can significantly re… related impingement, improve joint stability, and support ER torqu… posterior deltoid force in patients with posterosuperior cuff tears… insights for surgical planning, supporting the use of a late… repair to reduce the risk of scapular notching and joint s… generation.

Presenter

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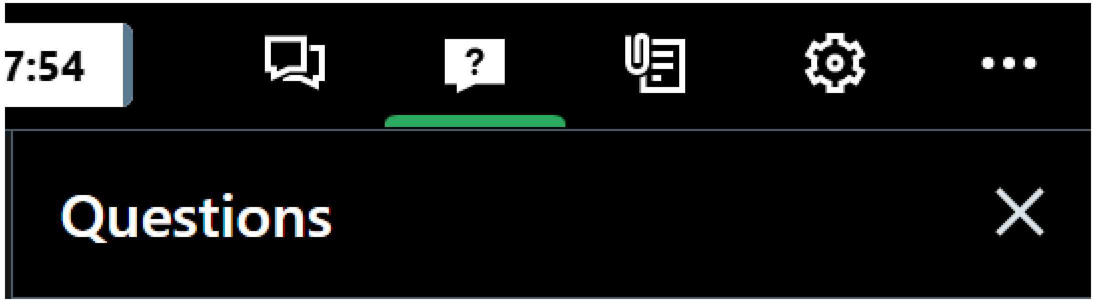
Control Panel

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

- Motion
- Forces

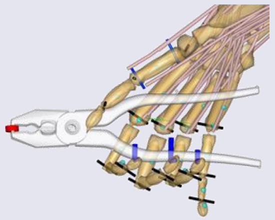
AnyBody Modeling System

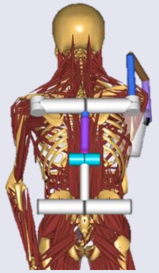
OUTPUT • Internal Body Loads

- Joint reaction forces
- Muscle forces
- Muscle activity
- Metabolic energy + fatigue

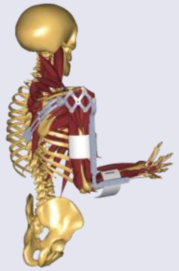
Motion analysis

Product design and optimization

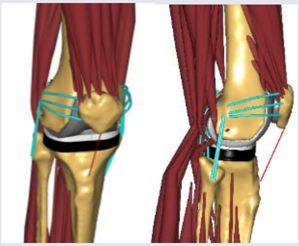




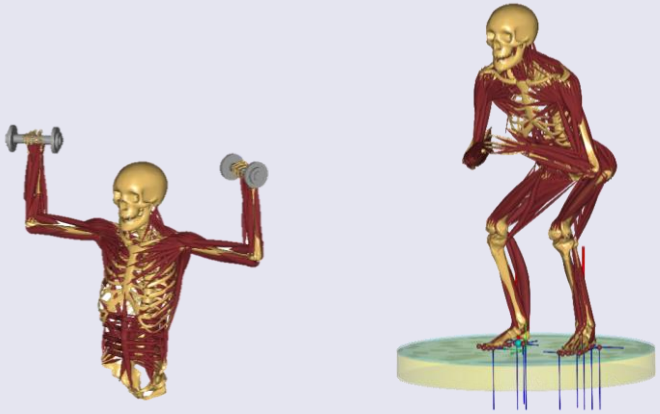
Ergonomics with/without exoskeletons



AnyBody Modeling System



Orthopedics and Rehabilitation



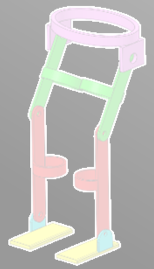
Sports

Automotive

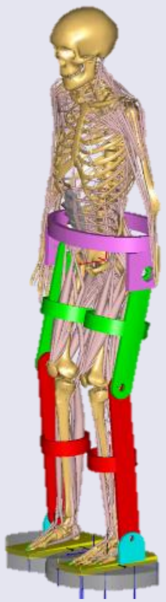
Workflow

Motions and forces

Body model

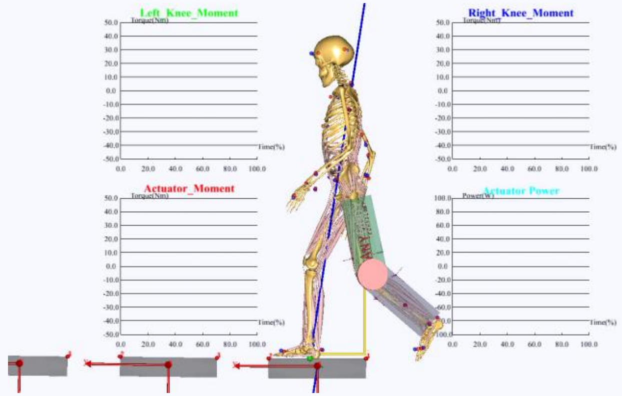


Environment model



Simulation

Inverse dynamics
Muscle recruitment



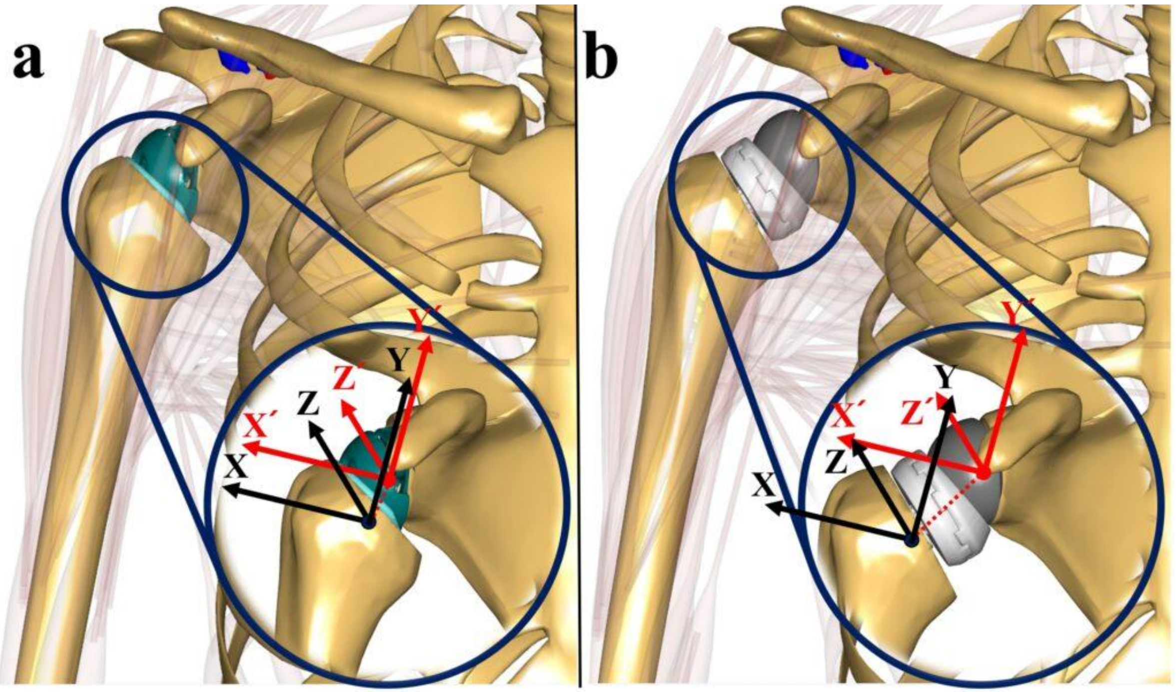
Internal body loads:

- Muscle forces
- Joint forces

Design Optimization

Post Processing
(e.g. Finite Element tools)

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

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Biomechanics and Biomedical Engineering Laboratory

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

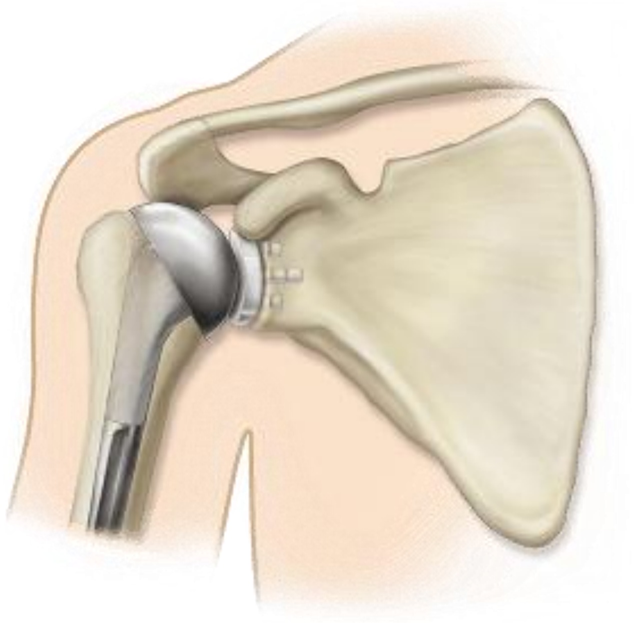


Fig. 1 Anatomic total shoulder arthroplasty (Exactech Equinoxe).

