Diagnosis of Proximal Bicep Tendon Pathology:

Commonly associated with other shoulder problems (SLAP, Supraspinatus and Subscapularis tears)
Tenosynovitis of the LHB tendon may occur with concomitant bursitis, rotator cuff tendonitis, SLAP, rotator cuff tear, and AC joint disorders, frozen shoulder (Neer), impingement or sometimes a combination of these conditions
However, may present as an isolated source of shoulder pain.
Diagnosis: combine history of anterior shoulder pain with pain to palpation over the intertubercular groove, and positive provocative biceps tendon tension tests.
Although recognized for >50 years, LBH tendonitis is increasingly recognized as a sole source of shoulder pain, or in combination with one (or more) of the aforementioned disorders

Pathophysiology

Commonly regarded as a degenerative process of the tendon, although not well substantiated
Blood supply – critical decrease of blood flow as tendon enters the bicipital groove
NOTE: The anterior-superior labrum and glenoid has an area devoid of vascular supply that is in the area of the anterior attachment of the biceps root which is likely to adversely affect the normal healing response, either following injury or surgery. (Abrassart et al, JSES 2006;15:232-238)
Mechanical forces -As the tendon is fixed to the superior labrum, it is subjected to shear forces, friction, traction, and pressure. Mechanical causes of biceps degeneration probably predominate (Refior JSES 1995)

Deposits of acid mucopolysaccharide and disorganized collagen (disrupted) at groove exit
Continued mechanical stress at narrow sites (distal biceps groove, under acromion, CA ligament, CHL area), and impingement under the CA arch with flexion may cause degeneration.
A thin rotator cuff may increase mechanical stress on the tendon, thus the hypothesis that those with cuff dysfunction (tendonitis, partial tears, or full tears) have an increased risk for LHB tenosynovitis (Refior JSES 1995)
Incidence is related to the extent of rotator cuff degeneration and 50% of biceps tendons do not have evidence of macroscopic evidence of disease at the time of arthroscopy (Murthi, JSES 2000)
There is also degeneration of the tendon at origin on the glenoid (SLAP area) – disorganized collagen
and increased mucoid may be precursors to problems in this area and ultrastructure changes may be visible.

**Innervation** - LHB tendon contains sensory and sympathetic fibers, especially proximally (Alpantaki *JBJS* 2005), possibly involved in the pathogenesis of shoulder pain. LHB tendons removed during arthroscopic tenodesis demonstrate less axons and less vascularity compared to controls obtained from cadavers. There was a moderate correlation (R=0.5) between LHB vascularity scores and pain scores (Singaraju, *JSES* 2008).

**Intraarticular pathology into groove** – The “hourglass” biceps has been described – hypertrophy observed and buckling found with elevation of the arm during arthroscopy – incarceration of the tendon. Excision of intraarticular portion (remove all diseased tendon) recommended via tenodesis.(Boileau *JSES* 2004). I have not recognized this unique pathology of tendon incarceration in my practice, but maybe it has seen me…I will keep looking…

From Boileau *et al.* *JSES* 2004, 13:249-57

**Physical Exam**

**Tenderness**
- over the intertubercular sulcus (most common finding)
  - Rotate arm to 10 degrees on IR, palpate 7 cm below acromion, tenderness should move laterally with external rotation to differentiate from subcoracoid impingement.
  - Tenderness below the pectoralis major tendon at the level of the axilla

**Impingement Tests**
- Neer, Hawkins- Often painful (sensitive, but not specific)
- Flexion / Internal Rotation (Gerber)

**Biceps Instability Test**
- Full abduction + External Rotation
- Painful Click, palpable

**Yergason’s Test (JBJS-A 1931)**
- Elbow flexed at 90 resist supination while palpating proximal biceps

**Compression Rotation Test**: looking for SLAP lesions in younger patients
Supine, Abduct to 90 degrees, compression (Analogous to McMurray’s compression test)

Evaluation of Subscapularis Tendon

- Gerber Lift Off
- Belly – press test (Resch)
- Speeds Test-Pain with resisted forward flexion, palm up (supinated forearm)
- O’Briens Test-Pain with resisted arm flexion and adduction in pronation rather than supination

Special Tests

Selective injections

Begin with subacromial injection
- Associated impingement syndrome or rotator cuff tears may dramatically improve with subacromial injection.

If biceps pain persists, consider injection into biceps tendon sheath
If considering SLAP, intraarticular injection as a test or temporary relief.

