BIOMECHANICAL COMPARISON OF A NOVEL BICEPS TENODESIS TECHNIQUE

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Disclosures

- I have no disclosures

Biomechanical Comparison of a Novel Biceps Tenodesis Technique

- Proximal biceps tenodesis is a well described and accepted treatment option for various symptomatic long head biceps related pathologies
  - *potentially preserves elbow flexion and supination as well as cosmesis vs tenotomy*
- Subpectoral interference screw fixation is a commonly used technique given the abundance of literature supporting its excellent fixation strength reliable clinical outcomes in pain reduction, functional improvement
  - *post-operative fracture*

Unicortical Button

- Decreased cortical violation and thus reduced fracture risk makes this an attractive alternative to interference screw fixation

Distal biceps tendon repairs

- *Chavan 2008, Sethi 2010*
  - UCB outperformed IS

Proximal Biceps Tenodesis

- *Arora 2013, Deangelis 2015*
  - UCB equivalent with IS
- *Sethi 2013*
  - Ultimate load to failure significantly higher in IS group vs UCB

Unicortical Button + Suture Anchor Augmentation

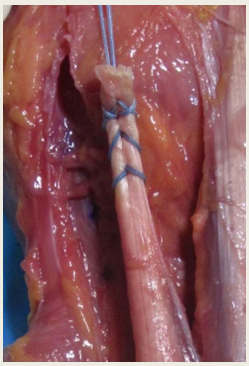
- **Purpose:** To compare the biomechanical characteristics of a novel subpectoral biceps tenodeses technique using unicortical button with suture augmentation to previously described fixation methods, specifically solitary unicortical button fixation and interference screw fixation.
- We hypothesize the unicortical button with suture anchor augmentation (SAA) will have ultimate failure load strengths greater than unicortical button alone (UB) and equivalent to that of interference screw fixation (IS)

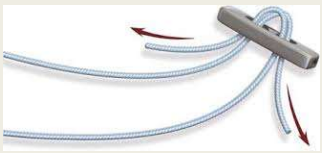
Methods

- Twenty-six fresh-frozen human cadaveric shoulders (13 matched pairs) were included
- Specimens were divided into two study groups:
  - *1. UB (n=6) versus IS (n=6)*
  - *2. UB (n=7) versus UB +SAA (n=7)*
- All soft tissue structures were dissected leaving only the long head biceps tendon and muscle belly remaining
- A computer generated randomization system was used to assign laterality for fixation method to be performed in each pair

Tendon Preparation

- All tendons detached from glenoid and resected proximal to the musculotendinous junction
  - *UCB, UCB+SAA = 2cm*
  - *IS = 2.5cm*
- Modified whipstitch created using No. 2 FiberLoop (Arthrex, Naples, FL)
  - *UCB/UCB+SAA*
    - Each suture limb passed in opposite directions through a unicortical proximal tenodesis button (Arthrex, Naples, FL) to create a tension slide
  - *IS*
    - Suture limbs passed through eyelet of 8x23 Biocomposite screw (Arthrex, Naples, FL)

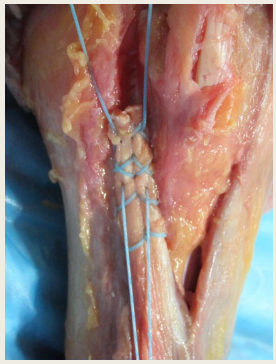




Tension slide technique

Tunnel Preparation/Fixation

- UCB
  - *unicortical hole was created using a 3.2-mm spade-tip drill approximately 4 cm distal to the lesser tuberosity*
  - *Alternating tension was applied to each suture limb to flip the button on the underside of the cortex and shuttle the tendon flush to the bone. A free needle was then used to pass each suture limb back through the tendon and tied with a surgeon's knot.*
- UCB+SAA
  - *1.6mm drill hole ~1cm distal to above. FiberTak all suture anchor (Arthrex, Naples, FL) manually placed. One limb of each suture passed through the tendon prior to advancing the tendon to the bone via UCB tension slide technique as described above*

