Graft Elongation Occurs Beyond Intraoperative Dimensions After Superior Capsular Reconstruction: An *In Vivo* Analysis

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Disclosures

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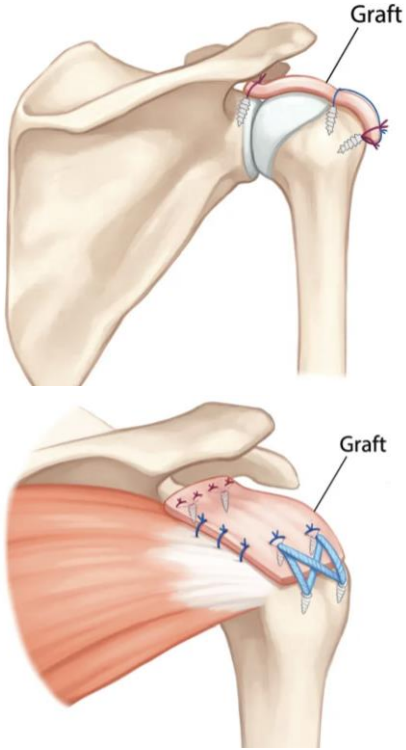
Superior Capsular Reconstruction

- Superior capsular reconstruction (SCR) is commonly used to provide superior stability of the glenohumeral (GH) joint in patients with irreparable rotator cuff tears [1,2].
- Recent *in vivo* studies have suggested SCR may not depress the humeral head during abduction as previously postulated [3].
- Knowledge of *in vivo* graft deformation and its relationship to healing may provide valuable knowledge to improve graft placement.



[1] Mihata et al. *AJSM.* 2012.
[2] Sochaki al. *J Arthroscopy.* 2021.
[3] Kane et al. *J Arthroscopy.* 2021.

Study Aims and Hypotheses

Aims

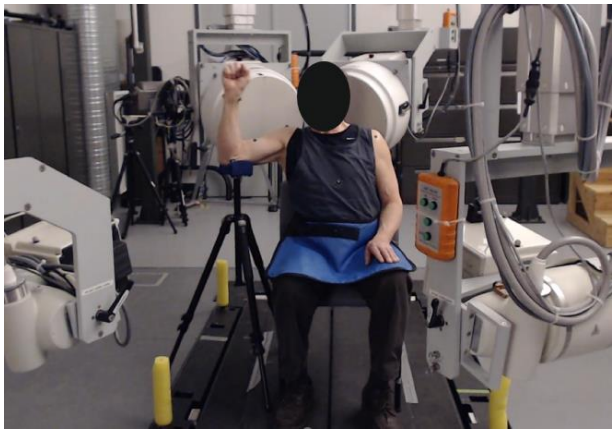
1. Determine regional graft elongation after SCR.
2. Determine if graft elongation is related to graft healing.
3. Determine the effect of the graft on kinematics.

Hypotheses

1. Anterior and posterior regions of the graft would elongate uniformly.
2. Greater graft elongation would be associated with graft failure.
3. Graft would affect shoulder kinematics by decreasing the distance between graft anchor points after surgery compared to before.