➡ **In anatomic TSA, rotator cuff tears (RCTs) can lead to joint instability due to reduced joint compression.**[2]

[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).[3]
- Improving **joint stability** compared to anatomic TSA.[4]
- Recruiting **more fibers of the deltoids** to act as abductors.[4]

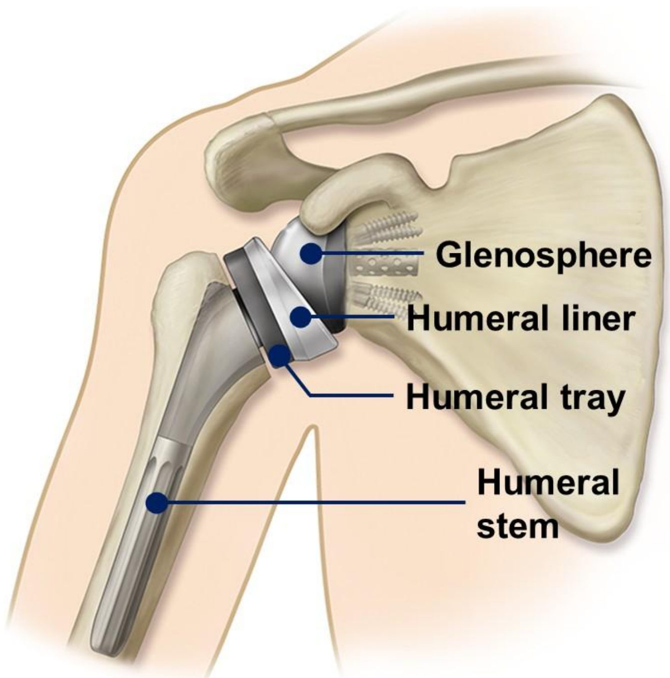


Fig. 2 Reverse total shoulder arthroplasty (Exactech Equinoxe).

➡ **However, even in RTSA, massive RCTs can still increase the risk of joint instability or dislocation.**[5,6]

[3] Boileau et al., *J Shoulder Elbow Surg.*, 2006
[4] Boileau et al., *J Shoulder Elbow Surg.*, 2005
[5] Wall et al., *J Bone Jt Surg.*, 2007
[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009

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

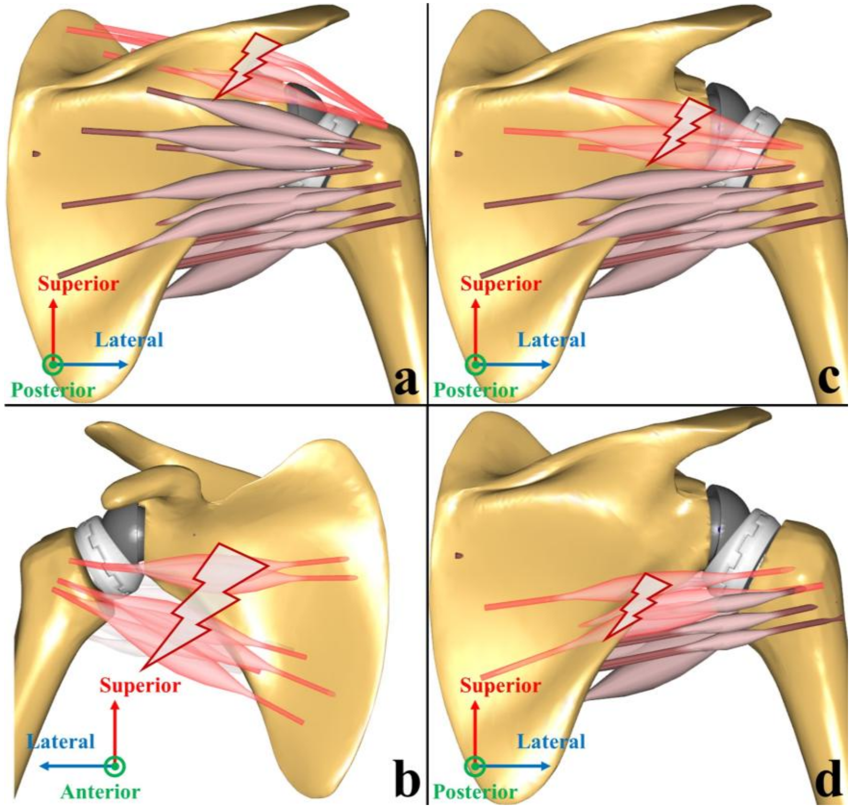


Fig. 3 Cuff conditions: **a** supraspinatus tear, **b** subscapularis tear, **c** partial infraspinatus tear, and **d** complete infraspinatus tear.

[1] Boileau et al., *J Shoulder Elbow Surg.*, 2006
[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009
[7] Gerber et al., *J Bone Jt Surg.*, 2000
[8] Cofield et al., *J Bone Jt Surg.*, 2001

1. Supraspinatus

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

➡ **This tear increases muscle forces in the subscapularis and infraspinatus.**[10]

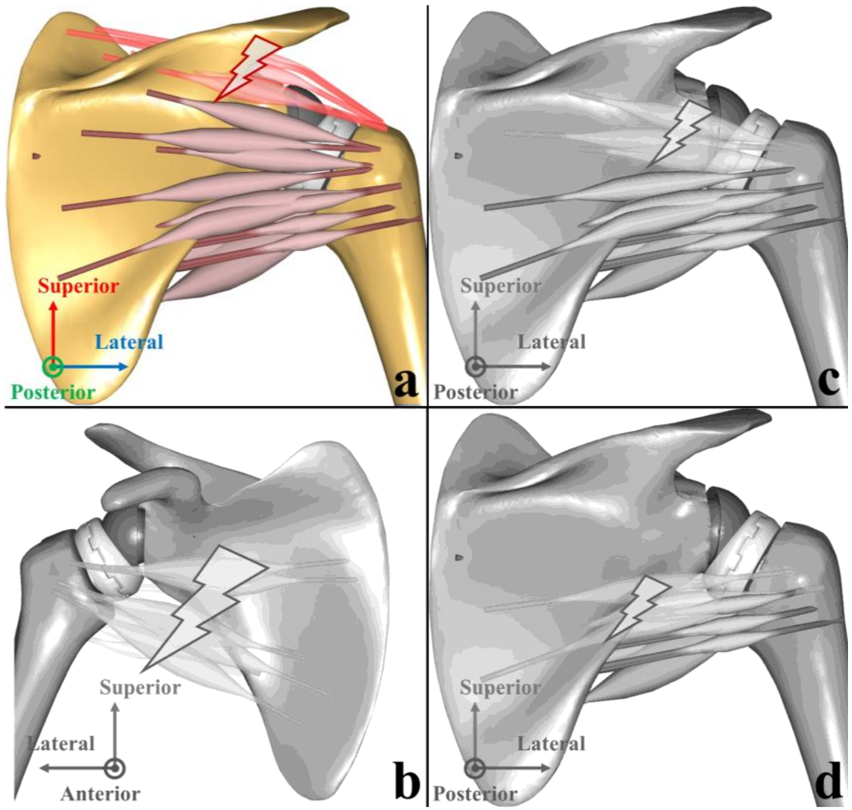


Fig. 3 Cuff conditions: **a** supraspinatus tear, **b** subscapularis tear, **c** partial infraspinatus tear, and **d** complete infraspinatus tear.

