Cyclic and Load to Failure Properties of All-Suture Anchors in Synthetic Acetabular Cancellous Bone

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Disclosures

- Dr. Safran
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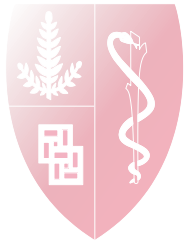


Introduction

- Metal, polyether ether ketone (PEEK) and various biocomposites have been routinely used in shoulder labral repair
- However, there is a paucity of data on the performance of the more recently-developed all-suture anchors (ASAs) [1-3]
- In particular, ASAs have not been tested in acetabular bone, or bone substitute simulating the range of bone properties found in the acetabulum.

Questions

- 1. Do all-suture anchors have better or worse fixation than a commonly used standard suture anchor?
- 2. Is there variation in fixation between all-suture anchors of different designs?
- 3. Does high density bone affect the fixation of these various suture anchors?

Methods

Test all ASAs marketed for hip labral repair

- 12 anchors
- Bioraptor 2.3 PK = control (PEEK ribbed implant)
- 7-11 anchors per group based on previous studies [1-3]

Sawbones with properties replicating:

- High density – acetabular rim (30 pcf)
- Low density – glenoid (20 pcf)
- Based on multiple cadaveric studies [4-12]

Comparing outcomes in 20 pcf vs. 30 pcf for each anchor

- Welch T-test

Comparing anchors to each other, in both densities

- Welch ANOVA with Games-Howell post hoc test

Comparisons only made when at least 3 anchors survived (or were present)

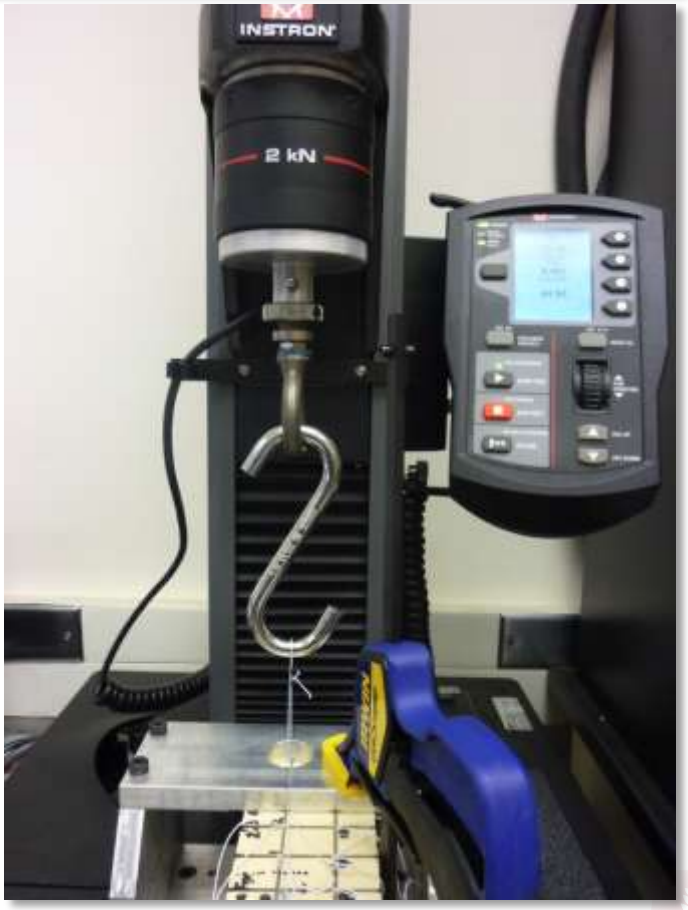
Commercially-Available All-Suture Anchors