**Imaging studies**

Plain radiographs

- Standard series
- “Groove view” by Cone (historical value)
  - Demonstrates depth and width of groove
  - Patient supine, arm in external rotation
  - X-ray beam directed cephalad + 15 degrees medial to long axis of the humerus

Arthrogram

- Outline of tendon and sheath suggest no inflammation
- Absent in > 30%
- Loss of contour may suggest inflammation / synovitis

MRI

- Visualize bicep, bicep groove, bony osteophytes, fluid; most studies are not precise, accurate and of high enough quality to get consistent information in the community setting; Centers with dedicated Shoulder Radiologists seem to report better information (often Level 5 evidence, occasionally level 4)
- Evaluation of SLAP lesion remains a challenge for many (< 70% accurate)

MRI with arthrogram

- Improved accuracy for partial-thickness rotator cuff tears, small full-thickness rotator cuff tears, recurrent tears after surgery, SLAP lesions, biceps lesions - most of us believe this gives us more information, but the truth is, we currently have no idea if the additional information is changing the way we manage biceps pain beyond what we learn clinically and arthroscopically. Indirect contrast (IV versus intraarticular injection) and High Resolution MRI (T3 magnets) are gaining popularity.

Ultrasound

- Excellent for LHB subluxation and dislocation, unreliable for intra-articular partial thickness tears (Armstrong *JSES* 2006); definitely an underutilized imaging method in the USA.

**Treatment**

Tendonopathy

Initial treatment is based on the principles of treating tendinopathy.

Rest, ice, NSAID’s, activity modification
Physiotherapy, +/- modalities such as ionophoresis (not much scientific support)
Cortisone injection(s) if initial treatment unsuccessful
  Begin with subacromial; if biceps remains systematic, then inject biceps sheath
  May consider intraarticular injection
  May precipitate bicep tendon rupture (does not directly cause rupture)

Bicep Tendon rupture - ACUTE
  Operative vs. Nonoperative
    No change in elbow flexion strength
    10-20% loss of supination strength
    Change in shoulder function for overhead throwers is likely/possible
    Recent abstract/presentation (Hawkins) did not demonstrate strength deficit after recovery from initial event

Biceps Tendon rupture – CHRONIC
  May present to your clinic with fatigue pain complaints – do well for the first 30-60 minutes of work and then becomes increasingly painful with markedly decreasing lifting capabilities
  I consider operative tenodesis of the chronic proximal LHB rupture in laborers, heavy lifters, and those that complain of shoulder fatigue pain not related to another diagnosis.

Bicep Tendon instability – operative intervention (treat the associated pathology – think SSc tear or other rotator cuff tear)

SLAP lesion – operative intervention
  Overhead athlete (posterior release? Anterior Capsulorrhaphy?)
  Athletes in association with an instability lesion (Bankart)
  Work comp injury, especially secondary to “traction” → Bicep tenodesis, +/- labral repair
  (In my practice, results in terms of return to work after SLAP repair alone for a work related injury are Fair/Poor – much different than a sports-related injury)

Surgical Treatment

Tenotomy Versus Tenodesis

Results:
  Frost, Zafar, Maffulli. AJSM 2008
  Systematic Review of Literature
  Low quality of evidence: 1 RCT, 7 prospective cohort studies, 11 retrospective cohort studies(Coleman Methodology Score 58 ± 14)
  Lack of evidence to advocate one technique over the other
TABLE 4

<table>
<thead>
<tr>
<th>Article</th>
<th>Osbahr24</th>
<th>Edwards12</th>
<th>Boileu9</th>
<th>Paulos28</th>
<th>Franceschi13</th>
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<td>RCT and SAD</td>
<td>RCT</td>
<td>SLAP lesion and RCT</td>
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<td>Excellent/good outcome</td>
<td>Generally good</td>
<td>Beneficial effect from surgery</td>
<td>65%</td>
<td>83% reasonable outcome</td>
<td>100%</td>
<td>All significant improvement in UCLA score</td>
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<td>Poor outcome</td>
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<td>Few poor</td>
<td>11%</td>
<td>16% still had pain over biceps</td>
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<td>Increased PS in tenotomy no other differences</td>
<td>None</td>
<td>Tenotomy group better function and satisfaction</td>
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<td>80/59</td>
<td>21/21</td>
<td>67/65</td>
<td>79/75</td>
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</table>

*RCT, rotator cuff tear; SAD, subacromial decompression; SLAP, superior labrum anterior and posterior; UCLA, University of California–Los Angeles; PS, Popeye sign.