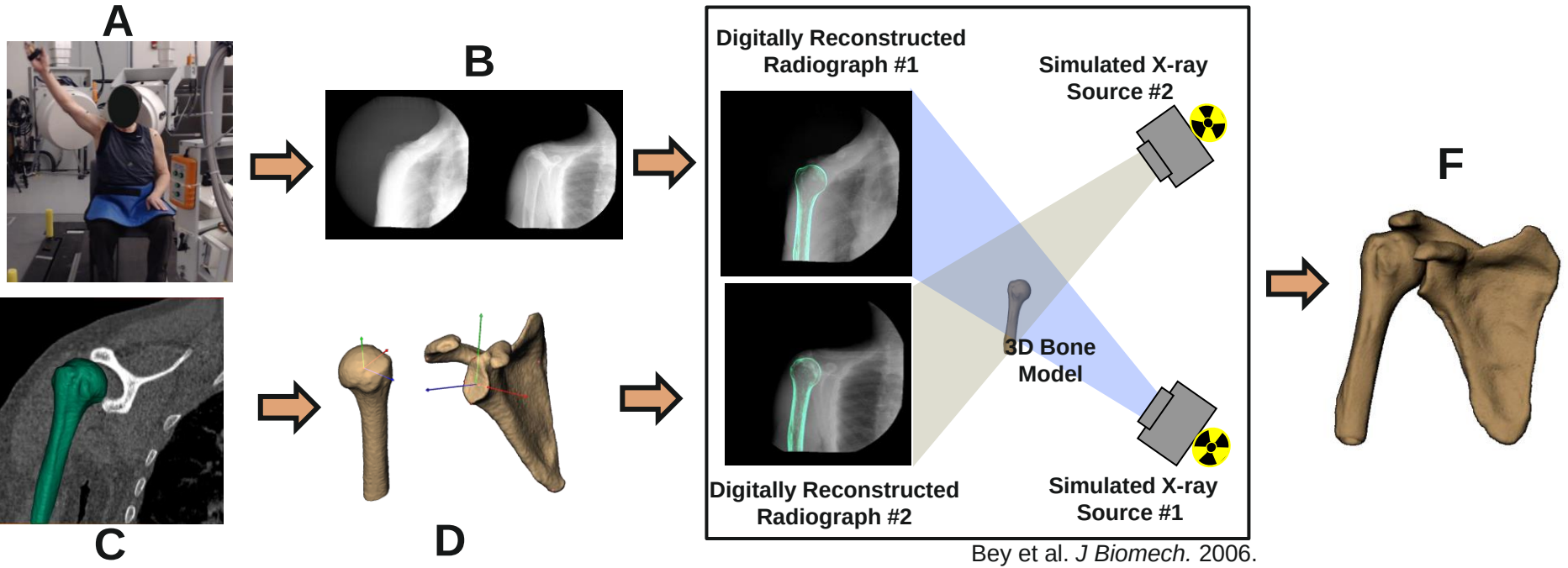
Data Collection

- Patients who were scheduled to receive human dermal allograft SCR were enrolled in this IRB approved study.
- Intraoperative graft lengths were measured prior to implantation.
- MRI was obtained one year after SCR to assess graft healing [4].
- Kinematic testing was performed before (PRE) and 1 year after (POST) SCR.
    - 3 trials of scapular plane abduction
    - 3 trials of internal/external rotation



[4] Hughes et al. *JSES.* 2021.

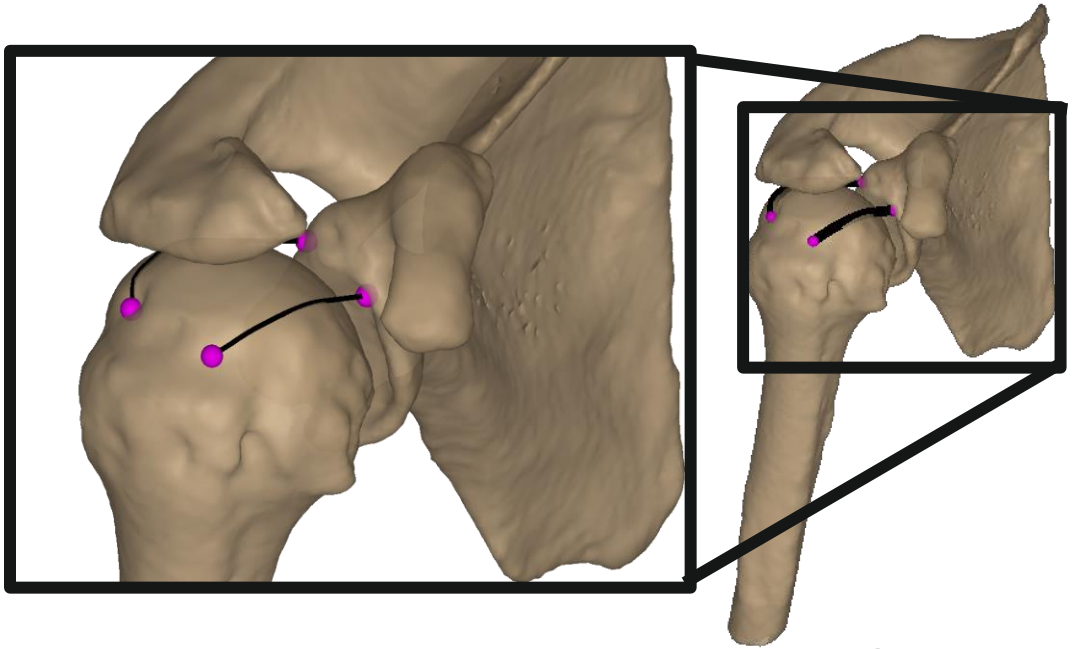
Data Processing



Bey et al. *J Biomech.* 2006.