[1] Boileau et al., *J Shoulder Elbow Surg.*, 2006
[6] Edwards et al., *J Shoulder Elbow Surg.*, 2009
[9] Sirveaux et al., *Orthop Traumatol Surg Res.*, 2010
[10] Ackland et al., *J Orthop. Res.*, 2019

2. **Infraspinatus**

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

This tear reduces joint compression, potentially leading to joint instability.[11]

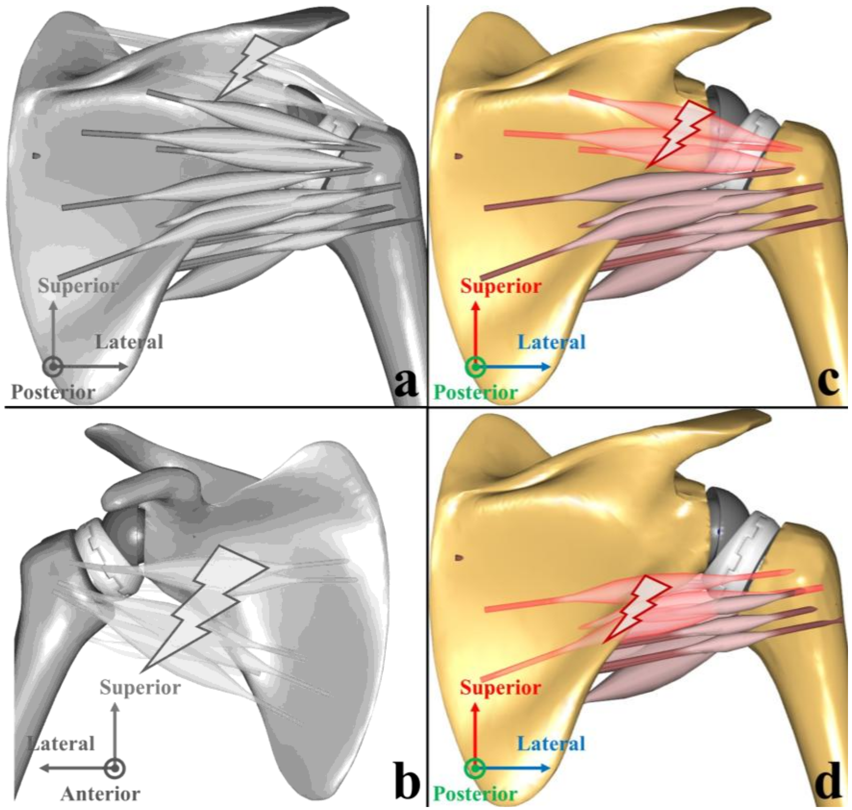


Fig. 3 Cuff conditions: **a** supraspinatus tear, **b** subscapularis tear, **c** partial infraspinatus tear, and **d** complete infraspinatus tear.

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

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

3. Subscapularis

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

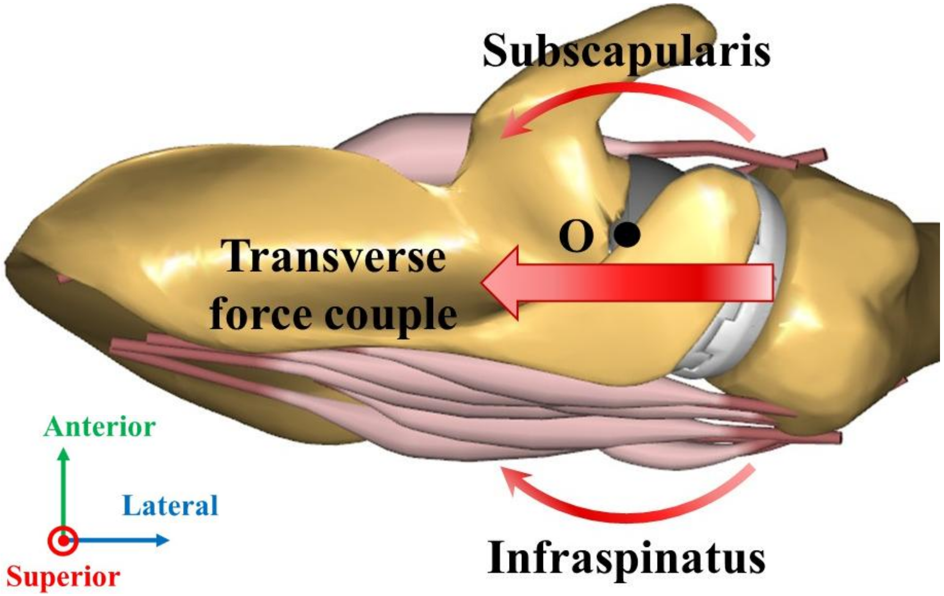


Fig. 4 Illustration of a transverse force couple between the subscapularis and infraspinatus.

➡ **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.[12]

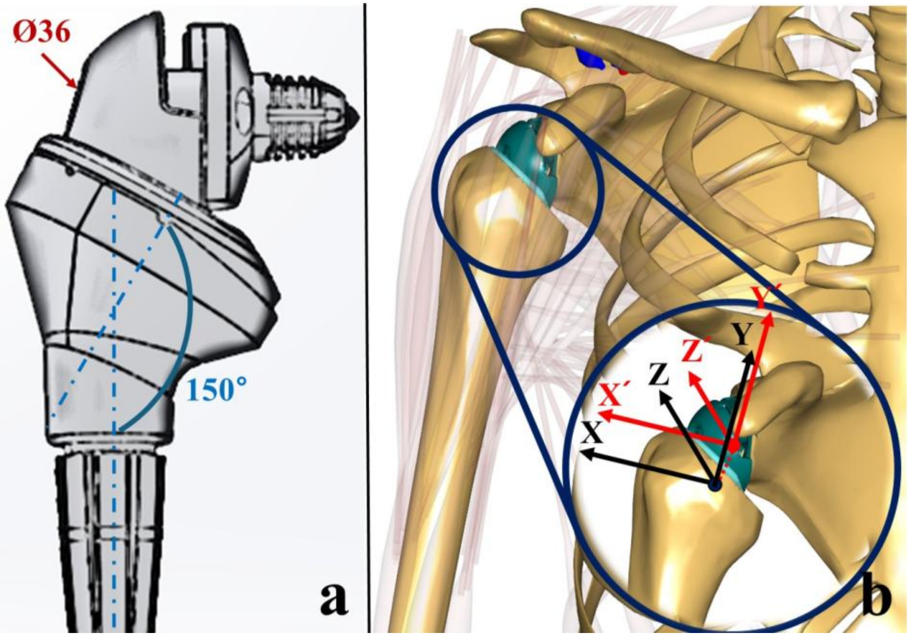


Fig. 5 Illustration of medialized reverse total shoulder arthroplasty.

→ **In medialized RTSA, subscapularis repair can reduce the risk of joint instability or dislocation.**[6,12]

[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.[12]

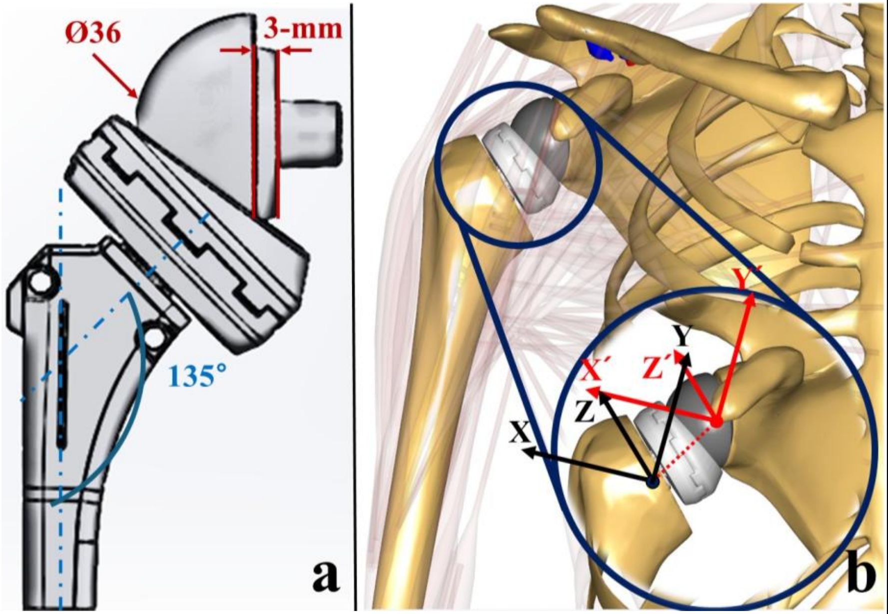


Fig. 6 Illustration of lateralized reverse total shoulder arthroplasty.

