Anterior Cable Reconstruction (ACR) Using the Proximal Biceps Tendon for Large Rotator Cuff Defects Limits Superior Migration and Subacromial Contact Without Inhibiting Range of Motion

Maxwell C. Park, MD; Yasuo Itami, MD, PhD; Charles C. Lin, BS; Adam Kantor, BS; Michelle H. McGarry, MS; Chong J. Park, PhD; Thay Q. Lee, PhD

AOSSM Annual Meeting
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Conflict of Interest

- Arthrex research grant
- TQL is a consultant for Arthrex
Background

- Minimally retracted tears (crescent-shaped tears), no tissue loss: TOE indicated
- Large irreparable tears: SCR indicated
- What about moderate-large tears/defects, partial repairs, or medialized repairs?
  - Can tendon coverage restore a functional ligament as well?

Knotless Transosseous-Equivalent Rotator Cuff Repair Improves Biomechanical Self-reinforcement Without Diminishing Footprint Contact Compared With Medial Knotted Repair

Maxwell C. Park, M.D., Alexander B. Peterson, B.A., Michelle H. McGarry, M.S., Chong J. Park, Ph.D., and Thay Q. Lee, Ph.D.

Arthroscopy 2017

Adv Shoulder Recon, AAOS 2016

Arthroscopy 2006
Park et al, JSES 2007

Mihata et al, AJSM 2016
Background

- Two functional structures:
  - Dynamic tendon
  - Static ligament

- Medialized, partial repairs, or residual defects require the tendon to act as both tendon and ligament

- Normal anatomy dictates that the dynamic tendon be supported by a static ligamentous structure
Can the residual or repaired tendon act as both a tendon and ligament?

- Proximal long-head biceps as a graft?
  - Local
  - Available
  - Anatomically consistent

- Providing static ligament support to any residual or repaired tendon might improve:
  - Longevity
  - Function
  - Outcomes
Background

- **Hypothesis:** Local autograft proximal long-head biceps tendon can be used to stabilize the GHJ with large rotator cuff defects

- Use validated biomechanical testing methods (Mihata et al 2012)
  - ROM
  - AP translation
  - Superior migration
  - Subacromial contact pressures

*Anterior Cable Reconstruction*
Biomechanical Evaluation: “Anterior Cable Reconstruction”

Consists of:

- Side-to-side sutures
- Medial-row fixation
- Bony trough for healing and stability
- Lateral-row attachment
Biomechanical Evaluation: “Anterior Cable Reconstruction”

Essentially the long head biceps tendon (LHBT) is a surrogate for an anterior cable region, consistent with the anatomic relationship between the anterior cable region and LHBT.
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Biomechanical Evaluation: “Anterior Cable Reconstruction”
Testing Conditions

Does a Critical Rotator Cuff Tear Stage Exist?

A Biomechanical Study of Rotator Cuff Tear Progression in Human Cadaver Shoulders

Joo Han Oh, MD, PhD, Bong Jae Jun, PhD, Michelle H. McGarry, MS, and Thay Q. Lee, PhD

JBJS 2011
Testing Conditions

- Intact condition
- Stage II tear
- Stage II + ACR
- Stage III tear
- Stage III + ACR

Intact

Stage 2 Tear
Stage 2 ACR
Stage 3 Tear
Stage 3 ACR
ACR

Key Technical Considerations:

- **Tenodesis**
  - ***30 ABD and 30 ER***
    (in relation to the body)
  - “Loop-around”
    - “Forgiving fixation”
    - ROM adaptability

- **Side-to-side suturing**
  - Re-activate native posterior capsule that has become insufficient with RCT

- **RC Defects**
  - Stage II
  - Stage III
Biomechanical Testing

- 9 fresh shoulders
  - Based on power analysis

- Measurements
  - Humeral rotation
  - Kinematic pathway
  - Humeral head translation
  - Subacromial contact pressure
Biomechanical Testing

- **Abduction**
  - 0°
  - 20°
  - 40°

- **Rotation**
  - Max IR
  - 0°
  - 30°
  - 60°
  - 90°
  - Max ER
# Muscle Loading

<table>
<thead>
<tr>
<th>Stage</th>
<th>Balanced load</th>
<th>Unbalanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>Subs 10, SSP 5, ISP 5, TM 5, Deltoid 40, LD 20, PM 20, LHB 5</td>
<td>Subs 10, SSP 5, ISP 5, TM 5, Deltoid 80, LD 0, PM 0, LHB 5</td>
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<tr>
<td>Stage 2 tear</td>
<td>Subs 10, SSP 0, ISP 5, TM 5, Deltoid 40, LD 20, PM 20, LHB 5</td>
<td>Subs 10, SSP 0, ISP 5, TM 5, Deltoid 80, LD 0, PM 0, LHB 5</td>
</tr>
<tr>
<td>Stage 2 + ACR</td>
<td>Subs 10, SSP 0, ISP 5, TM 5, Deltoid 40, LD 20, PM 20, LHB 0</td>
<td>Subs 10, SSP 0, ISP 5, TM 5, Deltoid 80, LD 0, PM 0, LHB 0</td>
</tr>
<tr>
<td>Stage 3 tear</td>
<td>Subs 10, SSP 0, ISP 2.5, TM 5, Deltoid 40, LD 20, PM 20, LHB 5</td>
<td>Subs 10, SSP 0, ISP 2.5, TM 5, Deltoid 80, LD 0, PM 0, LHB 5</td>
</tr>
<tr>
<td>Stage 3 + ACR</td>
<td>Subs 10, SSP 0, ISP 2.5, TM 5, Deltoid 40, LD 20, PM 20, LHB 0</td>
<td>Subs 10, SSP 0, ISP 2.5, TM 5, Deltoid 80, LD 0, PM 0, LHB 0</td>
</tr>
</tbody>
</table>
RESULTS
Humeral ROM

