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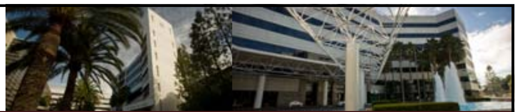

Trapezius Transfers for Irreparable Rotator Cuff Tears

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Disclosures

Smith & Nephew (Consultant)
Integra (Consultant, Royalties)

Incidence

- Anatomic/cadaveric studies on asymptomatic patients have shown cuff tears in 30-50% of patients, especially >70 years.
  - Sher JBJSAm 1995: 10-15
  - Tempelhof JSES 1999: 296-99
- Incidence of irreparable tears is unknown

Massive Rotator Cuff Tears

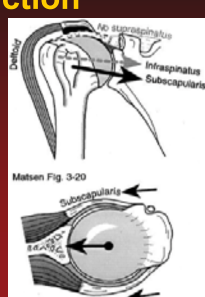
- **Cofield** (JBJSAm 1985: 974-9)
  - ≥ 5cm in AP dimension (>1cm, 1-3, 3-5, >5)
- **Nobuhara** (CORR 1994:(304) 54-9)
  - Amount of humeral head exposed
- **Gerber** (JBJSAm 2000: 505-515)
  - 2 or more tendons

Irreparable Tears

- **Rockwood:** JBJSAm 1995: 857-866
  - Tears that cannot be repaired primarily to their insertion onto the tuberosities despite adequate mobilization techniques
- **Goutallier:** CORR 1994 (304): 78-83
  - Based on amount of atrophy and fatty infiltration/degeneration demonstrated on CT scans.
  - Grade 3&4 generally irreparable
- **Others:**
  - AH distance <7mm
  - Static proximal humerus migration
  - Lag signs on PE

Biomechanics of Rotator Cuff Function

- Rotator cuff is comprised of 4 tendons that create concavity compression at the glenohumeral joint
- This dynamic stabilizer of the shoulder resists upward motion of the humeral head during contraction of the deltoid.

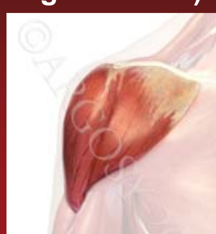


Biomechanics

- With loss of the force couple stabilizing the shoulder in the GH joint, superior subluxation with possible escape can occur.
- Proximal migration
  - Keener JBJSAm 2009: 1405-13
- Anterior subluxation

Nonoperative Treatment

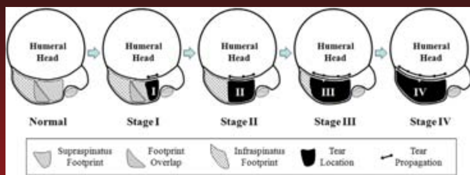
- Deltoid reconditioning (Reading Unit - UK)



Hansen et al JBJSAm 2008: 316-25

- Stable GH abduction without excessive superior head migration could be maintained with massive tears but require the generation of higher forces in the deltoid and remaining intact cuff
- Subscapularis forces increased 30-85% depending on tear

Oh et al JBJSAm 2011: 2100-9



Stage 3 critical size (involves 50% of IS)

Latissimus and pectoralis major strengthening

Surgical Options?

Surgical Options

- Debridement/SAD (grade C)
- Biceps tenotomy/tenodesis (grade B)
- Partial Repair (Insufficient)
- SSN Decompression ???
- Repair with augmentation (Grade C)
- Tendon Transfer (Grade B)
- Arthroplasty (Grade B)

Tendon Transfers

- Latissimus Dorsi
- Pectoralis Major
- Lower Third Trapezius

Posterosuperior Cuff Tears

- Supraspinatus and Infraspinatus (possible TM)
- More common
- Better prognosis
- Treat with Latissimus or Trapezius

Requirements for Success with Latissimus or Trapezius

- Young, minimal arthritis
- Needs strength or ER
- Full elevation
- Intact Subscapularis
- Intact TM
- Full PROM

Latissimus Dorsi Transfer

- Posterosuperior tears
- IR and adductor becomes an ER and abductor???
- Difficult rehab
- Inconsistent results
- Good for pain relief

Latissimus Dorsi Transfer

- Literature shows the importance of subscapularis, deltoid, teres minor, number of prior surgical procedures as factors that affect outcome:
  - Gerber CORR 1988: (232) 51-61
  - Gerber CORR 1992: (275) 1120-7
  - Miniaci JBJSAm 1999: 1120-7
  - Warner JSES 2001: 514-521
  - Costouros JSES 2007: 727-734