➡ **However, in lateralized RTSA, the effects of subscapularis repair remain controversial.**[12–15]

[12] De Fine et al., *Arch Orthop Trauma Surg.*, 2022
[13] Franceschetti et al., *Int Orthop.*, 2019
[14] Caceres et al., *Iowa Orthop J.*, 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).[14,15]
- **Cons:** no significant effect on **stability** or **dislocation**.[12,13]

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

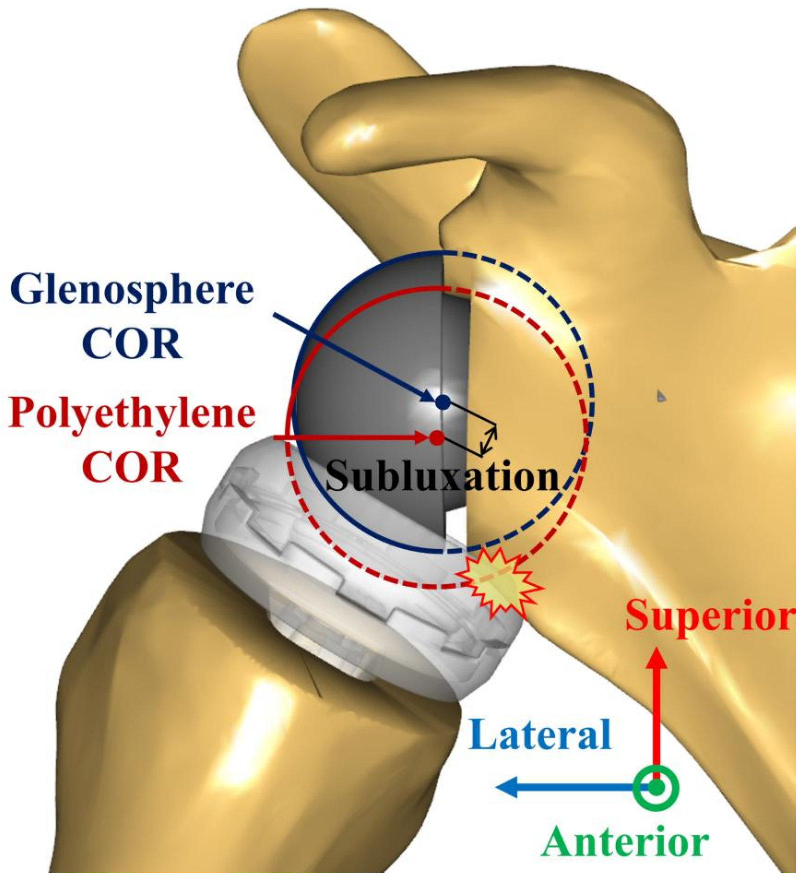


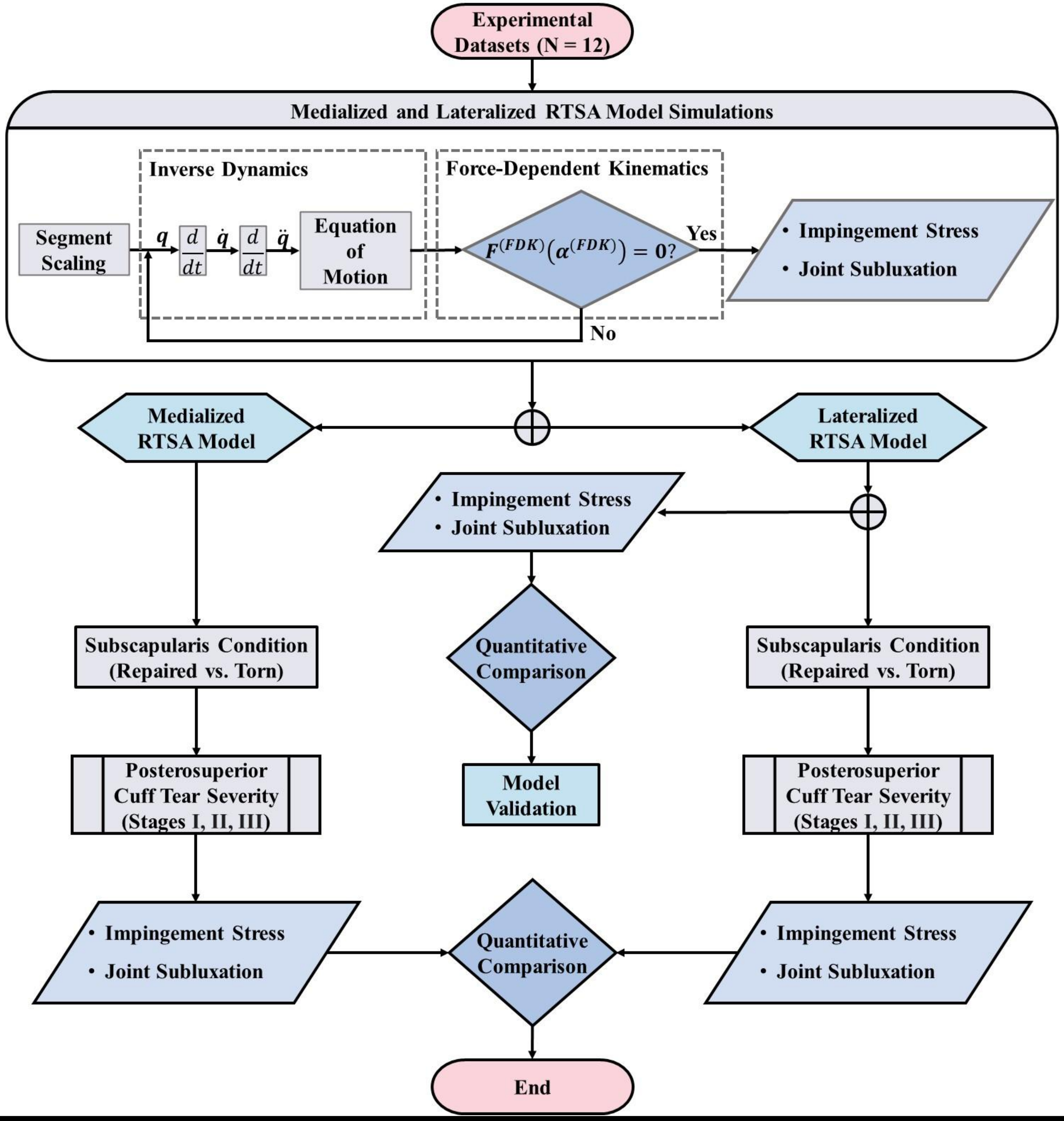
Fig. 7 Impingement and subluxation.

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

[12] De Fine et al., *Arch Orthop Trauma Surg.*, 2022
[13] Franceschetti et al., *Int Orthop.*, 2019
[14] Caceres et al., *Iowa Orthop J.*, 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 Datasets (N = 12)
Medialized and Lateralized RTSA Model Simulations
Inverse Dynamics
Force-Dependent Kinematics
Segment Scaling
q
d/dt
q̇
d/dt
q̈
Equation of Motion
$F^{(FDK)}(\alpha^{(FDK)}) = 0?$
Yes
No
• Impingement Stress
• Joint Subluxation
Medialized RTSA Model
Lateralized RTSA Model
• Impingement Stress
• Joint Subluxation
Quantitative Comparison
Model Validation
Subscapularis Condition (Repaired vs. Torn)
Subscapularis Condition (Repaired vs. Torn)
Posterosuperior Cuff Tear Severity (Stages I, II, III)
Posterosuperior Cuff Tear Severity (Stages I, II, III)
• Impingement Stress
• Joint Subluxation
Quantitative Comparison
• Impingement Stress
• Joint Subluxation
End

- ***Experimental Protocol***
  - **Twelve males** (age: 24.7 ± 2.3 years, weight: 76.8 ± 7.9 kg, height: 174.7 ± 6.1 cm).
  - Marker placements[16]: clavicle, head, humerus, right hand, scapula, and thorax (Fig. 22).
  - **45° of external rotation** (ER) from the neutral position (Fig. 8).