Retrospective Cohort Study
72 shoulders with irreparable RCT treated with tenodesis (N=39) or tenotomy (N=33)
78% Satisfied, Constant Murley 66.5
Healthy-appearing Teres Minor increased ER and greater Constant score (P<0.05)

63 shoulders RCT with Type 2 SLAP over 50 years, followed 2.9 years
Group 1(RCR + SLAP): 27.9 vs. Group 2(RCR + LHB tenotomy): 32.1 (P<0.05)
RCR
22 shoulders with arthroscopic tenodesis incorporated into RCR, followed 47,2 months
Group 1 (tenodesis without tenotomy): UCLA 33
Group 2 (tenodesis with tenotomy): UCLA 32.9
No differences between groups

**Arthroscopic Treatment of Type II SLAP Lesions: Biceps Tenodesis as an Alternative to Reinsertion**
Level 3 Cohort Study
Inclusion criteria: Isolated type II SLAP tear with activity related pain that failed conservative treatment
Exclusion criteria: GH instability, RCT, posterosuperior glenoid impingement, biceps tendinopathy, prior shoulder surgery
SLAP repair group (N = 10, mean age 37 yrs): Constant 65 to 83 pts, 60% disappointed due to persistent pain, 20% return to previous level of sport, 4 pts failed and revised to biceps tenodesis
Biceps tenodesis group (N = 15, mean age 52 yrs): Constant 59 to 89 pts, 93% satisfied / very satisfied, 87% return to previous level of sport
Conclusions: Biceps tenodesis is an effective alternative to SLAP repair, BUT sig difference in age b/w two groups
Recommendation: SLAP repair under 30 yrs, biceps tenodesis over 30 yrs

Tenotomy
Indications: Bicep pathology
Multiple Severe co-morbidities (can not tolerate tenodesis)
Contraindication for tenodesis
Results:
Mean ASES score: 81.8
Significant reduction in pain and improvement in function
Complication rate 13.3%
No statistically significant difference between tenotomy and tenodesis

30% incidence of cosmetic change with tenotomy

54 patients with arthroscopic release of LHB (some concomitant procedures)
70% had Popeye sign (at rest or during flexion) – 87% men and 36% women
68% rated E/VG/G.
**38% complained of fatigue discomfort after resisted elbow flexion**

Many others that suggest tenotomy is effective for relief of pain related to biceps

Open Tenodesis
Performed for > 50 years
Variety of techniques and procedures
54 shoulders, followed 13 years. Found persistent pain in 1/3 of the patients
15 shoulders keyhole tenodesis, followed 7 years. Up to 60% success.
Local anesthetic injection prior to the operation valuable in determining Success

50 shoulders subpectoral biceps tenodesis, followed 29 months.
ASES 81 (89 without RCT vs. 78 with RCT),
Arthroscopic Tenodesis

Indications:
- Bicep pathology
- Avoid / treat cramping and discomfort with strenuous use of bicep
- Maintain muscle length
  - Blix curve: the greatest muscle contraction occurs when the muscle is at
    its normal resting length

Cosmesis

Techniques:
- Suture to intact rotator cuff (eg. PITT technique - Rodowsky)
- Incorporate into rotator cuff repair
- Transfer to coracoid process (Obrien)
- Suture anchors in bicipital groove (Gartsman, Snyder, others)
- Interference screw (Boileau/Walch, Burkhart, Romeo/Mazzocca)
Arthroscopic Tenodesis with Interference Screw Fixation

Cut Tendon Intraarticularly

Move arthroscope to subacromial space, lateral portal. Find falciform ligament of pectoralis tendon and underneath is the biceps tendon.

Localize accessory anterior portal with a spinal needle and remove tendon trough skin

Remove 20mm of proximal tendon. This eliminates diseased tendon from the tenodesis as well recreates an anatomic fit. Whip stitch or Krakow tendon stitch 15mm in tendon

Localize Intertubercular groove and insert 2mm guide wire. Ream over guide wire with 7 or 8mm cannulated reamer to a depth of 30mm.
Take tendon out of accessory anterior portal and insert one suture through screw and tenodesis driver

Draw tendon tight against driver and insert into bone tunnel

Use arthroscopic knot pusher to tie suture over the top of the tenodesis screw. This technique establishes interference screw and suture anchor fixation.
**Mini-Open Bail Out**

Extend accessory anterior portal at the level of the Intertubercular groove. Be aware of location of axillary nerve. Insert 2mm guide wire, and ream to 30mm

Withdraw tendon from biceps groove and place #2 Fiberwire (Arthrex Inc) in a Krakow type whipstitch. Insert screw and tie knot over the top.
Open Subpectoral Tenodesis - preferred choice


Advantages:
- Tendon marked arthroscopically and tenotomized at origin
- Subpectoral approach is utilized (2 cm incision) near axillary fold longitudinally
- Tenodesed with bioabsorbable interference screw fixation deep to pectoralis tendon
- Relevant anatomy is clearly identified
- Very efficient and reproducible with “easy learning curve”
- Removes tendon from confines of intertubucular groove and synovium associated (which may be cause of persistent pain)

Procedure:
- Evaluate biceps “dry” upon initial scope to evaluate inflamed tendon
- Draw biceps tendon into joint (looks at portion in the groove)
- Fraying almost always indicative of pathologic tenosynovitis
- Tenotomize at base