Iannotti JBJSAm 2006: 342-348

- EMG activity seen in all 14 patients with adduction
- EMG activity seen in 1/14 patients with FE
- EMG activity seen in 6/15 patients with ER

- These results have been shown by other authors as well

Irlenbusch JSES 2008: 492-99

- 45 patients with surface electrodes showed activity in the transferred latissimus
- Surface electrodes vs needle electrodes
- Unknown benefits

Trapezius Transfer

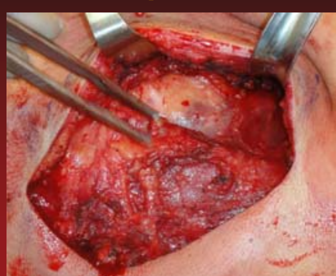
- More "in line" muscle vector to improve ER
- Indications developing

Oh et al JSES 2013: 150-7

- The posterosuperior rotator cuff deficient shoulder, the **pectoralis major and latissimus dorsi play an important role in humeral head stabilization.**
- The **use of an exogenous force couple** (i.e. the lower trapezius transfer) would allow the latissimus dorsi to provide stabilization to the humeral head from its native insertion, providing a more normal anterior-posterior force balance at the glenohumeral joint.

Surgical Technique

Where is the “Lower Trapezius”



J Shoulder Elbow Surg (2015) 24, 1353-1358

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Surgical anatomy of the lower trapezius tendon transfer

CrossMark

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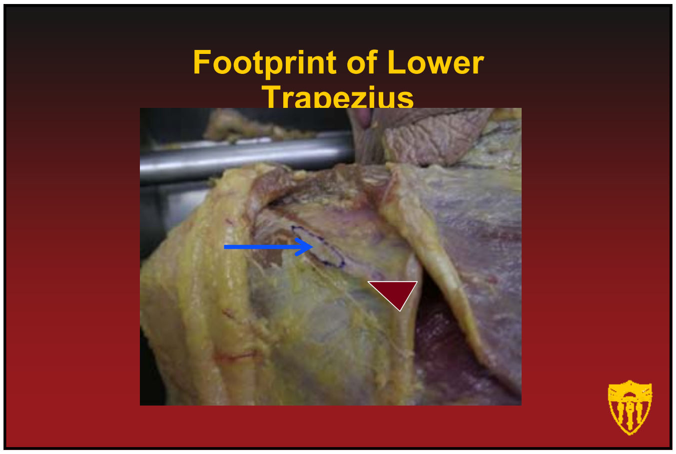
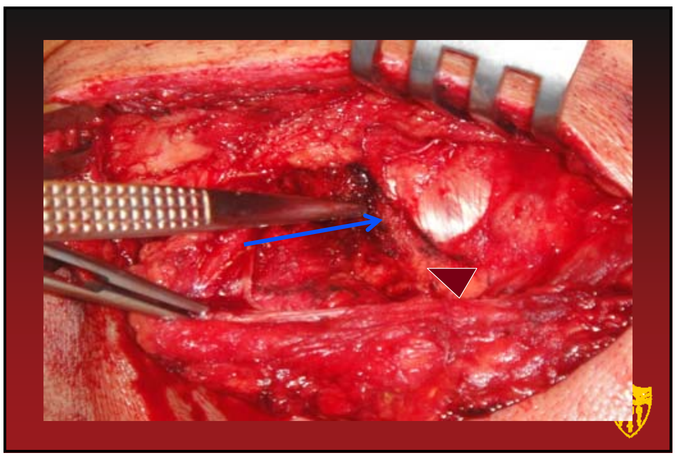
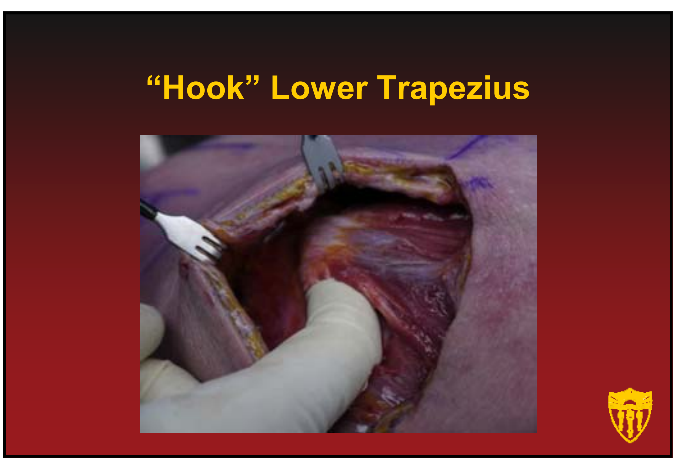
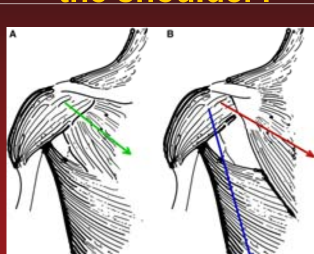

Footprint of Lower Trapezius




“Hook” Lower Trapezius

Is the Lower Trapezius Transfer better able to restore kinematics of the shoulder?