(A) While participants were moving **(B)** synchronized biplane radiographs were collected at 50Hz for 2s. **(C)** bone tissue of scapula and humerus were segmented from CT scans and used to **(D)** create subject specific bone models. **(E)** Bone motions were tracked in the biplane radiographs using a validated tracking process. **(F)** This process resulted in the 3d kinematics of the GH joint.

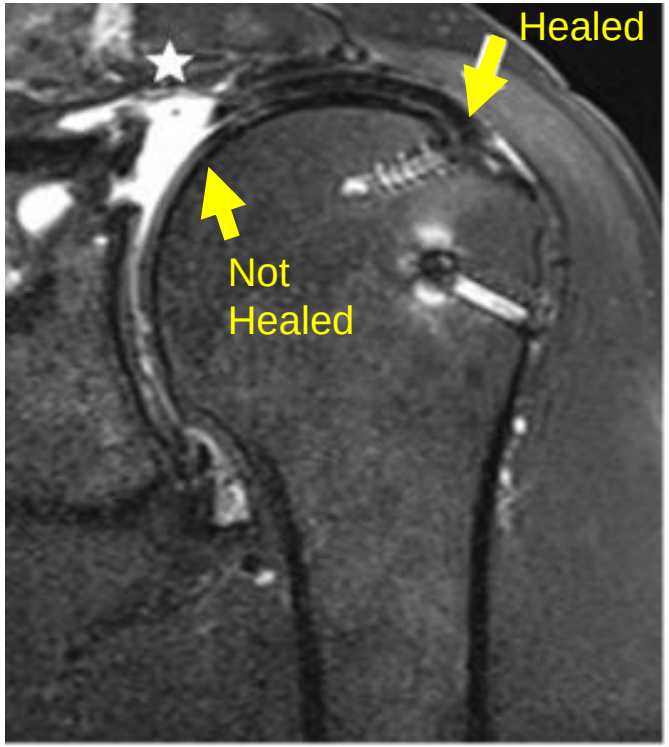
Data Analysis



- For every frame of data, the minimum distance between the corresponding anchor points on the humerus and glenoid were found, with the line wrapping around the surface of the humerus when necessary.
- Graft lengths throughout the entire tracked motion were found and interpolated to each degree of movement and averaged across trials.
- Graft elongation was calculated as the change in length from intra-op divided by the intra-op length.

$$\textit{Graft Elongation} = \frac{\textit{Graft Length} - \textit{Intraoperative Length}}{\textit{Intraoperative Length}}$$

Graft Healing



- Graft healing on this cohort was evaluated by a fellowship-trained orthopedic surgeon at each of the 4 anchor locations.
- Anchor locations were evaluated for presence of healing and each region of the graft was determined to be “healed” if both anchor locations were labeled healed.

[4] Hughes et al. *JSES.* 2021.

Statistical Analysis

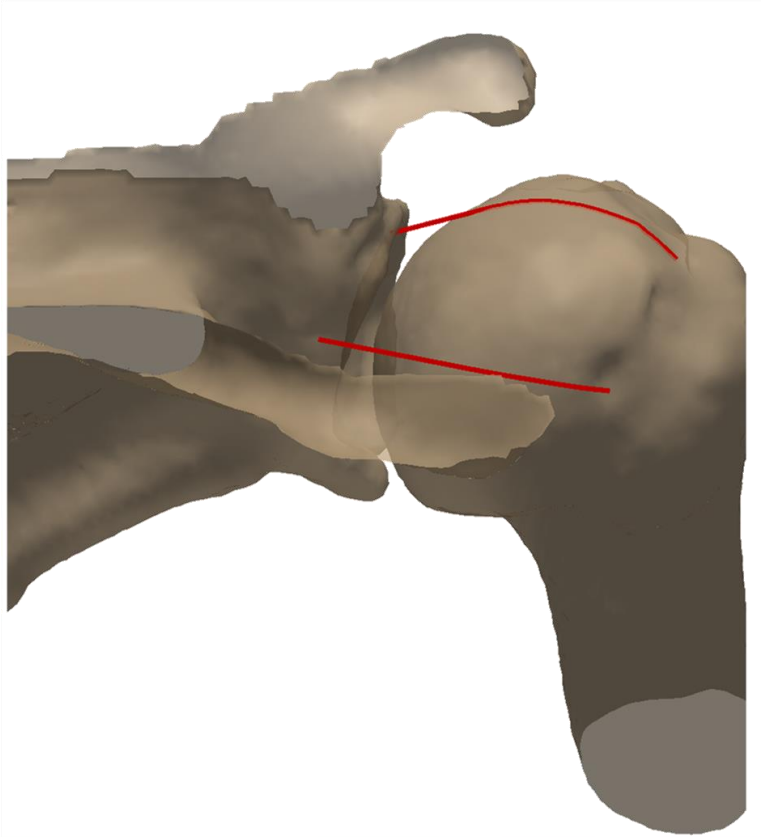
Mann-Whitney U test:

- Differences between abduction angle at which the graft reached the intra-op length between healed and not healed grafts

Wilcoxon signed-rank test

- Differences between regions
- Differences in graft origin to insertion distance from PRE to POST surgery

Significance: $p < 0.05$.



Results: Demographics & Patient Outcomes

10 patients

- 8 M
- Average age: 63±7 years
- Post-op testing: 11.5-13.0 months post SCR

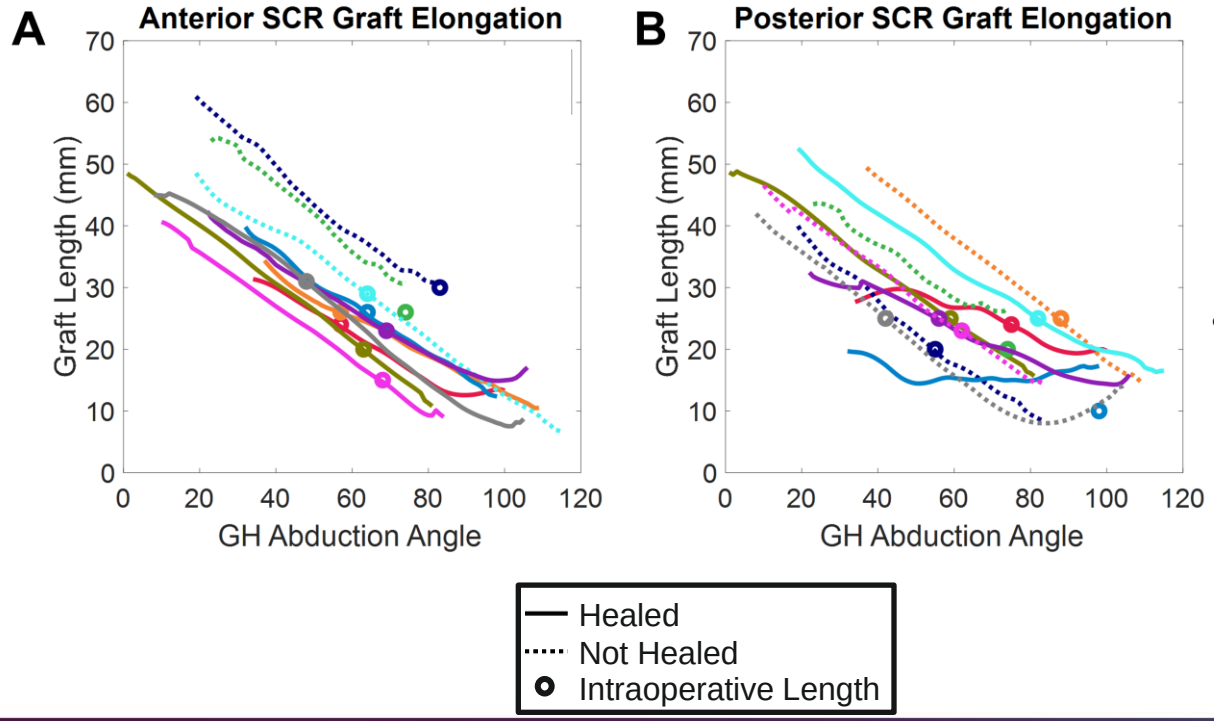
Intraoperative graft lengths

- Anterior: 23.2±6.3mm