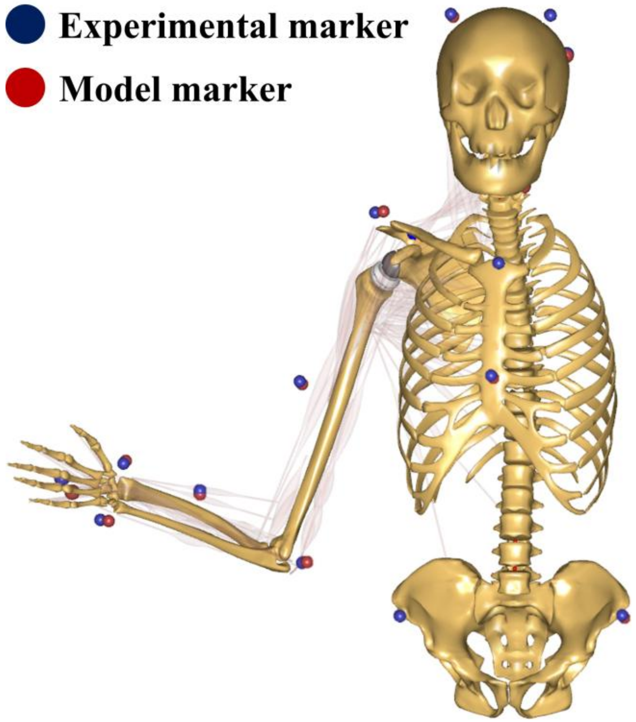


Fig. 8 External rotation.

[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).

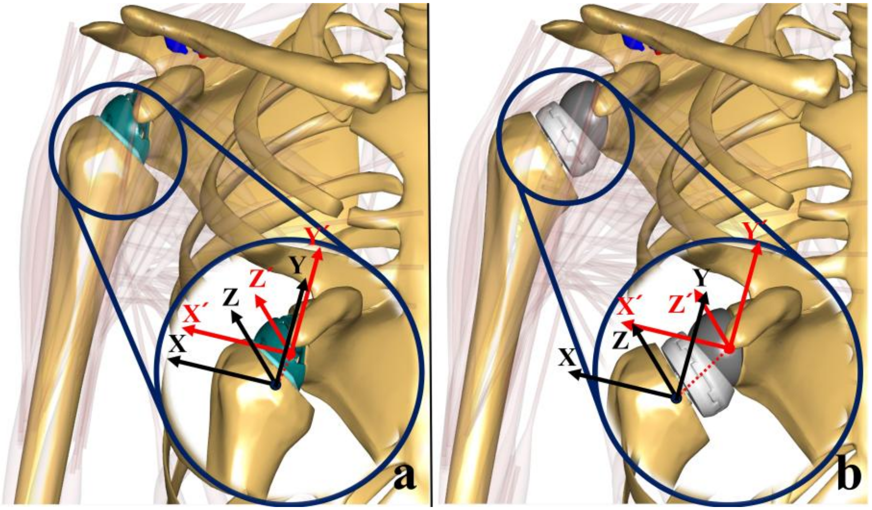


Fig. 9a medialized and **b** lateralized RTSA models.

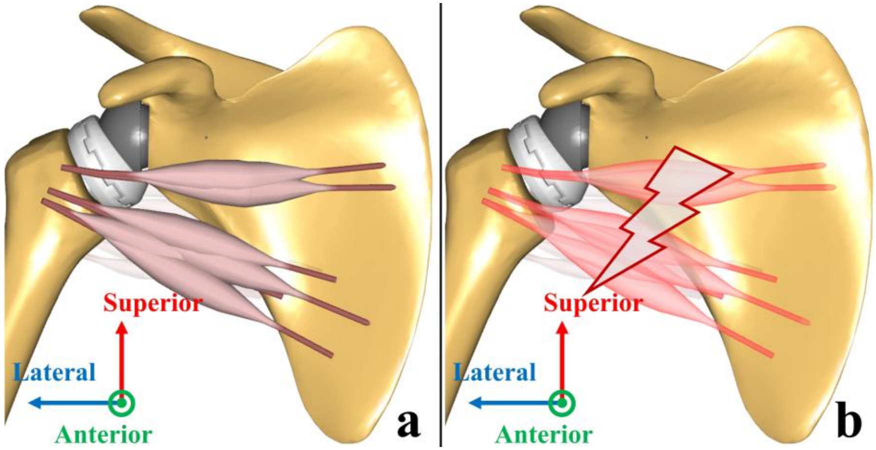


Fig. 10a subscapularis-repaired and **b** subscapularis-torn models.

- ***Musculoskeletal Modeling***

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

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

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

$$P_v = \left(\frac{(1+v_1)(1-2v_1)h_1}{(1-v_1)E_1} + \frac{(1+v_2)(1-2v_2)h_2}{(1-v_2)E_2} \right)^{-1} \quad \cdots (3)$$

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

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 ; σ_i is the impingement stress. The pressure module was calculated as 3.55e^{11} N/m^3 in medialized RTSA and 3.93e^{11} N/m^3 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[18] (mm):** quantified as the sum of the square roots of the three-dimensional joint translations between the CORs of the glenosphere and humeral liner.

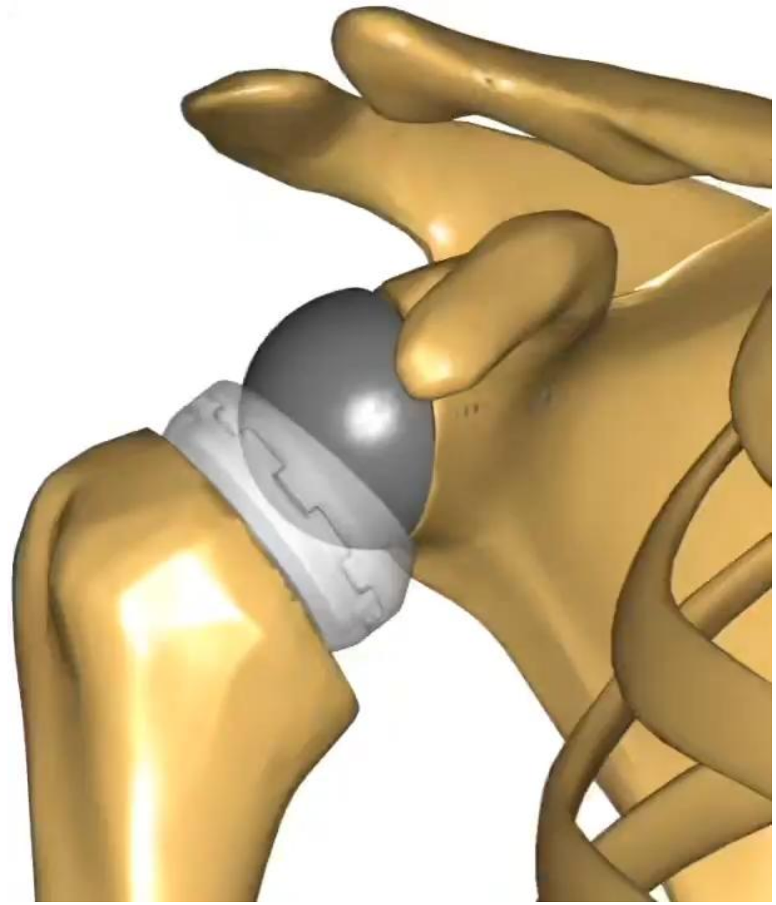
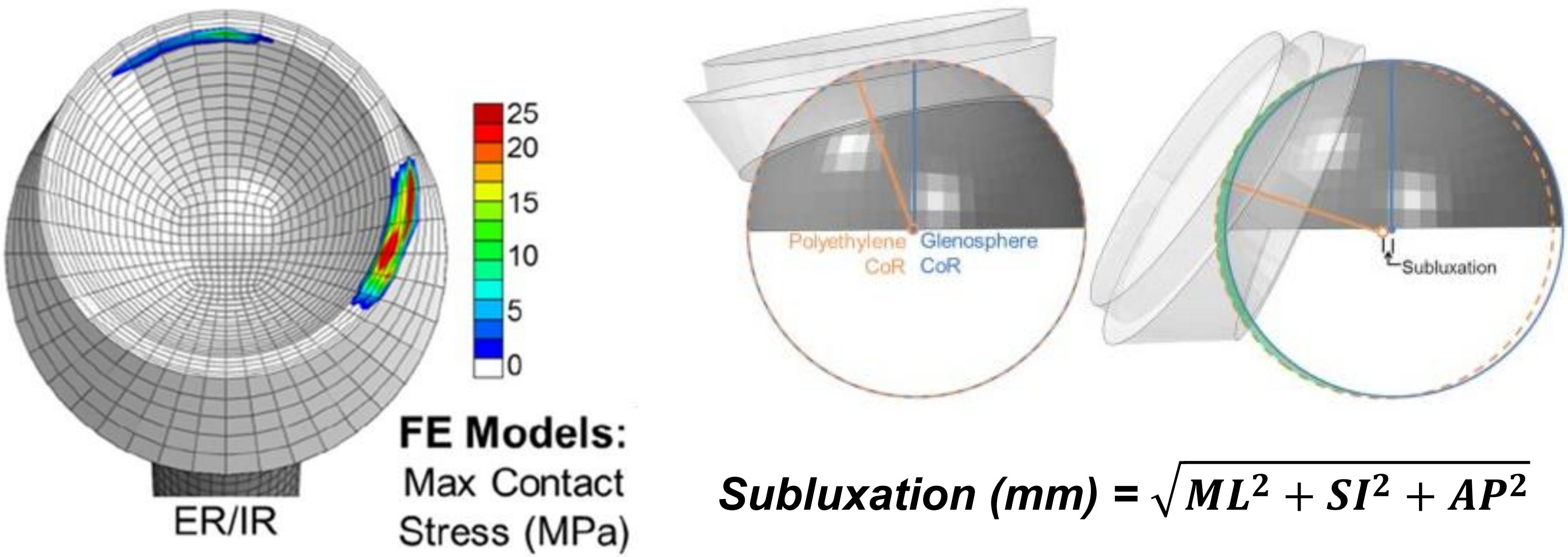


Fig. 7 Impingement and joint subluxation.