ACR does not restrict ROM

Statistically significant vs:

*: Intact
#: Stage II tear
†: Stage II + ACR
@: Stage III tear
Superior Translation
Unbalanced Load

ACR helps normalize superior translation

Statistically significant vs:

*: Intact
#: Stage II tear
†: Stage II + ACR
@: Stage III tear
AP Translation
Unbalanced Load

ACR helps normalize AP translation

Statistically significant vs:
* : Intact
#: Stage II tear
†: Stage II + ACR
@: Stage III tear
Subacromial Pressures

ACR helps normalize peak pressures

Statistically significant vs:

*: Intact
#: Stage II tear
†: Stage II + ACR
@: Stage III tear
Mode of Failure

Tendon cut-out when sutures passed through the biceps (with non-failure loads):

- Tensioning beyond 40° ABD $\rightarrow$ failure w/ adduction
- Tensioning at less than 30° ER $\rightarrow$ failure w/ ER
- Strategy to limit this risk $\rightarrow$ “Loop-around” fixation
Key Concept

- The biceps has variable length with changes to humeral head rotation
- Fixing the biceps in situ risks over-constraining the GHJ
Key Concept

Yellow arrow represents biceps length
Key Concept

External rotation arc requires biceps length
Key Concept

Blue arrow represents length at 30° ER
Key Concept

Red arrow represents length at 45° ER
Key Concept

Biceps is too short (represented by residual Blue and Red arrows)!

ACR must account for this!
Key Concept

Residual native capsule is *dysfunctional*
ACR acts as a suspension cable to recruit and re-activate native posterior capsule that has fallen away.
ACR with “loop-around” fixation cannot be under-tensioned when relying on native capsule!
Conclusion

Summary:

- ACR can restore anterior cable function
- Not an SCR
- Helps normalize superior migration
- Does not over-constrain the GHJ
- Provides static support to dynamic cuff
- ACR is placed in relation to the individual unique RC defect

ACR → Key points:

- ***Fix at 30ABD/30ER***
- Trough for biceps tendon → increased healing contact/stability
- Medial anchor → fixation around graft (NOT THROUGH)
- Allow forgiving fixation → adaptability with ROM
- Side-to-side suture → fixation around graft
- Lateral anchor for graft-end stability
Case Example

63 yo active woman

Supraspinatus tendon anterior cord with tissue loss and retraction
Case Example

Proximal biceps tendon available
Case Example
**Case Example**

**Key points →**
- Minimal OA
- Biceps intact
- Stage 2 or 3 defect
Case Example

Key points

- Stage 2 residual

Infra repair
Case Example

Key points →

- Bony trough
- Anchor at capsular attachment site

Cartilage margin

Trough

Anchor placed at articular margin
Case Example

Key points

- “Loop-around” fixation
Case Example

Key points →

- Fixation at: 
  ***30 ABD/30 ER***
Case Example

Lateral anchor for graft maintenance within bony trough

6 weeks post-op with FULL ACTIVE ROM

ACR supports the RCR
Discussion

New Technique

Long Head of the Biceps as a Suitable Available Local Tissue Autograft for Superior Capsular Reconstruction: “The Chinese Way”

Achilleas Boutsiadis, M.D., Ph.D., Shiyi Chen, M.D., Ph.D., Chunya Jiang, M.D., Ph.D., Hubert Lenoir, M.D., Philippe Delso, and Johannes Barth, M.D.

Arthroscopy Techniques 2017

Multiple suture-passes through tendon

Neutral rotation fixation

ACR Distinctions:

- “SCR”
- Tenotomy, then fixate
- Lasso-loops through tendon
- AP anchor location “just behind the bicipital groove”
- Humeral rotation not specified
- No formal trough
- RCR AFTER “SCR w/ LHBT”
- (ACR is done AFTER RCR in order to support unique RCR)
Discussion

**ACR Distinctions:**

- **Biceps re-routing** “SCR”
- **Tenotomy prn** (“if tendon integrity is not sufficient to maintain itself”)
- **Lasso-loops through tendon**
- **Lateral anchor** “midlateral aspect of footprint,” medial anchor at sulcus
- **Humeral rotation not specified**
- **No formal trough**
- **RCR AFTER “SCR” w/ biceps** (ACR is done AFTER RCR)

**New Technique**

*Arthroscopic In Situ Superior Capsular Reconstruction Using the Long Head of the Biceps Tendon*

Yang-Soo Kim, M.D., Ph.D., Hyo-Jin Lee, M.D., Ph.D., In Park, M.D., Ph.D., Gwang Young Sung, M.D., Dong-Jin Kim, M.D., and Jong-Ho Kim, M.D.

*Arthroscopy Techniques 2018*

**Biceps “re-routing”**

**Humeral rotation not specified**

**Side-to-side suture not mentioned**
Future Directions

- Should we routinely tenotomize the biceps?
- Indications based on tear size?
- Effect of SLAP tear?
- Healing, outcomes
- IRB

Oh et al, JBJS 2011
Thank you