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BASIC SCIENCE

Biomechanical comparison between the trapezius transfer and latissimus transfer for irreparable posterosuperior rotator cuff tears

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Latissimus Dorsi Transfer

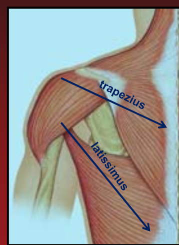
- Latissimus dorsi tendon transfers were first described in patients with brachial plexopathies causing lack of external rotation.
- Gerber applied this concept to improve external rotation in cuff deficient shoulders[31].
    - Gerber CORR 1988

Latissimus Dorsi Transfer

- Pros:
  - May restore over head function & ER
  - Predictably decreases pain
- Cons:
  - Converts an internal rotator to an external rota
  - Requires long hours of PT
  - Variable functional recovery
  - Progression of glenohumeral OA?
  - EMG studies have shown inconsistent results
  - *(Ioki et al. , 1996; Iannotti et al., 2006)*

Trapezius Transfer

- Described for use in brachial plexopathy but not RC deficient shoulders
- Trapezius transfer utilizes the inferior third of the trapezius
  - Muscle pull is parallel to the infraspinatus
- Still unknown:
  - Is the trapezius transfer is better situated to restore ER?
  - Is the trapezius transfer better at restoring native glenohumeral biomechanics than the latissimus transfer?



Question

Does the trapezius transfer restore native shoulder biomechanics (e.g. ROM, kinematics, and forces) better than the latissimus transfer

Hypothesis

The trapezius transfer will restore ROM, restore kinematics, and forces better than the latissimus transfer

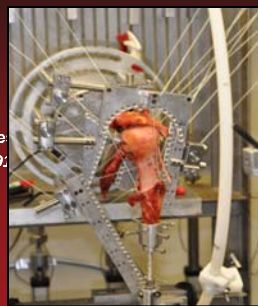
Materials & Methods:

- 8 cadavers
- Cadavers dissected of all soft tissue except
  - Preserved glenohumeral capsule and tendonous insertions of deltoid, infrapinatus, supraspinatus, teres minor, subscapularis, pectoralis major, LHBT and latissimus dorsi
- Modified Bunnell stiches placed in the tendonous insertions for muscle loading
- Neutral humeral rotation set at 60 abduction, with anterior acromion and bicepital groove alignment set to 20 degrees ER

Materials & Methods

Independent variables:

- Testing conditions:
  - » Intact cuff
  - » Massive cuff tear (entire supra and infra)
  - » Trapezius transfer
  - » Latissimus transfer
- Abduction angles: 0, 30, 60 degree
- Muscle loading: *(Veeger et al., 199*
  - » Biceps – 10N
  - » Supraspinatus – 10N
  - » Infra + teres minor – 24N
  - » Subscap – 24N
  - » Pec major – 24N
  - » Trapezius – 12N, 24N, 36N
  - » Latissimus – 24N
  - » Deltoid – 48N (16N to all 3 heads)



Materials & Methods

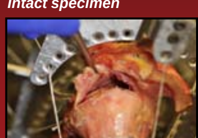
Dependent variables:

- ROM: max IR & max ER, and rotation due to muscle loading
- Kinematics: max IR, -30, 0, +30, and max ER
  - Microscribe
- Joint reaction forces at all abduction and rotational angles

Images

Intact specimen

Intact specimen



Massive cuff tear

Massive cuff tear

Images

Trapezius transfer

Trapezius transfer

Lat transfer

Lat transfer

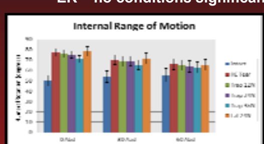
Latissimus Transfer Vector

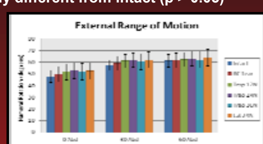
Trapezius Transfer Vector

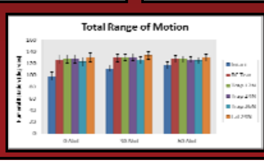
Results

Range of Motion

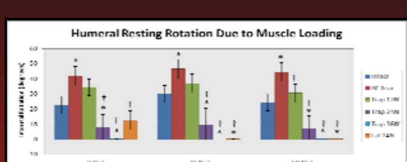
IR & total ROM – all conditions significantly different from intact ($p < 0.05$)
ER – no conditions significantly different from intact ($p > 0.05$)