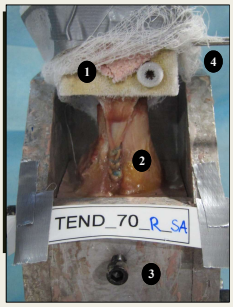


Tunnel Preparation/Fixation

- IS
  - *An 8-mm reamer used to open the anterior cortex 4cm below the lesser tuberosity*
  - *The screw was placed superior to the tendon in the bone tunnel until it was flush with the cortical bone.*
  - *The tendon suture limbs were passed back through the tendon and secured to the suture limb through the screw with a surgeons knot*

Testing Apparatus

- Each humeri was resected to the proximal 1/3 of the shaft.
- Testing was conducted by placing the humerus in an inverted fashion into high strength resin coupled to an MTS Bionix test frame (MTS Systems, Eden Prairie, MN).
- The biceps tendon was attached to the MTS actuator with a cryoclamp and tensile forces were applied parallel to the long axis of the humerus.



Descriptive illustration of test setup

1.) Brass cryoclamp used to grip biceps tendon. Freezing of the tendon inside the clamp was accomplished with dry ice;

2.) Inverted humerus potted in high-strength resin;

3.) Aluminum potting box coupled to test frame;

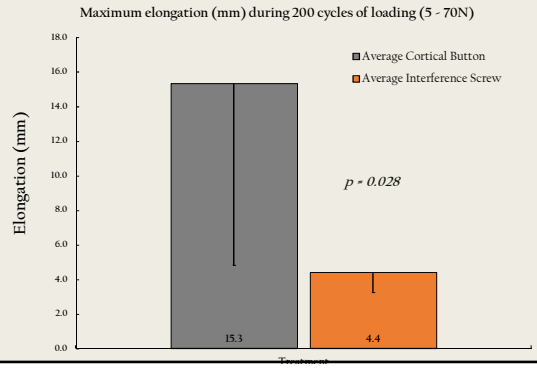
4.) Thermocouple probe – failure testing commenced when the temperature inside the cryoclamp measured -22°C.

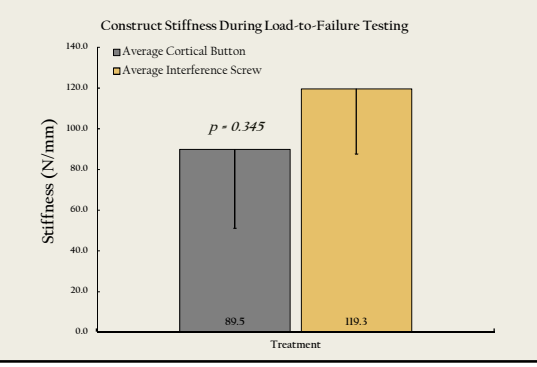
Testing Protocol

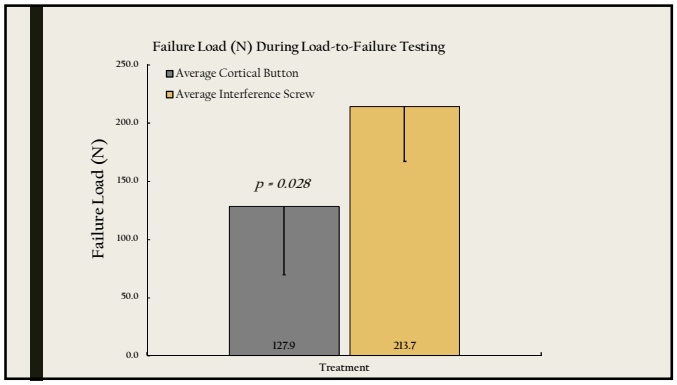
- Testing included 3 phases:
  - *preconditioning (static 5N load for 2 mins)*
  - *dynamic loading (5-70N for 200 cycles at 0.5 Hz)*
  - *ramp to failure (1 mm/s).*
  - *Maximum elongation during cyclic loading (mm), repair stiffness (N/mm), failure load (N) and failure mode were recorded for each construct and compared between test groups.*
- All parameters were compared in the matched pair components of this study (UB vs SAA and UB vs IS) as well as across the SAA vs IS repairs
- A non-parametric Wilcoxon Signed-Rank test was used for all statistical comparisons between groups.

