The PASTA Bridge – A Repair Technique for Partial Articular-Sided Rotator Cuff Tears: A Biomechanical Evaluation of Construct Strength

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Take-Home Points

- The PASTA Bridge is biomechanically equivalent to the gold-standard transtendon repair technique.
- The configuration is a double-row repair, increasing the number of fixation points.
- The lateral anchor of the PASTA Bridge assumes the stress of the repair, allowing the medial anchors to act as pivot points.
- The PASTA Bridge is strong and capable of withstanding excessive forces.
- The PASTA Bridge poses less risk of complication.

Rotator cuff tears can be classified as full-thickness or partial-thickness; the latter being further divided into the bursal surface, articular-sided, or intratendinous tears. A study analyzing the anatomical distribution of partial tears found that approximately 50% of those at the rotator cuff footprint were articular-sided and predominantly involved the supraspinatus tendon. These partial-thickness articular-sided supraspinatus tendon avulsion tears have been coined “PASTA lesions.” Current treatment recommendations suggest that a debridement, a transtendon technique, or a “takedown” method of completing a partial tear and performing a full-thickness repair be utilized for partial-thickness rotator cuff repairs.

The primary goal of a partial cuff repair is to reestablish the tendon footprint at the humeral head. It has been argued that the “takedown” method alters the normal footprint and presents tension complications that can result
in poor outcomes. Also, if the full-thickness repair fails, the patient is left with a full-thickness tear that could be more disabling. The trans-tendon technique has proven to be superior in this sense, demonstrating an improvement in both footprint contact and healing potential. This article aims to evaluate the biomechanical effectiveness of a new PASTA lesion repair technique, the PASTA Bridge, when compared with a traditional transtendon suture anchor repair.

Materials and Methods

Biomechanical Operative Technique: PASTA Bridge Repair

A 17-gauge spinal needle was used to create a puncture in the supraspinatus tendon approximately 7.5 mm anterior to the centerline of the footprint and just medial to the simulated tear line. A 1.1-mm blunt Nitinol wire (Arthrex) was placed over the top of the spinal needle, and the spinal needle was removed. A 2.4-mm portal dilation instrument (Arthrex) was placed over the top of the 1.1 blunt wire (Arthrex) followed by the drill spear for the 2.4-mm BioComposite SutureTak (Arthrex). A pilot hole was created just medial to the simulated tear using the spear and a 1.8-mm drill followed by insertion of a 2.4-mm BioComposite SutureTak (Arthrex). This process was repeated approximately 5 mm posterior to the centerline of the footprint. A strand of suture from each anchor was tied in a manner similar to the “double pulley” method described by Lo and Burkhart. The opposing 2 limbs were tensioned to pull the knot taut over the repair site and fixed laterally with a 4.75-mm BioComposite SwiveLock (Arthrex) placed approximately 1 cm lateral to the greater tuberosity.

Biomechanical Operative Technique: Control (4.5-mm Corkscrew FT Group)

A No. 11 scalpel was used to create a puncture in the tendon for a transtendon approach. A 4.5-mm titanium Corkscrew FT (Arthrex) was placed just medial to the beginning of the simulated tear. The No. 2 FiberWire (Arthrex) was passed anterior and posterior to the hole made for the transtendon approach. A horizontal mattress stitch was tied using a standard 2-handed knot technique.

Biomechanical Analysis

The proximal humeri with intact supraspinatus tendons were removed from 6 matched pairs of fresh-frozen cadaver shoulders (3 males, 3 females; average age, 49 ± 12 years). The shaft of the humerus was potted in fiberglass resin. For each sample, a partial tear of the supraspinatus tendon was replicated by using a sharp blade to transect 50% of the medial side of the supraspinatus from the tuberosity. From each matched pair, 1 humerus was selected to receive a PASTA Bridge repair, and the contralateral repair was performed using one 4.5-mm titanium Corkscrew FT. Half of the samples of each repair were performed on the right humerus to avoid a mechanical bias. Each repair was performed by the same orthopedic surgeon.