[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.[18]



$$\textbf{\textit{Subluxation (mm)}} = \sqrt{ML^2 + SI^2 + AP^2}$$

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].

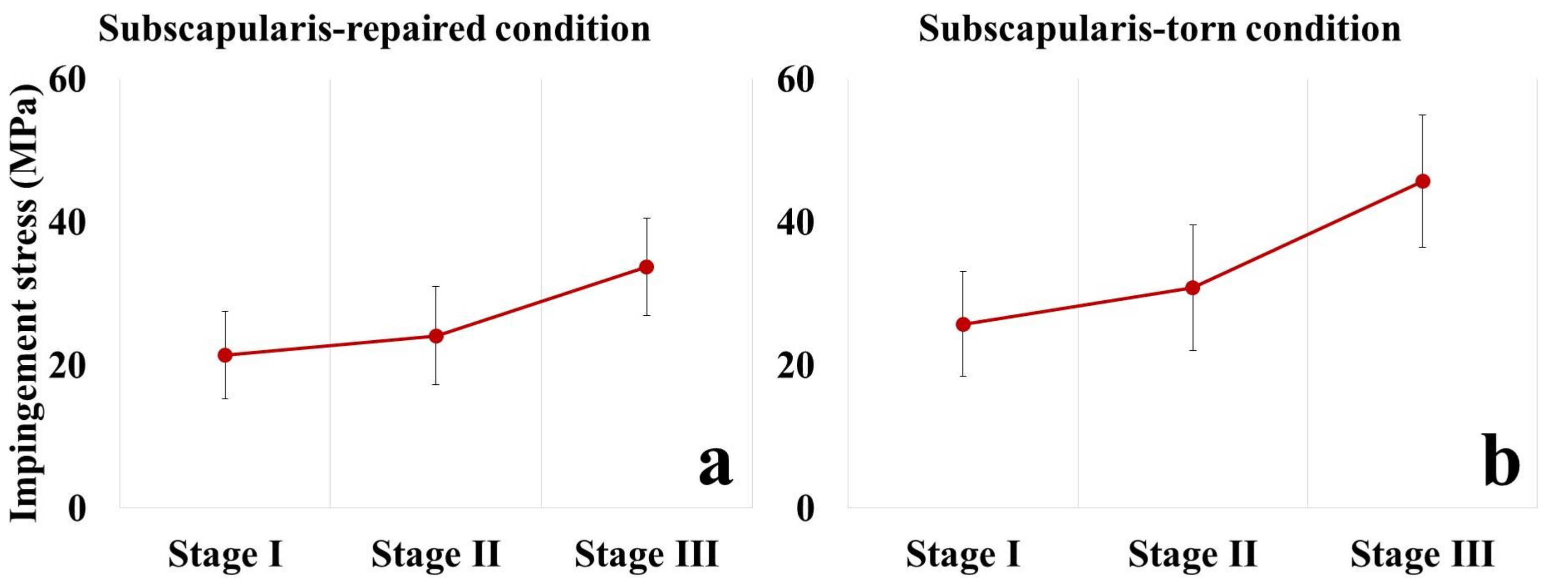


Fig. 12 Peak impingement stress under **a** subscapularis-repaired and **b** subscapularis-torn conditions, based on the three stages of posterosuperior cuff tear severity.

[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].

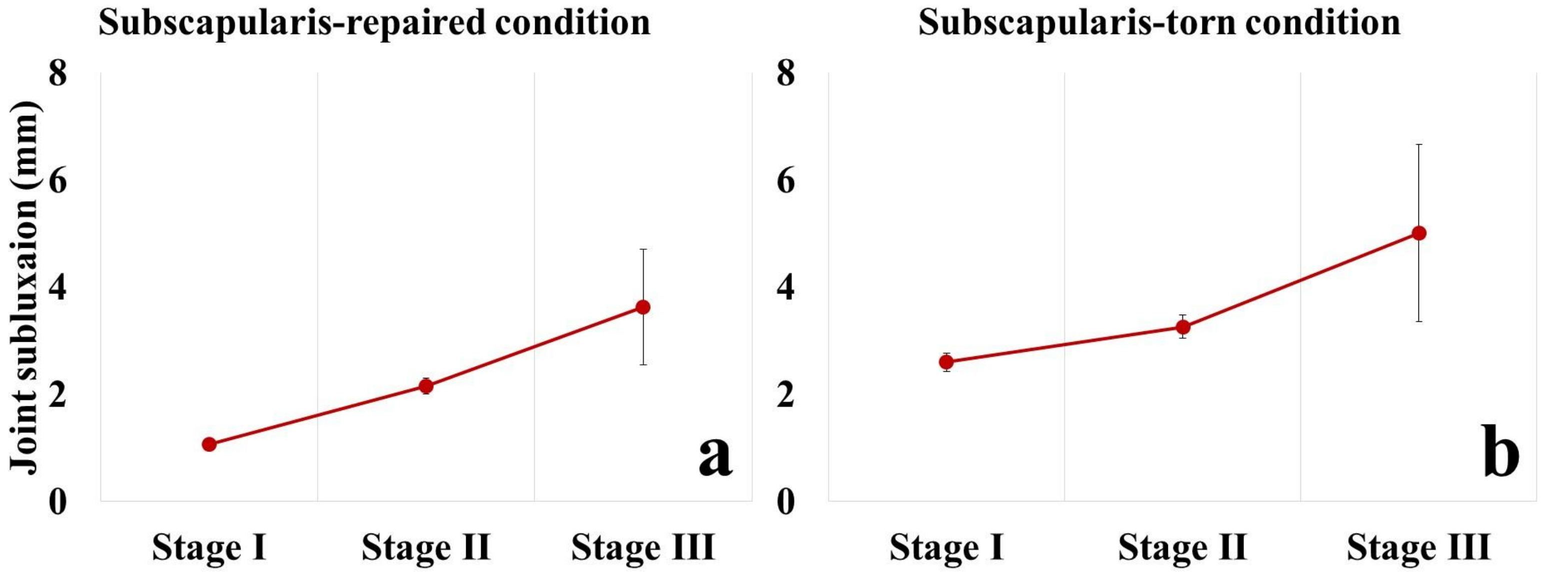


Fig. 13 Peak joint subluxation under **a** subscapularis-repaired and **b** subscapularis-torn conditions, based on the three stages of posterosuperior cuff tear severity.

[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).