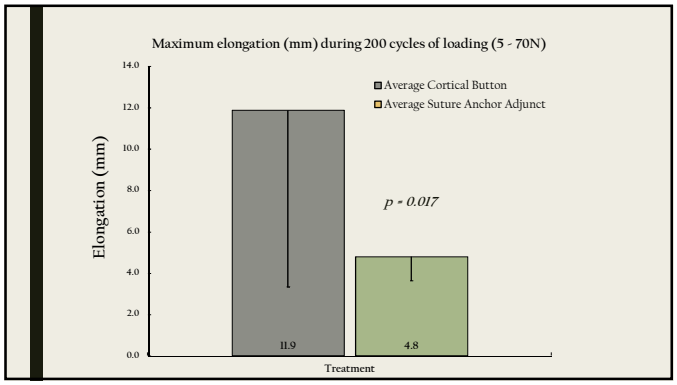
Results

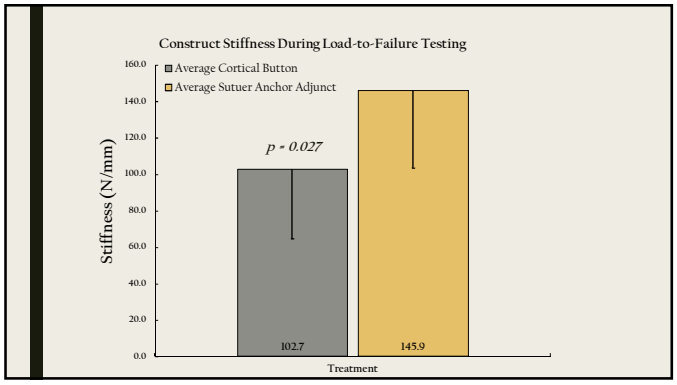
- There was no statistical difference in demographics of the humeri with respect to age, gender height, weight, BMI within or between comparison groups
- Matched pair comparisons:
  - *Both the IS and SAA outperformed UCB in all parameters*

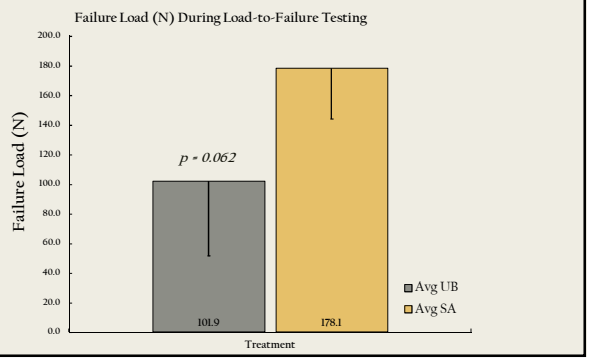





Failure Load (N) During Load-to-Failure Testing
Average Cortical Button
Average Interference Screw
Failure Load (N)
250.0
200.0
150.0
100.0
50.0
0.0
p = 0.028
127.9
213.7
Treatment


Maximum elongation (mm) during 200 cycles of loading (5 - 70N)
Average Cortical Button
Average Suture Anchor Adjunct
Elongation (mm)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
p = 0.017
11.9
4.8
Treatment


Construct Stiffness During Load-to-Failure Testing
Average Cortical Button
Average Sutuer Anchor Adjunct
Stiffness (N/mm)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
p = 0.027
102.7
145.9
Treatment