Name	Company	Drill size (mm)	Suture size	# suture strands	Indications
Suturefix Ultra 1.7	Smith & Nephew	1.7	2	1	hip and shoulder labrum
Suturefix Ultra 1.9	Smith & Nephew	1.9	1	2	shoulder labrum
JuggerKnot 1.0	Biomet Sports Medicine	1.0	2-0 or 3-0	1	hand, small joint
JuggerKnot 1.4	Biomet Sports Medicine	1.4	1	1	shoulder labrum
JuggerKnot 1.45 #1	Biomet Sports Medicine	1.45	1	1	hip labrum
JuggerKnot 1.45 #2	Biomet Sports Medicine	1.45	2	1	hip labrum
JuggerKnot 1.5	Biomet Sports Medicine	1.5	2	1	shoulder labrum
JuggerKnot 2.1	Biomet Sports Medicine	2.1	1	1	shoulder labrum
JuggerKnot 2.9	Biomet Sports Medicine	2.9	2	2	rotator cuff
Y-Knot 1.3	ConMed Linvatec	1.3	2	1	hip and shoulder labrum
Y-Knot 1.8	ConMed Linvatec	1.8	2	2	shoulder labrum
Iconix 1	Stryker Endoscopy	1.4	2	1	broad, including hip
Iconix 2	Stryker Endoscopy	2.3	2	2	broad, including hip
Iconix 3	Stryker Endoscopy	2.3	2	3	broad, including hip
Iconix 25	Stryker Endoscopy	2.3	5	2	broad, including hip
Q-Fix 1.8	ArthroCare	1.8	2	1	hip and shoulder labrum
Q-Fix 2.8	ArthroCare	2.8	2	2	rotator cuff

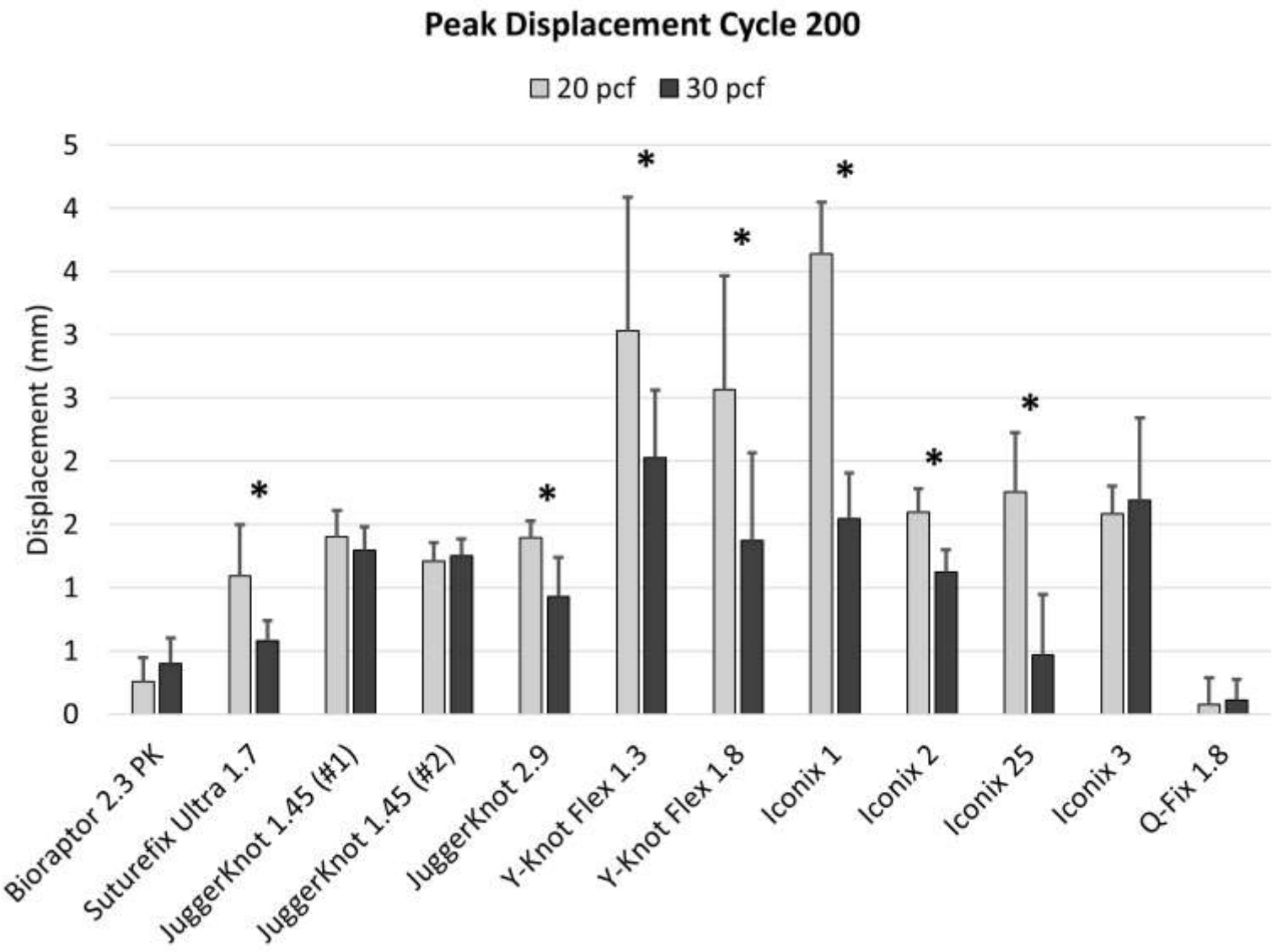
Red arrowhead indicates anchor tested in this study