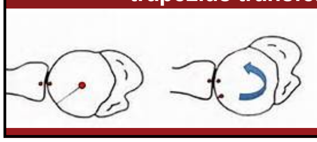
Humeral Resting Postition



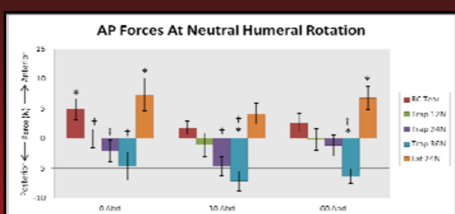
* – different from intact ($p < 0.05$); † – different from RC tear ($p < 0.05$)

Humeral Resting Postition

- The amount of internal rotation due to muscle loading increased with massive cuff tear at 0°, 30°, 60° abduction ($p < 0.05$)
- This was restored with the latissimus transfer at 0° abduction and the trapezius transfer at all abduction



Change in AP Force From Intact



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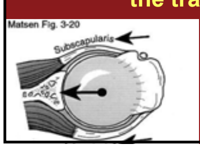
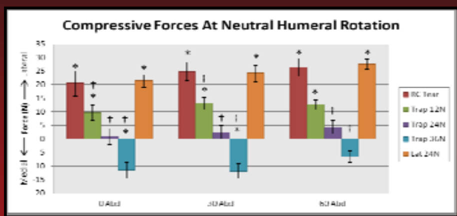
Change in AP Force From Intact

- At neutral rotation and 0° abduction, there was an increase in the anteriorly directed force for the cuff tear and latissimus transfer conditions ($p < 0.05$).
- This was restored to intact values by the trapezius transfer ($p < 0.05$).



ΔCompressive Force From Intact



* – different from intact ($p < 0.05$); † – different from RC tear ($p < 0.05$)

ΔCompressive Force From Intact

- The cuff tear decreased glenohumeral joint compressive force. ($p < 0.05$).
- Restored with the trapezius transfer at all positions ($p < 0.05$).
- Latissimus transfer failed to restore the intact compressive force ($p < 0.05$).

Summary of Results

- Trapezius has better centering force (AP force)
- Trapezius restores compressive forces

Oh et al JSES 2013: 150-7

- The posterosuperior rotator cuff deficient shoulder, the pectoralis major and latissimus dorsi play an important role in humeral head stabilization.
- The use of an exogenous force couple (i.e. the lower trapezius transfer) would allow the latissimus dorsi to provide stabilization to the humeral head from its native insertion, providing a more normal anterior-posterior force balance at the glenohumeral joint.

Osteoarthritis

- Abnormal glenohumeral kinematics caused by both the massive rotator cuff tear and subsequent latissimus dorsi tendon transfer may contribute to pain and long-term sequelae such as osteoarthritis.
- Gerber et al/Moursy et al/Aoki et al observed progression of glenohumeral osteoarthritis in 29- 42% of their patients following latissimus transfer
- The progression of osteoarthritis may be seen after the latissimus transfer because of its inability to restore normal joint kinematics and glenohumeral force in both the anterior-posterior and compressive-distractive planes.

Shortcomings

- Use of an Achilles tendon allograft (graft healing and graft creep issues).
- This was a cadaveric study, so pain, which may have a significant effect on glenohumeral kinematics or rotational range of motion, cannot be considered.
- In this time-zero study, physiologic adaptation of the transferred tendons cannot be evaluated, and complete physiologic adaptation of transferred tendon after long-term rehabilitation might result in proper tension restoring the biomechanics of the shoulder joint.
- The exact physiologic muscle loads were not produced, and the muscle forces may be more complex than our model.
- Failure to incorporate the ST joint

Conclusions

- The trapezius transfer was able to provide a better AP centering force than the latissimus transfer and restored contact forces to the intact condition.
- Compressive forces and were restored closer to intact state.
- In our model, The lower trapezius transfer is biomechanically superior to the latissimus transfer in restoring native glenohumeral kinematics and forces.