Biomechanical testing was conducted using an INSTRON 8871 Axial Table Top Servo-hydraulic Testing System (INSTRON), with a 5 kN load cell attached to the crosshead. The system was calibrated using FastTrack software (AEC Software), and both the load and position controls were run through WaveMaker software (WaveMaker). Each sample was positioned on a fixed angle fixture and secured to the testing surface so that the direction of pull would be performed 45° to the humeral shaft. A custom fixture with inter-digitated brass clamps was attached to the crosshead, and dry ice was used to freeze the tendon to the clamp. The test setup can be seen in Figures 1A,
Each sample was pre-loaded to 10 N to remove slack from the system. Pre-loading was followed by cyclic loading between 10 N and 100 N, at 1 Hz, for 100 cycles. One-hundred cycles were chosen based on literature stating that the majority of the cyclic displacement occurs in the first 100 cycles. Post cycling, the samples were loaded to failure at a rate of 33 mm/sec. Load and position data were recorded at 500 Hz, and the mode of failure was noted for each sample.

Before loading, a soft-tissue marker was used to create individual marks on the supraspinatus in-line with the articular margin and lateral edge of the tuberosity (Figures 1A, 1B). The individual marks, a digital camera, and MaxTraq video tracking software (Innovision Systems) were used to calculate displacement and strain.

For each sample, the ultimate load, yield load, and stiffness were determined from the load-displacement results. Video tracking software was used to determine the cyclic displacement of each sample at both the articular margin (medial dots) and at the repair site. The strain at these 2 locations was calculated by dividing the cyclic displacement of the respective site by the distance between the site of interest and the lateral edge of the tuberosity (lateral marks) (ΔL/L). Paired t tests (α = 0.05) were used to determine if differences in ultimate load or strain between the 2 repairs were significant.

Results

Biomechanical Analysis

The results of the biomechanical testing are provided in the Table. There were no significant differences between the 2 repairs in ultimate load (P = .577), strain at the repair site (P = .355), or strain at the margin (P = .801). A post-hoc power analysis revealed that a sample size of at least 20 matched pairs would be needed to establish a significant difference for strain at the repair site. The modes of failure were mid-substance tendon tearing, the humeral head breaking, tearing at the musculotendinous junction, or the tendon tearing at the repair site. All 4 modes of failure occurred in at least 1 sample from both repair groups (Figures 2A-4). Visual inspection of the samples post-testing revealed no damage to the anchors or sutures. A representative picture of the tendon tearing at the repair site can be seen in Figures 2A, 2B.

Discussion

The purpose of this study was to evaluate the biomechanical strength of a new technique for PASTA repairs—the PASTA Bridge. After creation of a partial-thickness tear on a cadaveric model, we compared the PASTA Bridge technique with a standard transtendon suture anchor repair. We hypothesized that the PASTA Bridge would yield equivalent or better biomechanical properties including the ultimate load to failure and the degree of strain at different locations in the repair. Our results supported this hypothesis. The PASTA Bridge was biomechanically equivalent to transtendon repair.

For repairs of partial-thickness rotator cuff tears, 2 traditional techniques are transtendon repairs and the “takedown” method of completing a partial tear into a full tear with a subsequent repair. While clinical outcomes of the 2 methods suggest no superiority over the other, studies have demonstrated a biomechanical advantage with transtendon repairs. Repairs of PASTA lesions exhibit both lower strain and displacement of the repaired tendon compared with a full-thickness repair. Failure of the “takedown” method results in a full-thickness rotator cuff tear.
cuff tear as opposed to a partial tear. This outcome can prove to be more debilitating for the patient. Furthermore, Mazzocca and colleagues illustrated that for partial tears >25% thickness, the cuff strain returned to the intact state once repaired.