Tenotomize at base. Debride SLAP area if necessary. Open incision - 1 cm superior to inferior border of pectoralis major tendon, continue 2-3 cm below inferior border OR, place in axillary crease for best cosmesis.
Identify inferior border of pectoralis major, dissect below this level, and the sheath needs to be gently incised directly over the tendon. Palpation will identify the longitudinal structure of the biceps. Blunt Chandler is placed medially (watch musculocutaneous n.) Use right angle to identify tendon and retract out of the wound. Whip-stitch into most proximal 15 mm of the tendon, adjacent to the musculotendinous border (critical for tensioning and cosmesis)

Biotenodesis (Arthrex, Naples, FL) screw system is utilized to fix in place using 8 mm x 12 mm interference screw.

Complications
Over 3 yrs, 8 of 373 Biceps Tenodesis had complications with incidence of 0.71% per year.
   2 pts (0.18%) with persistent bicipital pain
   2 pts (0.18%) with failure of fixation with Popeye deformity
   1 pt (0.09%) with deep wound infection
   1 pt (0.09%) with temporary musculocutaneous neuropathy
   1 pt (0.09%) with RSD
   1 pt (0.09%) with proximal humerus fracture

**Postoperative protocol**

Sling x 4 weeks during sleep, during work for 2-3 weeks
Discontinue sling completely at 4 weeks (if isolated procedure)
Overall protocol and sling frequently dictated by concomitant procedures
Progress full PROM (x 6 weeks) to active ROM
Start elbow range of motion and grip strength (immediately)
Avoid supination strengthening and active elbow flexion for 4 weeks
May resume light work at 3-4 weeks depending on job, sooner if less demand.


**Biomechanics of Proximal Biceps Tenodesis** (Bone versus Soft Tissue Fixation)


Summary:

**What are the loads on the biceps tendon?**

Difficult to fully characterize – *in vivo* determination of LHB force

To maintain weight of forearm at 90 degrees to hold a 1 kg object is 112 N (Nordin 2001)

Thus, it is generally inferred from biomechanical failure studies.

Almost all have shown failure at the bicipital-labral complex with progressive loads in several models

Force required to cause failure of superior labral complex is 289 +/- 39 N (Arm in ABER, Kuhn 2003)

External/internal rotation with rapid change in position of the humeral head affect magnitude of tension in biceps (Yeh AJSM 2005), deceleration caused the highest stress/load.

Ultimate strength in a simulated biomechanical model was 508 N (+/- 134N) in deceleration, 262 (+/- 88N) in late cocking (Shepard AJSM 2004). All failed by generation of a SLAP II injury.

Kuhn demonstrated failures of 289 N in late cocking, vs. 346 N in deceleration. (Kuhn Arthroscopy ‘03)

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![Loading Conditions and Maximum Principal Stresses Under Different Phases of Throwing and Origins of the Long Head of the Biceps Tendon](image)

(From Yeh, AJSM 2005)

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**Interference screw technique:**

- Highest ultimate load to failure (NO Question; you want strong fixation, this is it)
- Least amount of displacement with cyclical loading
- Most rapid healing (increase fixation strength at 3 weeks in sheep model)
- High clinical success in multiple studies (85 – 90%)


Biceps tenodesis with interference screw is stronger than double suture anchor

Mazzocca *Arthroscopy* 2005:1296-1306

Interference screw demonstrated least amount of displacement (versus open bone
tunnel, suture anchor)
Kilicoglu AJSM 2005: 1536-44
Sheep shoulder study – Fixation improved over time (healing?), tenodesis screw exhibited higher failure at week 3 versus day 0 (419 N versus 164 N). Tenodesis screw fixation improves over time

**Suture anchors:**
- Less fixation strength at time zero and 3 weeks (however, it often is “enough” based on published clinical studies)
- Less resistance to displacement with cyclical loading

**Recommended Reading**
Zanetti M, Weishaupt D, Gerber C, Hodler J. Tendinopathy and rupture of the tendon of the long head of the biceps brachii.

**Distal Biceps Fixation:**

**Biomechanical Evaluation of 4 Techniques of Distal Biceps Brachii Tendon Repair**
Augustus D. Mazzocca, Kevin J. Burton, Anthony A. Romeo, Stephen Santangelo, Douglas A. Adams and Robert A. Arciero

![Figure 2](image_url)  
**Figure 2. Suture anchor repair technique.**

![Figure 4](image_url)  
**Figure 4. Interference screw technique.**

![Figure 3](image_url)  
**Figure 3. Endobutton technique.**

![Figure 5](image_url)  
**Figure 5. Testing apparatus with 50-N load and permitting 0° to 60° arc of motion.**

**Anatomical Repair of the Distal Biceps Tendon Using the Tension-Slide Technique**

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