- Posterior: 22.2±4.7mm

Graft Healing

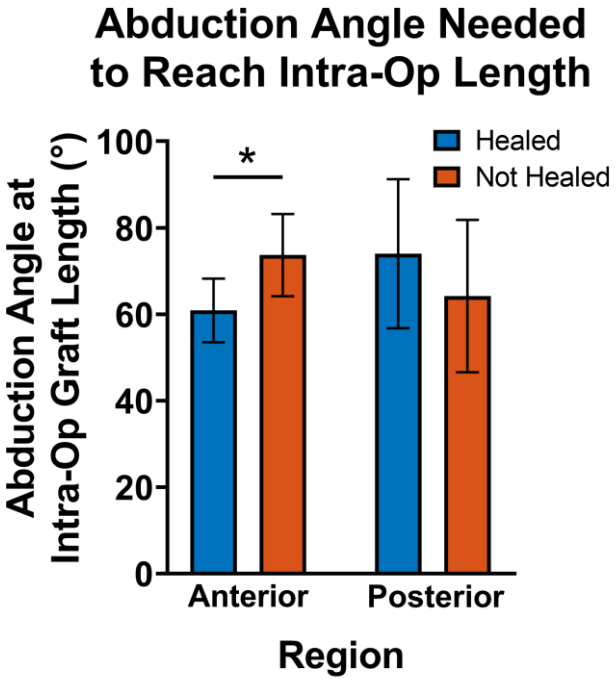
- Anterior: 7/10 were healed
- Posterior: 5/10 were healed

Graft Deformation During Abduction



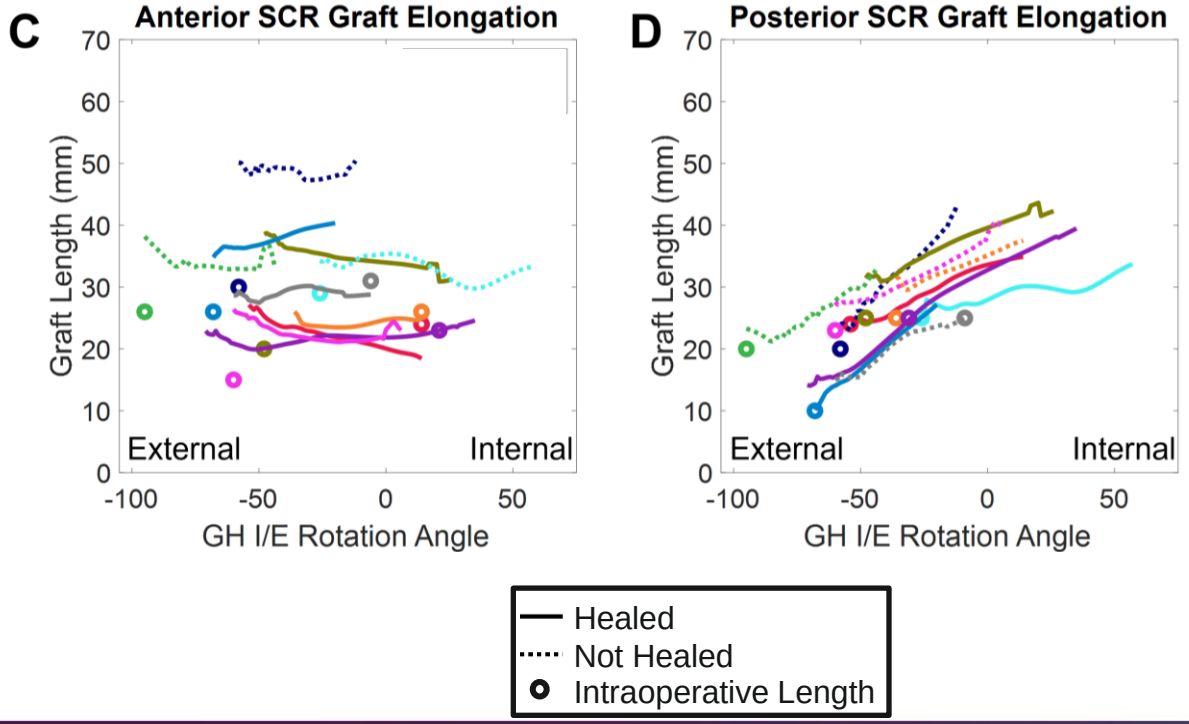
- Average maximum graft lengths were 50mm in the anterior region, corresponding to up to an 118% increase in length compared to the intraoperative length.
- Elongation was linearly related to abduction angle: with grafts shortening just under a half a mm per increase in a degree of abduction in both graft regions.