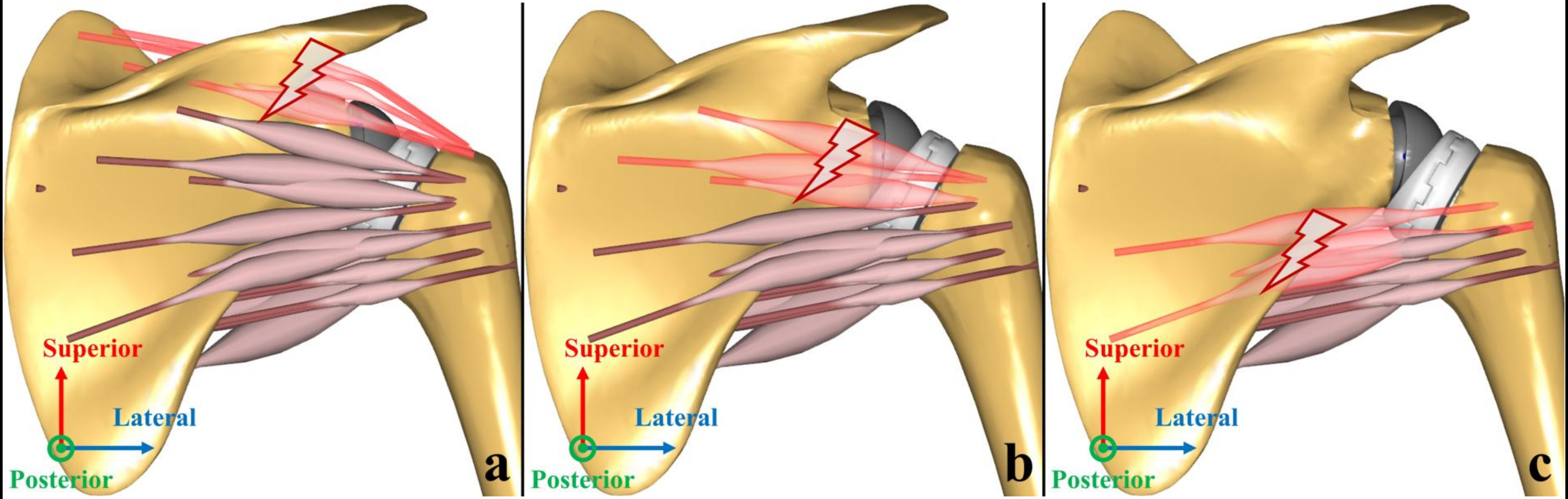


Fig. 14a Stage I: isolated supraspinatus bundle tears, **b** Stage II: Stage I + superior bundle tears of the infraspinatus, and **c** Stage III: complete posterosuperior cuff tears.

- ***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.

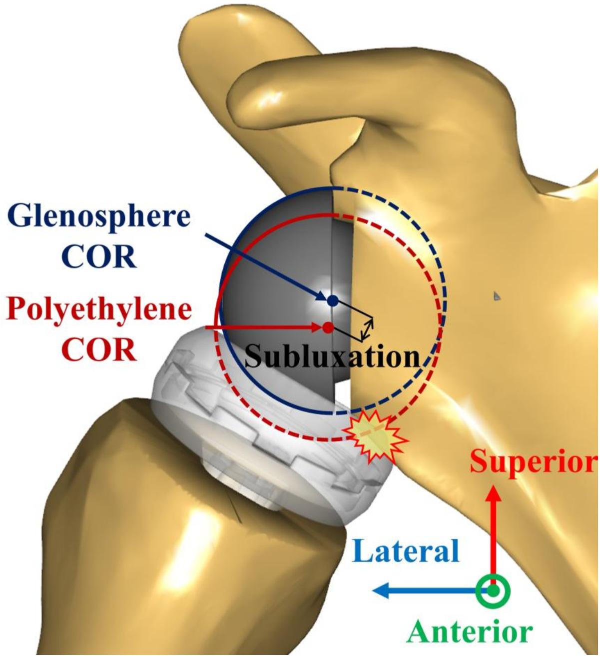


Fig. 7 Impingement and joint subluxation.

- ***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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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)*** [d]

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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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)[d]***

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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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)*** *a (I vs. II), b (II vs. III), c (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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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)*** *a (I vs. II), b (II vs. III), c (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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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)*** *a (I vs. II), b (II vs. III), c (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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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)*** *a (I vs. II), b (II vs. III), c (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
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	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
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Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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[a]	24.1 ± 6.9[a]	< 0.001
		III	65.3 ± 12.0[b, c]	33.7 ± 6.8[b, c]	< 0.001
	Torn	I	50.2 ± 9.7[d]	25.7 ± 7.3[d]	< 0.001
		II	58.6 ± 11.3[a, d]	30.9 ± 8.8[a, d]	< 0.001
		III	80.2 ± 14.6[b, c, d]	45.7 ± 9.3[b, c, d]	< 0.001
Subluxation (mm)	Repaired	I	6.0 ± 0.4	1.1 ± 0.1	< 0.001
		II	6.7 ± 0.5[a]	2.1 ± 0.1[a]	< 0.001
		III	9.7 ± 1.2[b, c]	3.6 ± 1.1[b, c]	< 0.001
	Torn	I	7.2 ± 0.5[d]	2.6 ± 0.2[d]	< 0.001
		II	8.6 ± 0.6[a, d]	3.3 ± 0.2[a, d]	< 0.001
		III	11.3 ± 0.8[b, c, d]	5.0 ± 1.7[b, c, d]	< 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**.[19,20]

➡ **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

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PhD Candidate (Aug 2026)

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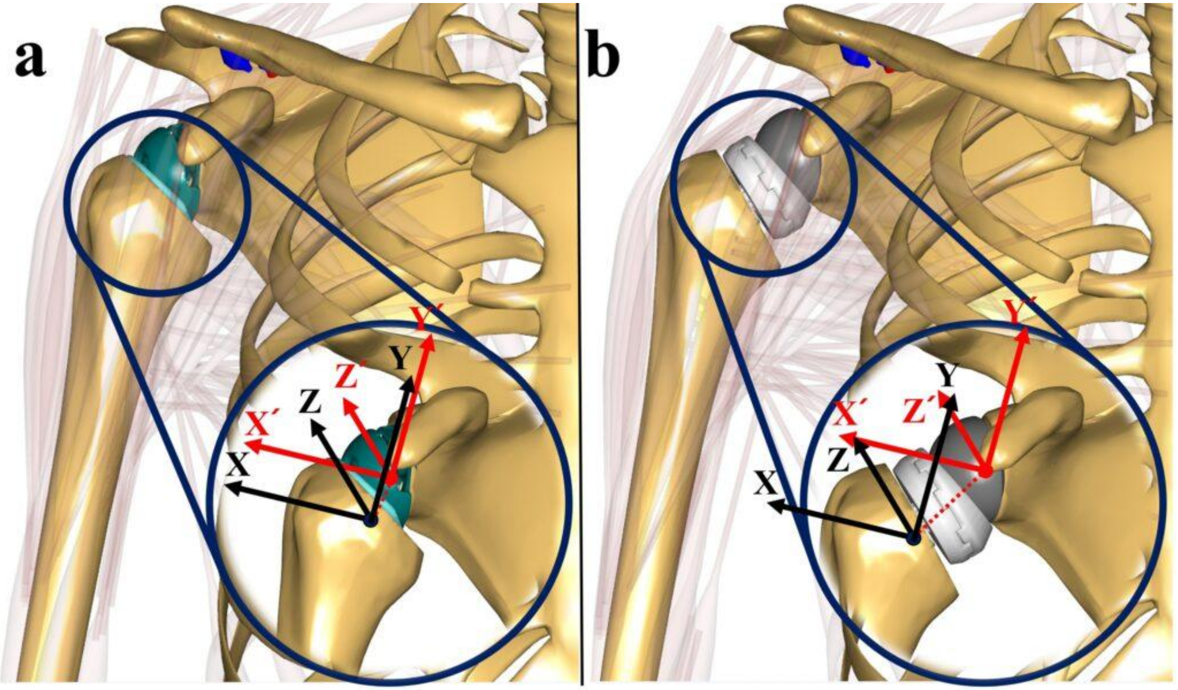
Poster #: 606 (Shoulder and Elbow)
Time: March 28 (Saturday), 6:30–7:15 PM