Our data suggest that biomechanically the transtendon and the PASTA Bridge techniques were equivalent. While the ultimate load and strain at repair sites are comparable, the PASTA Bridge is percutaneous and presents significantly less risk of complications. The PASTA Bridge uses a medial row horizontal mattress with a lateral row fixation to recreate the rotator cuff footprint. It has been postulated that reestablishing a higher percentage of the footprint can aide in tendon-bone healing, having valuable implications for both biological and clinical outcomes of the patient. Greater contact at the tendon-bone interface may allow more fibers to participate in the healing process. In their analysis of rotator cuff repair, Apreleva and colleagues asserted that more laterally placed suture anchors may increase the repair-site area. The lateral anchors of the PASTA Bridge help not only to increase the footprint and thereby the healing potential of the repair but also assist in taking pressure off the medial row anchors.

In their report on double-row rotator cuff repair, Lo and Burkhart suggest that double-row fixation is superior to single-row repairs for a variety of reasons. Primarily, double-row techniques increase the number of points of fixation, which will secondarily reduce both the stress and load at each suture point. This effect improves the overall strength of the repair construct. Use of the lateral anchor of the PASTA Bridge allows the medial anchors to act as pivot points. Placing the stress laterally, the configuration allows for movement and strain distribution without sacrificing the integrity of the repair. In our analysis, failure occurred by the tendon tearing mid-substance, humeral head breaking, tendon tearing at the repair site, and tearing at the musculotendinous junction (Figures 2-4). There was no instance of failure due to the construct itself indicating that the 2.4-mm medial anchors are more than adequate for the PASTA Bridge. When visually inspecting the samples after failure, there was no damage to the anchors or sutures. This observation indicates that the PASTA Bridge construct is remarkably strong and capable of withstanding excessive forces.

There were some potential limitations of this study. The small sample size modified the potential for identifying significant differences between the groups. A post-hoc power analysis revealed that a sample size of at least 20 matched pairs would be required to determine a significant difference between the 2 repair groups in strain at the repair site. We did not test this many pairs because the data was so similar after 6 matched pairs that it did not warrant continuing further. Additional research should be done with larger sample populations to evaluate the biomechanical efficacy of this technique further.

Conclusion

The PASTA Bridge creates a strong construct for repair of articular-sided partial-thickness tears of the supraspinatus. The data suggest the PASTA Bridge is biomechanically equivalent to the gold standard transtendon suture anchor repair. The PASTA Bridge is technically sound, percutaneous, and presents less risk of complications. It does not require arthroscopic knot tying and carries only minimal risk of damage to residual tissues. In our analysis, there were no failures of the actual construct, asserting that the PASTA Bridge is a strong, durable repair. The PASTA Bridge should be strongly considered by surgeons treating PASTA lesions.
Key Info

Figures/Tables

Figures / Tables:

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![Figure 1](hirahara1018_f1.jpg)

**Figure 1.** Test setup for (A) the trans tendon suture anchor repair and (B) the PASTA (Partial articular-sided supraspinatus tendon avulsion) Bridge. Individual pen marks on the supraspinatus represent the articular margin and lateral edge of the tuberosity. The marks, used in conjunction with a digital camera and MaxTraq video tracking software (Innovision Systems), were used to calculate displacement and strain.

hirahara1018_f2.jpg
Figure 2. Failure by mode of tendon tearing at the repair site for (A) the transtendon suture anchor repair and for (B) the PASTA (partial articular-sided supraspinatus tendon avulsion) Bridge. (Note: failure did not occur at the PASTA Bridge or transtendon suture anchor constructs.)

Figure 3. Failure by mode of muscle tearing for the PASTA (partial articular-sided supraspinatus tendon avulsion) Bridge construct. (Note: the PASTA Bridge construct itself did not fail.)
Figure 4. Failure by mode of humeral head breaking for the PASTA (partial articular-sided supraspinatus tendon avulsion) Bridge construct. (Note: the PASTA Bridge construct itself did not fail.)
Table. **Results for Each Sample of the 2 PASTA Repair Groups**

**SutureTak (Arthrex) and SwiveLock (Arthrex) PASTA Repair**

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**Average**

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**Titanium Corkscrew (Arthrex) PASTA Repair**

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Abbreviations: PASTA, partial articular-sided supraspinatus tendon avulsion.
References


**Multimedia**

**Product Guide**

- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
- BioComposite SwiveLock Anchor
- BioComposite SwiveLock C, with White/Black TigerTape™ Loop

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