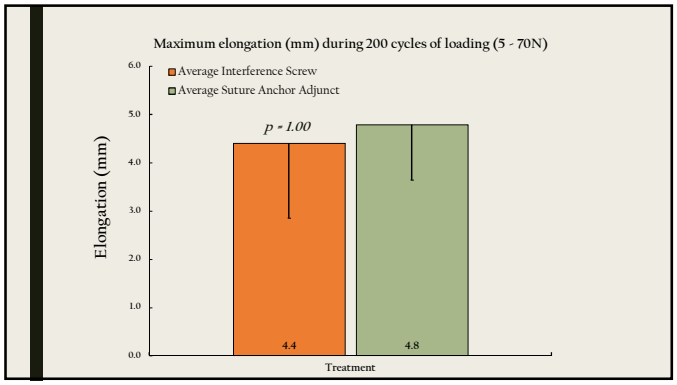


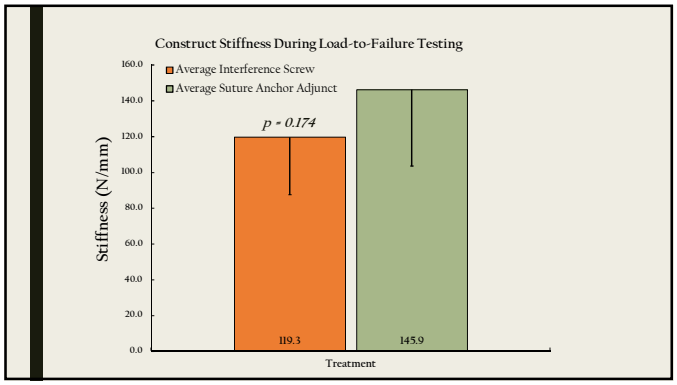
Results

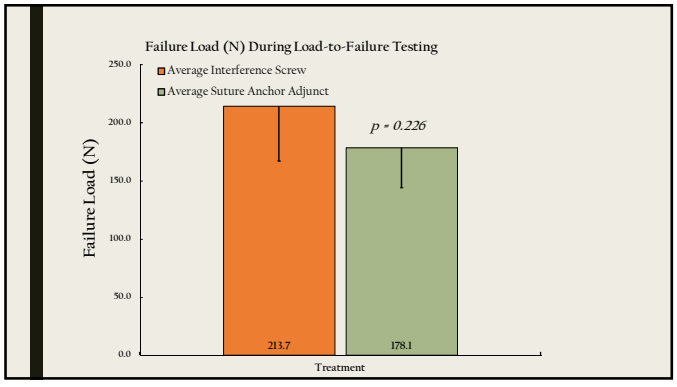
	Group 1		Pvalue	Group 2		Pvalue
	IS	UB	Pvalue	SAA	UB	Pvalue
Elongation (mm)	4.4 ± 1.5	15.3 ± 10.5	0.028	4.8 ± 1.1	11.9 ± 8.5	0.018
Stiffness (N/mm)	119.3 ± 89.5	89.5 ± 38.5	0.345	145.9 ± 42.4	102.7 ± 37.9	0.028
Ultimate Failure Load (N)	213.7 ± 46.6	127.9 ± 58.3	0.030	**178.1 ± 33.9**	101.9 ± 50.1	0.062

Results

- Cross group comparison (SAA vs IS):
  - ***NO statistical differences between UCB+SAA vs IS in any parameter***
- SAA group versus IS group
  - *Elongation: 4.8 ± 1.1 vs 4.4 ± 1.5*
  - *Stiffness: 145.9 ± 42.4 vs 119.3 ± 89.5*
  - *Ultimate load to failure:* ***178.1 ± 33.9 vs*** *213.7 ± 46.6*


Maximum elongation (mm) during 200 cycles of loading (5 - 70N)
Average Interference Screw
Average Suture Anchor Adjunct
p = 1.00
Elongation (mm)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4.4
4.8
Treatment


Construct Stiffness During Load-to-Failure Testing
Average Interference Screw
Average Suture Anchor Adjunct
p = 0.174
Stiffness (N/mm)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
119.3
145.9
Treatment

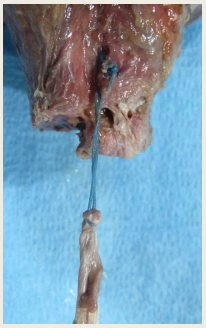

Failure Load (N) During Load-to-Failure Testing
Average Interference Screw
Average Suture Anchor Adjunct
p = 0.226
Failure Load (N)
250.0
200.0
150.0
100.0
50.0
0.0
213.7
178.1
Treatment

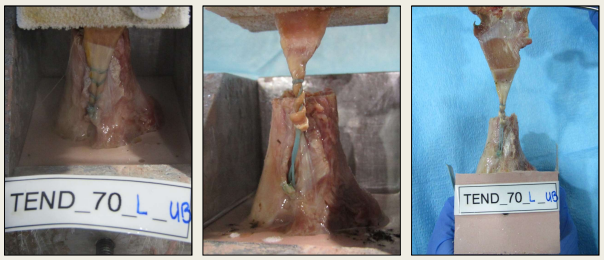
Results

	IS	SAA	Pvalue
Age			
Elongation (mm)	4.4 ± 1.5	4.8 ± 1.1	1.00
Stiffness (N/mm)	119.3 ± 89.5	145.9 ± 42.4	0.174
Ultimate Failure Load (N)	213.7 ± 46.6	**178.1 ± 33.9**	0.226