Methods

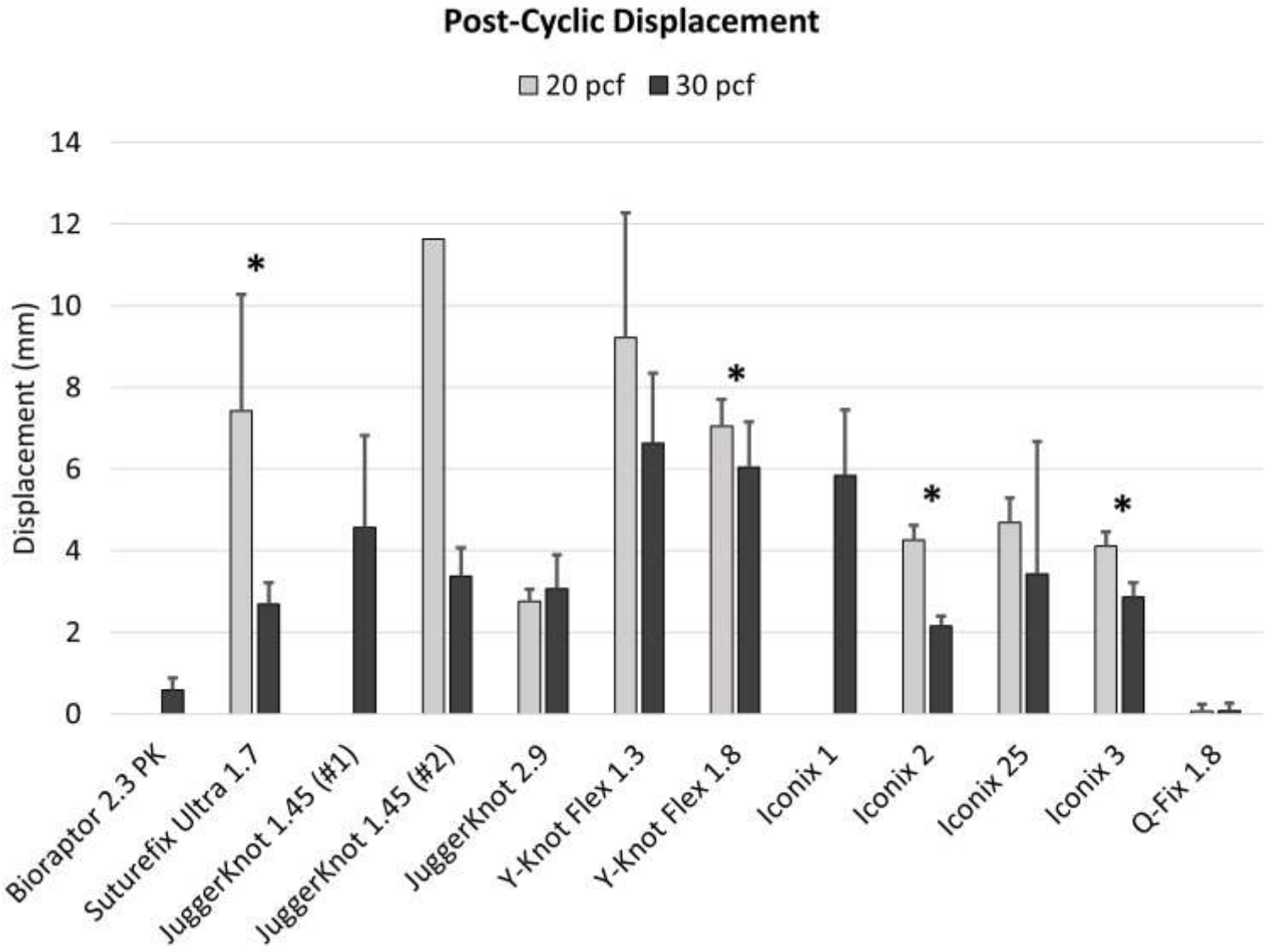
- Deployment Force: 40 N
- Cyclic loading protocol stages
    1. 10 – 50 N for 200 cycles, 0.5 Hz
    2. 10 – 100 N for 200 cycles
    3. Load to failure, 10 mm/s