10th World Congress of Biomechanics

JULY 11 – 15, 2026 I 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



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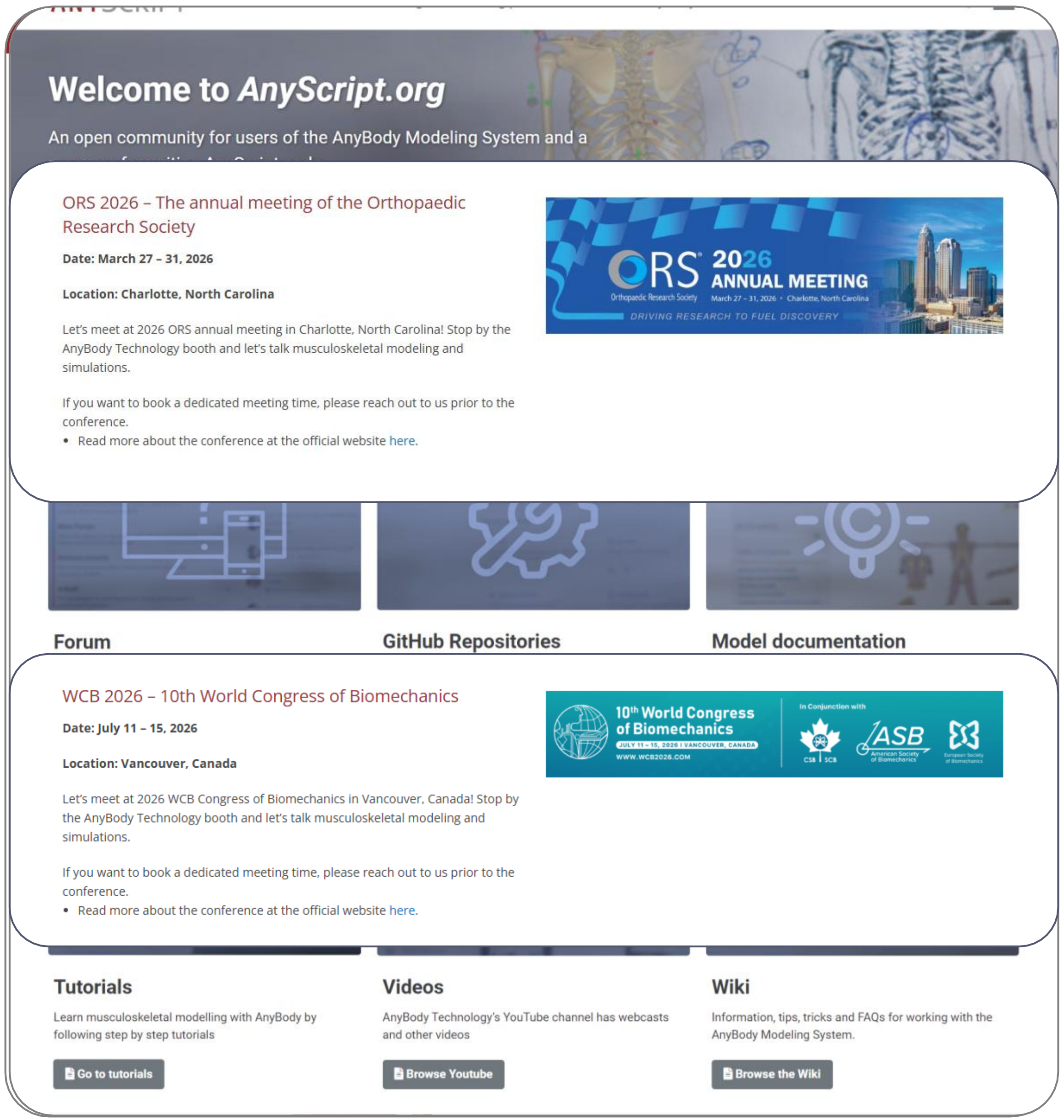
    - March 27 – 31, 2026; Charlotte, North Carolina, USA
  - WCB 2026 (10th World Congress of Biomechanics)
    - July 11 – 15, 2026; Vancouver Canada



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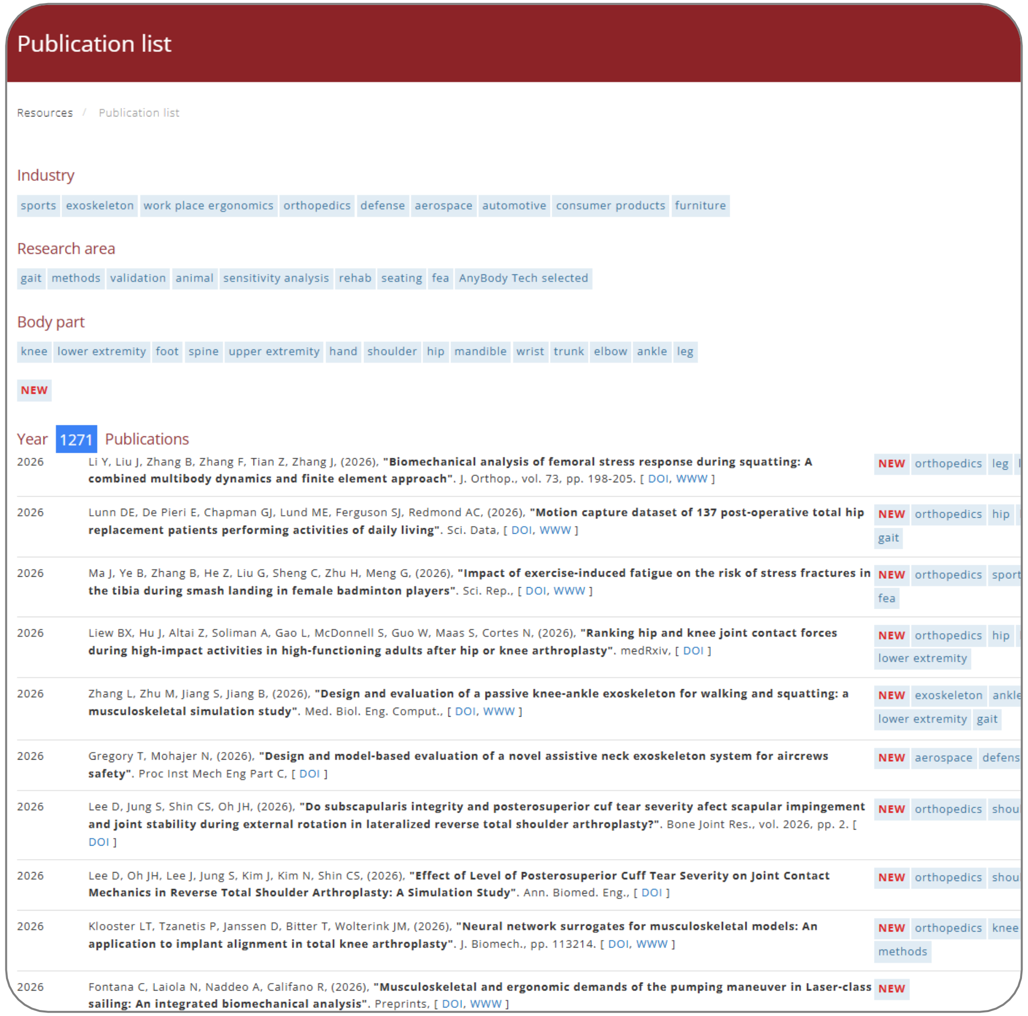

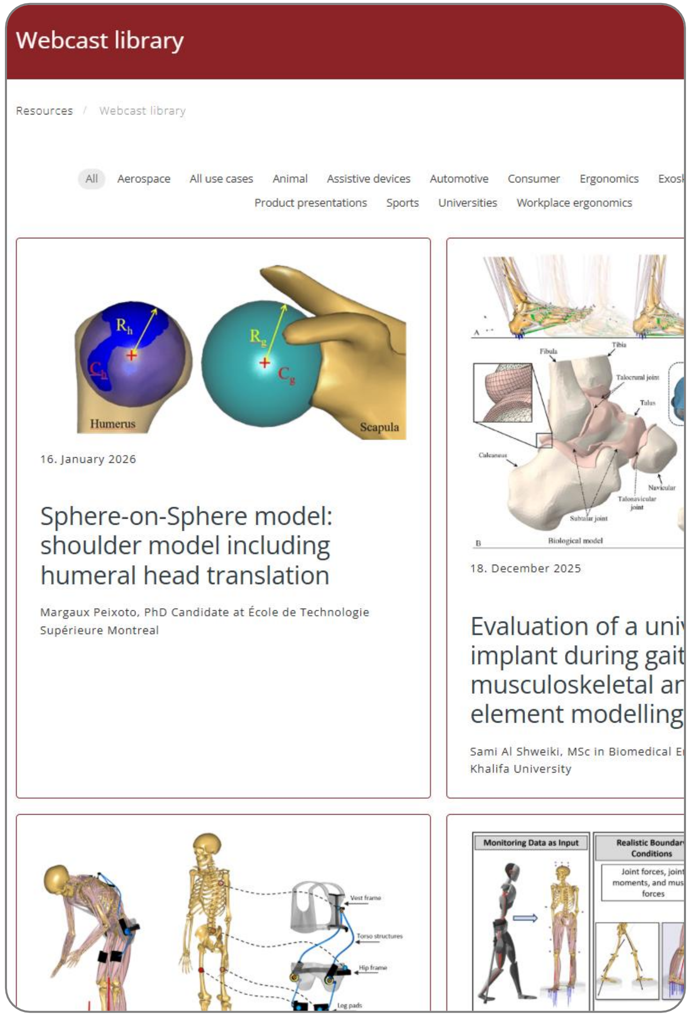

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