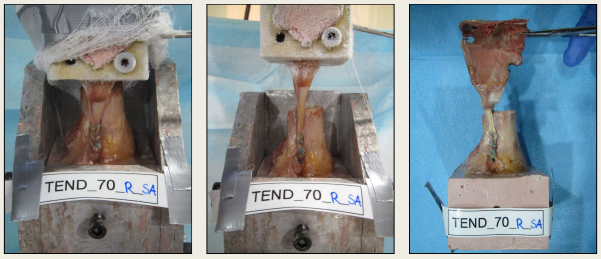
Modes of Failure

- UCB
  - *Suture-tendon*
- UCB+SAA
  - *Suture-tendon*
- IS
  - *Screw pullout*

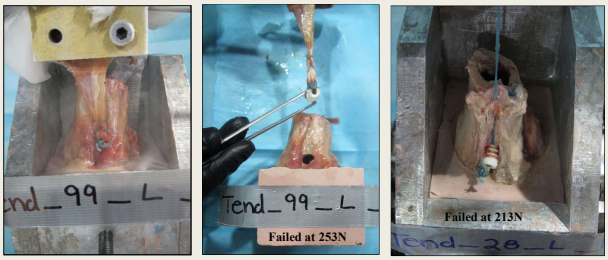




Unicortical button test specimen. Left – pretesting; Middle – after failure testing; Right – after testing and off the load frame. This test specimen did not survive 200 cycles of loading from 5 – 70 N and failure was manifested as progressive suture unraveling around the tendon.



Suture Anchor Augment test specimen. Left – pretesting; Middle – after failure testing; Right – after testing and off the load frame. Failure was manifested as suture pulling/tearing through the biceps tendon.



Interference Screw test specimens. Left – pretesting; Middle – after failure testing and off the test frame; Right – after testing and off the load frame. For this particular specimen, the interference screw was pulled out of the cortical hole. Right – another noted failure mechanism in the IS repair group. Failure was a combination of suture tearing through the tendon and screw pull out from the cortical hole.

Discussion

- Pitfalls
  - *May not completely replicate all biomechanical forces in clinical setting*
    - by replicating the testing methods previously described in prior studies, our results can be accurately compared from a purely biomechanical standpoint

Cross-Study Comparison

	Ultimate Load to Failure (N)				
	IS	UCB+SAA	UCB	BCB	IS+BCB
Gasser 2016	213.7 ± 46.6	**178.1 ± 33.9**	127.9 ± 58.3 (1) 101.9 ± 50.1 (2)		
DeAngelis 2015	191±64		183.61±61		
Arora 2013	205.64±66.86		174.22±37.59	169.11±15.94	196.74±58.03
Sethi 2013	275 ± 56 (7mm) 277.1±42 (8mm)			99.4±16.9	237.8±120.4
	Elongation (mm)				
Gasser 2016	4.4 ± 1.5	**4.8 ± 1.1**	15.3 ± 10.5 (1) 11.9 ± 8.5 (2)		
DeAngelis 2015	3.7± 2.2		1.9± 1.0		
Arora 2013	6.8± 9.69		8.88± 7.52	10.87± 7.52	3.25± 2.02
Sethi 2013	8.7±5.7(7mm) 8.68.7±5.2(8mm)			14.5± 7.9	9.4 ± 2.1

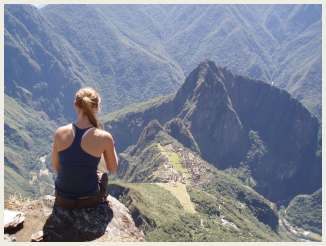
Discussion

- Pitfalls
  - *Does not account for strength provided by biologic healing*
    - When performing this technique in the operative room, the groove is roughened to create a bleeding bed for which the tendon to lie. Two points of fixation furthermore allows for a larger bone-to-tendon surface contact area compared to single point fixation
    - We theorize that these two factors may improve repair healing and thus ultimately increase strength and decrease failure rates

Conclusion

- The novel subpectoral biceps tenodesis technique of unicortical button fixation with suture augmentation biomechanically outperforms solitary unicortical button fixation and is equivalent to that of standard interference screw fixation.
- Theoretical advantages over other techniques include reduced fracture risk and improved biologic healing
- Further clinical studies needed

Thank You



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