Graft Deformation During Abduction



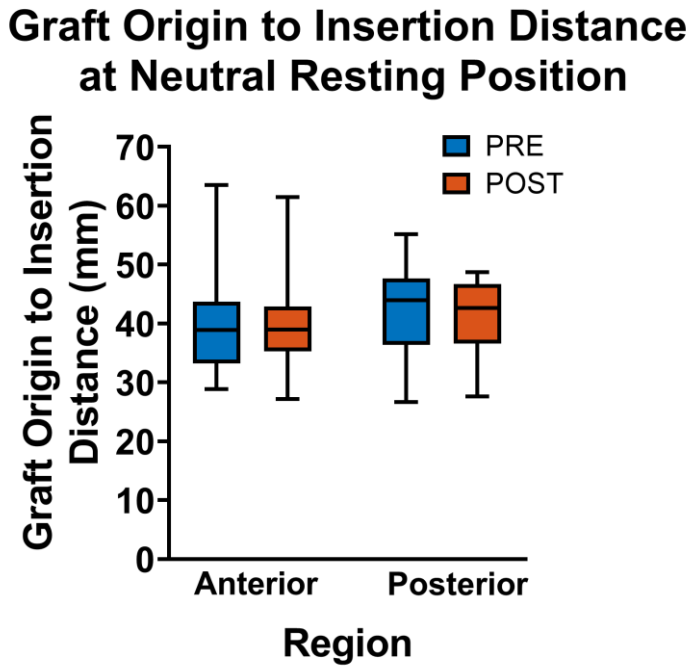
In the anterior region, the abduction angle needed to reach the intraoperative graft length in the healed grafts tended to be lower than in the not healed grafts, though no changes were seen in the posterior region.

Graft Deformation During Rotation



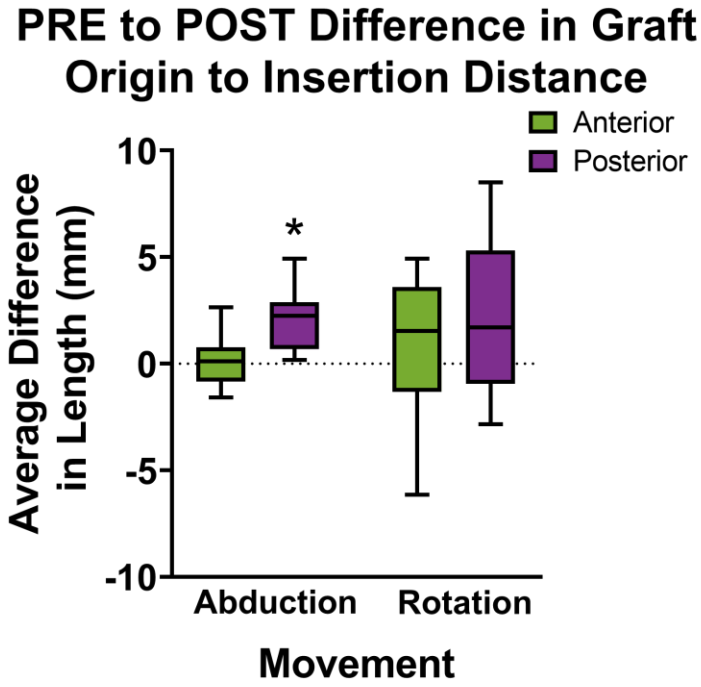
- Grafts reached lengths of up to 50mm which corresponded to a 220% increase from the intraoperative length.
- The anterior region did not elongate or shorten with external rotation, but the posterior region shortened 0.2mm for every 1 degree increase in external rotation.

Effect of SCR Graft on Static Kinematics



No differences were found in either anterior or posterior region in the static distance of the graft from pre to post surgery.

Effect of SCR Graft on Dynamic Kinematics



- The posterior portion of the graft was found to be significantly longer post surgery compared to pre-surgery during the abduction motion.
- No changes were seen in the anterior region, nor during the rotation movement.

Discussion

- Graft uniformly deformed during abduction, but not during rotation, partially supporting our first hypothesis.
- Grafts that were not healed in the anterior region required higher abduction angles to reach intraoperative lengths, supporting our second hypothesis.
- The distance between the anchor locations increased from before to after surgery, contrary to our third hypothesis.

Clinical Significance

SCR graft is elongated well beyond its implanted length one year after surgery; suggesting the improved clinical outcomes may be due to the spacer effect rather than improved glenohumeral joint stability.

Acknowledgements

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