Biceps Tenodesis with Interference Screw Fixation: A Biomechanical Comparison of Screw Size and Technique

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Introduction
Numerous surgical procedures have been developed to address pathology associated with the long head of the biceps tendon. Tenodesis might be preferred over tenotomy for several reasons, including improved cosmetic appearance, maintenance of elbow flexion and supination strength, and maintenance of the biceps muscle length-tension relationship.

To our knowledge, there have been no studies evaluating the fixation stability of biceps tenodesis either proximally or distally in relation to screw diameter or length. The objective of this study was to compare the cyclical and ultimate pullout strength of interference screws of different size and length at both proximal and distal insertion sites.

Materials and Methods
Forty-two fresh-frozen human cadaveric shoulders (22 left, 20 right, 16 male, 26 female, mean age 65 ± 9 years) were thawed at room temperature prior to dissection, repair, and testing. Specimens were randomly divided into 6 groups of similar BMD, with 7 specimens in each group as follows:

Arthroscopic interference screw technique:
- Group 1: 7x15 mm screw
- Group 2: 7x25 mm screw
- Group 3: 8x15 mm screw
- Group 4: 8x25 mm screw

Mini-Open interference screw technique:
- Group 5: 7x15 mm screw
- Group 6: 8x15 mm screw

Surgical Technique for Groups 1-4 – Arthroscopic Approach
All specimens in Groups 1-4 were prepared utilizing the same arthroscopic surgical technique, with the screw size differing on the group. This technique utilized a PEEK soft tissue interference screw (Biceptor, Smith & Nephew, Inc., Andover, MA) for fixation of the biceps tendon, according to a previously published surgical technique.

Surgical Technique for Groups 5-6 – Mini-open Approach
Only the 15mm interference screws were used in the mini-open location, since the location does not accommodate a 25mm screw. The technique for screw insertion was identical to the above listed procedure, with the exception that 8mm drill holes were used for both the 7x15mm and 8x15mm interference screws to accommodate the thicker distal biceps. The location of the interference screw for the mini-open approach was 1 cm proximal to the inferior border of the pectoralis major tendon.

Biomechanical Testing
Using a custom cryogenic grip and a materials testing system (MTS Insight 5, Eden Prairie, MN), the following test parameters were applied to each specimen: preload at 5 N for 2 minutes, followed by cyclical loading for 500 cycles from 5 to 70 N at 1 Hz, followed by a pull to failure test at 1 mm/sec.

Cyclical displacement was calculated as the peak actuator displacement of cycle 500 relative to that of cycle 1. Data computed from the failure test included ultimate load, linear stiffness, displacement at peak load and method/location of graft failure.

Statistical analysis was performed using GraphPad Prism 5 (GraphPad Software Inc., La Jolla, CA). 1-way ANOVA was used to compare the age, bone mineral density, tendon width, cyclical and failure data among the six experimental groups, followed by Tukey’s post-hoc analysis for multiple comparisons between each of the groups, when appropriate. Results were considered statistically significant at p < 0.05.

Results
Randomization into the 6 groups resulted in no statistical difference (p=0.97) in the BMD at either the proximal humerus (mean across groups, 0.50 ± 0.14 g/cm²) or proximal diaphysis (0.55 ± 0.15 g/cm²).

Seven specimens failed during the cyclical testing; two in the proximal 7x15 group (cycle 120 & 410), two in the distal 8x15 group (cycle 30, 119), one each in the proximal 8x15 group (cycle 22), proximal 8x25 group (cycle 497), and distal 7x15 group (cycle 210).

Each of these samples failed at the tendon/screw interface. Therefore, data are not reported for these specimens.

Cyclic testing: The mean cyclic displacement for each of the groups is illustrated in Figure 1. There was a statistically significant difference in the displacement between the 8x15 proximal group relative to that of the proximal 7x25 (p=0.008), proximal 8x25 (p=0.002), and distal 8x15 (p=0.004) groups. While there was a statistically significant difference in the cyclical displacement between the 8x15 proximal group relative to that of the 8x25 (p=0.002), there were no differences between the proximal 7x15 and 7x25 screws (p=0.05) nor between the two types of distally placed screws.

Failure testing: There was no significant difference in the pullout stiffness among any of the fixation locations or screw sizes. Similarly, there were no significant difference in the ultimate load to failure for any of the groups. All failures occurred at the tendon/screw interface. There were no humeral fractures or failures of the biceps tendon.

Discussion
Despite differences in loading parameters utilized during testing, the available literature suggests superior properties for interference screw fixation relative to suture anchor fixation. To our knowledge, there are no studies evaluating the fixation of different interference screw sizes and lengths for biceps tenodesis.

The findings of our study indicate that gap formation is increased with shorter screws at the proximal tenodesis site. 8x15mm screws showed statistically significant more gap formation than longer screws (7x25 and 8x25mm). Distally there was no difference in gap formation between smaller and larger screws (7x15 vs 8x15mm). Ultimate load to failure after cyclical loading was also shown to have no statistical difference between screw sizes and length either proximally or distally.

In summary, our study indicates that there is increased gap formation with shorter interference screw sizes in the proximal or distal tenodesis site. There were no differences in either gap formation or load to failure at the proximal or distal tenodesis site. No difference in ultimate load to failure was seen between any of the screw sizes or lengths at either proximal or distal sites. According to the subfailure (cyclical) testing, we therefore recommend longer screws for proximal tenodesis in the softer metaphyseal bone. Distally, screw diameter can be chosen to best accommodate humeral and tendon size.

References

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