Bone-Conserving All-Suture Anchor Technique Demonstrates Sufficient Biomechanics for Medial Patellofemoral Ligament Reconstruction: A Cadaveric Study

Benjamin L. Smith[1], Asheesh Bedi[2], Oliver L. Hauck[1], Coen A. Wijdicks[1], Jonathan C. Riboh[3]
[1]Arthrex, Inc., Naples, FL, [2]NorthShore Orthopedic and Spine Institute, Chicago, IL, [3]OrthoCarolina, Charlotte, NC
Email of Presenting Author: Benjamin.Smith@Arthrex.com

Disclosures: B.L. Smith & O.L. Hauck & C.A. Wijdicks (3A-Arthrex), Jonathan Riboh (3B-Smith & Nephew, Stryker, Arthrex; 4-Restor3d), A Bedi (1-Arthrex; 3B-Arthrex; 7B-SLACK Incorporated, Springer; 9 -AOSSM)

INTRODUCTION: Patellar dislocation is a common knee injury, especially in the active pediatric population. The medial patellofemoral ligament (MPFL) is the primary restraint to patellar dislocation and is typically reconstructed in individuals with recurrent dislocation. All-suture anchors (ASA) are promising implants for MPFL reconstruction, minimizing bone loss compared to traditionally-sized interference screws and hard suture anchors. While many biomechanical studies have evaluated hard implants, there is a paucity of studies evaluating ASAs. The primary study objective was to biomechanically compare a novel ASA to larger, hard implants for femoral and patellar fixation in a time-zero cadaveric model. The hypothesis was that the ASA would have comparable cyclic elongation to interference fixation and exceed native MPFL biomechanics.

METHODS: Fresh-frozen porcine stifles were dissected to isolate the femurs and patellas for use in MPFL reconstruction with cadaveric gracilis tendon grafts (4.0-5.0 mm diameter). Femoral graft fixation was achieved with one 6x20-mm biocomposite interference screw (IS, n=9) in a "loop-in" fashion or a 2.6-mm knotless hybrid ASA (n=9) in an "onlay" fashion. Patellar graft fixation was achieved with two 3.9x17.9-mm biocomposite suture anchors used like interference screws (ISA, n=9) in an "inlay" fashion or two 2.6-mm knotless hybrid ASAs (n=9) in an "onlay" fashion. Femurs and patellas were secured to the base plate of an electromechanical testing system and oriented to recreate worst-case anatomical tension angles with an exposed tendon length of 55 mm (Fig. 1). Specimens underwent 10 preconditioning load cycles of 5-15 N, manual re-tensioning (ASAs only), 100 load cycles of 5-30 N (Phase I) and 5-50 N (Phase II) each, and load-to-failure at 305 mm/min. Biomechanical outcomes included cyclic elongation, ultimate stiffness, and ultimate load to failure. Statistical analysis ($p<0.05$) utilized the Student's t-test and non-parametric t-tests as required for failed normality or equal variance.

RESULTS: All constructs survived biphasic cycling and completed load-to-failure (Table 1). No significant differences ($P>0.05$) were observed for total cyclic elongation following Phase I and Phase II cycling when comparing IS to ASA for femoral fixation and ISA to ASA for patellar fixation (Fig. 2). The IS had significantly greater ultimate stiffness ($P<0.001$) and ultimate load to failure ($P=0.019$) compared to the ASA. The ISA had significantly greater ultimate stiffness ($P<0.001$), but a significantly lower ultimate load to failure ($P=0.014$), compared to the ASA. Despite these differences, all implants exceeded known physiological values of native MPFL stiffness (Upper 95% CI_{Pooled}: 32.8 N/mm) and failure load (upper 95% CI_{Pooled}: 174 N).[1] Femoral IS constructs failed by graft pullout from the socket (9/9), while ASA failed by anchor pullout (6/9) or graft pullout from the cinched loop (3/9). Patellar ISA constructs failed by graft pullout (9/9), while ASA failed by anchor pullout (9/9).

DISCUSSION: The results indicate that the ASA had comparable time-zero cyclic elongation (i.e., induced laxity) to larger, hard implants for femoral and patellar fixation. While differences were observed for ultimate stiffness and ultimate load to failure, all implants exceeded documented physiological values for these parameters. Thus, the hypothesis is accepted. The findings suggest that the ASA technique is a biomechanically viable alternative to existing techniques for MPFL reconstruction based on time-zero performance, before any protective in vivo graft healing or dynamic muscle stabilization.

SIGNIFICANCE/CLINICAL RELEVANCE: All-suture anchors provide a bone-conserving option for MPFL reconstruction, which may be useful in mitigating risks of open physis damage, patella fracture, and articular surface violation. Onlay techniques also provide the surgeon with greater control over initial graft tensioning, which may reduce the likelihood of possible overconstraint when using interference screws.

REFERENCES: [1] Huber, C., Zhang, Q., Taylor, W. R., Amis, A. A., Smith, C., & Hosseini Nasab, S. H. (2020). Properties and Function of the Medial Patellofemoral Ligament: A Systematic Review. *The American journal of sports medicine*, *48*(3), 754–766. https://doi.org/10.1177/0363546519841304

IMAGES AND TABLES:

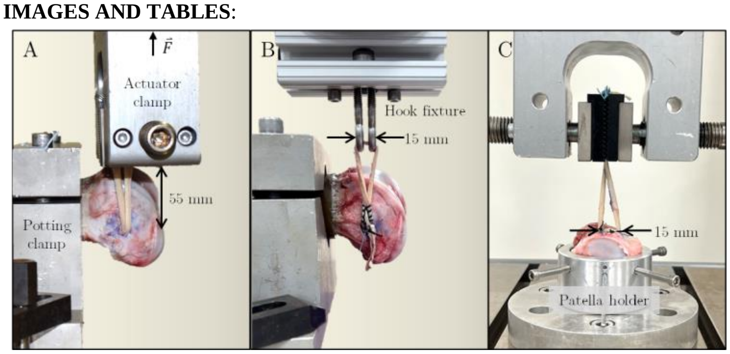

Fig. 1. MPFL reconstructions were tested in three configurations, approximating graft pull angles for each technique. Distal femurs were held in a potting fixture with the lateral graft clamped for the IS group (A) or looped over hooks for the ASA group (B). Patellas were held in a custom holder with peripheral set screws and a central pin, with the medial graft clamped for both groups (C).

Table 1. Biomechanical results of testing femoral and patellar fixation techniques. Mean (95% CI).

Anatomic Fixation	Implant(s)	Total Cyclic Elongation (mm)		Ultimate Stiffness (N/mm)	Ultimate Load to Failure (N)
		Phase I *(5-30 N)*	Phase II *(5-50 N)*		
Femur	6x20 mm IS	0.82 (0.70, 0.93)	1.58 (1.38, 1.77)	54.2 (51.0, 57.3)	366 (333, 400)
	2.6 mm ASA	0.72 (0.52, 0.93)	1.58 (1.32, 1.83)	46.1 (42.9, 49.3)	278 (207, 348)
Patella	3.9x17.9 mm ISA (2x)	0.51 (0.44, 0.59)	1.01 (0.89, 1.13)	70.5 (64.3, 76.7)	244 (228, 259)
	2.6 mm ASA (2x)	0.42 (0.25, 0.59)	1.03 (0.79, 1.28)	53.1 (49.2, 56.9)	307 (256, 357)