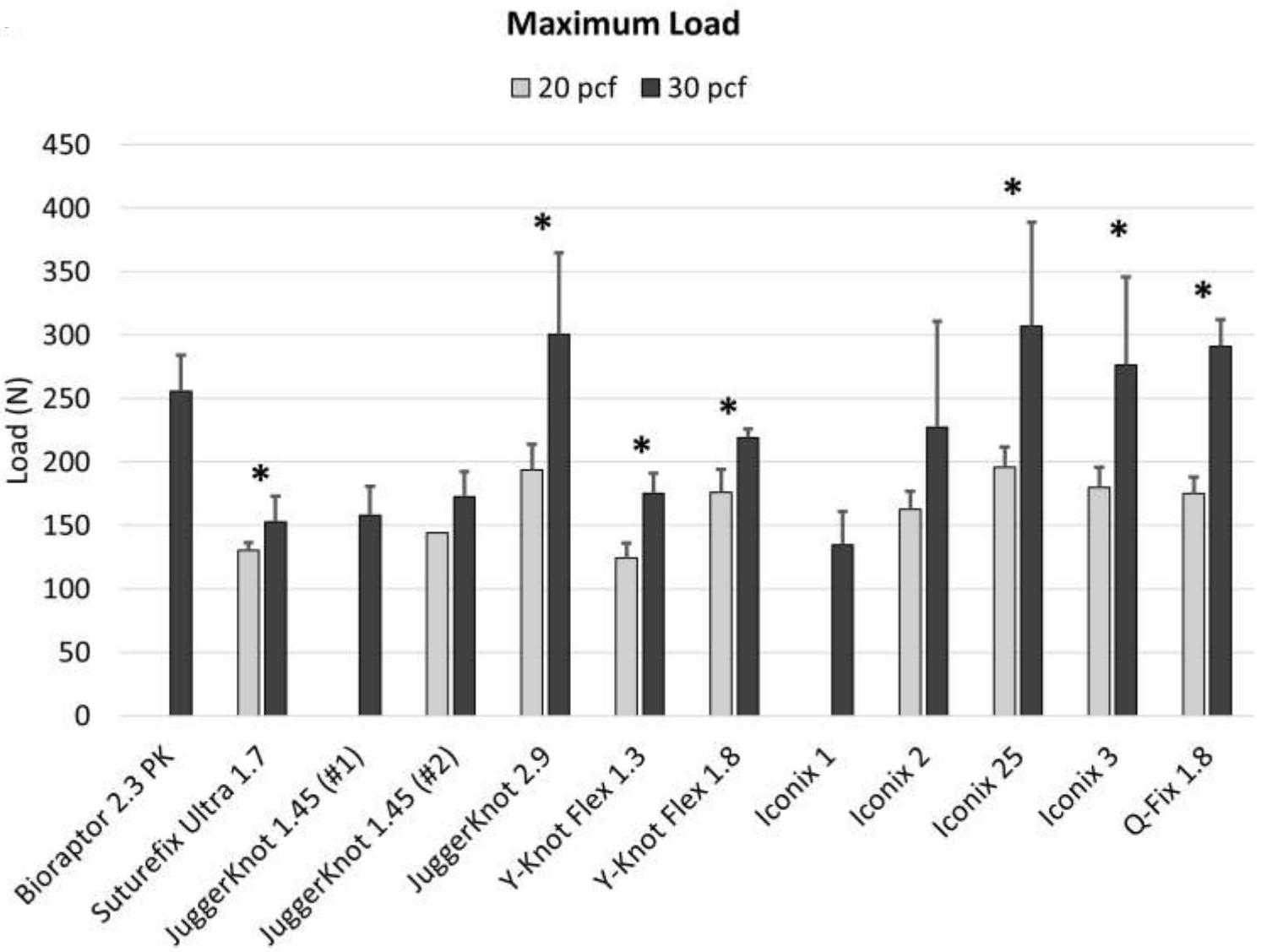
Instron testing setup



- In 20 pcf test blocks, the Bioraptor 2.3 PK and Q-Fix 1.8 showed significantly ($p < 0.002$) less peak displacement than all other anchors
- In 30 pcf test blocks, the Q-Fix 1.8 showed a trend towards less displacement than the Bioraptor 2.3 PK ($p = 0.11$) but not Iconix 25, and significantly less than all others ($p < 0.02$).



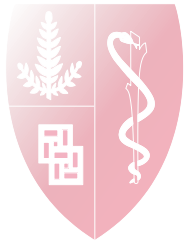
- In 20 pcf test blocks, the Q-Fix 1.8 displaced less ($p < 0.01$) than all other anchors.
- In 30 pcf test blocks, the Q-Fix 1.8 displaced less than all anchors ($p < 0.02$), except the Iconix 25 ($p = 0.18$)



- Higher failure loads in 30 pcf than 20 pcf for all anchors, except Iconix 2 ($p = 0.09$)
- No statistically significant differences among top performers in either 20 or 30 pcf blocks
- Anchors routinely failed by suture pullout, except the Q-Fix 1.8 which failed by suture breakage in 30 pcf blocks

Limitations

- Synthetic bone substitute
- Non-aqueous environment
- Absence of cortical layer
  - Does not affect majority of rotator cuff anchors [1, 13, 14]
  - However, cortical layer often disrupted by acetabuloplasty or preparation
- 400 Cycles
  - Based on previous studies Barber and Herbert
  - Hip / Shoulder often braced post-operatively
- Unknown clinically relevant load to failure, displacement
  - 250N in rotator cuff [15-18]



Discussion

- ASAs have improved *fixation* in higher density bone
  - Did not test *deployment* directly with imaging
- ASAs generally performed worse than control standard anchor
  - With exceptions - not in 20 pcf, with over 50 N load
- Q-Fix 1.8 outperformed all anchors including the control anchor in all testing conditions

References

- 1. Barber FA, Herbert MA. Cyclic loading biomechanical analysis of the pullout strengths of rotator cuff and glenoid anchors: 2013 update. *Arthroscopy*. 2013;29(5):832-844.
- 2. Mazzocca AD, Chowaniec D, Cote MP, Fierra J, Apostolakos J, Nowak M, et al. Biomechanical evaluation of classic solid and novel all-soft suture anchors for glenoid labral repair. *Arthroscopy*. 2012;28(5):642-648.
- 3. Galland A, Airaudi S, Gravier R, Le Cann S, Chabrand P, Argenson J-N. Pullout strength of all suture anchors in the repair of rotator cuff tears: a biomechanical study. *Int Orthop*. 2013;37(10):2017-2023.
- 4. Dalstra M, Huiskes R, Odgaard A, van Erning L. Mechanical and textural properties of pelvic trabecular bone. *J Biomech*. 1993;26(4-5):523-535.
- 5. Helgason B, Perilli E, Schileo E, Taddei F, Brynjólfsson S, Viceconti M. Mathematical relationships between bone density and mechanical properties: a literature review. *Clin Biomech (Bristol, Avon)*. 2008;23(2):135-146.
- 6. Speirs AD, Beaulé PE, Rakhra KS, Schweitzer ME, Frei H. Increased acetabular subchondral bone density is associated with cam-type femoroacetabular impingement. *Osteoarthr Cartil*. 2013;21(4):551-558.
- 7. Kalouche I, Crépin J, Abdelmoumen S, Mitton D, Guillot G, Gagey O. Mechanical properties of glenoid cancellous bone. *Clin Biomech*. 2010;25(4):292-298. doi:10.1016/j.clinbiomech.2009.12.009.
- 8. Mansat P, Barea C, Hobatho MC, Darmana R, Mansat M. Anatomic variation of the mechanical properties of the glenoid. *J Shoulder Elbow Surg*. 1998;7(2):109-115.
- 9. Frich LH, Jensen NC, Odgaard A, Pedersen CM, Søjbjerg JO, Dalstra M. Bone strength and material properties of the glenoid. *J Shoulder Elbow Surg*. 1997;6(2):97-104.
- 10. Frich LH, Odgaard A, Dalstra M. Glenoid bone architecture. *J Shoulder Elbow Surg*. 1998;7(4):356-361.
- 11. Adler E, Stuchin SA, Kummer FJ. Stability of press-fit acetabular cups. *J Arthroplasty*. 1992;7(3):295-301.
- 12. Bardana DD, Burks RT, West JR, Greis PE. The effect of suture anchor design and orientation on suture: An in vitro study. *Arthroscopy*. 2003;19(3):274-281.
- 13. Barber FA, Herbert M a., Beavis RC, Barrera Oro F. Suture anchor materials, eyelets, and designs: update 2008. *Arthroscopy*. 2008;24(8):859-867.
- 14. Barber AF, Herbert MA, Hapa O, Rapley JH, Barber CAK, Bynum JA, et al. Biomechanical analysis of pullout strengths of rotator cuff and glenoid anchors: 2011 update. *Arthrosc - J Arthrosc Relat Surg*. 2011;27(7):895-905.
- 15. Burkhart SS, Diaz Pagàn JL, Wirth MA, Athanasiou KA. Cyclic loading of anchor-based rotator cuff repairs: confirmation of the tension overload phenomenon and comparison of suture anchor fixation with transosseous fixation. *Arthroscopy*. 1997;13(6):720-724.
- 16. Schneeberger AG, von Roll A, Kalberer F, Jacob HAC, Gerber C. Mechanical strength of arthroscopic rotator cuff repair techniques: an in vitro study. *J Bone Joint Surg Am*. 2002;84-A(12):2152-2160.
- 17. Gerber C, Schneeberger AG, Beck M, Schlegel U. Mechanical strength of repairs of the rotator cuff. *J Bone Joint Surg Br*. 1994;76(3):371-380.
- 18. Mazzocca AD, Millett PJ, Guanche CA, Santangelo SA, Arciero RA. Arthroscopic single-row versus double-row suture anchor rotator cuff repair. *Am J Sports Med*. 2005;33(12):1861-1868.