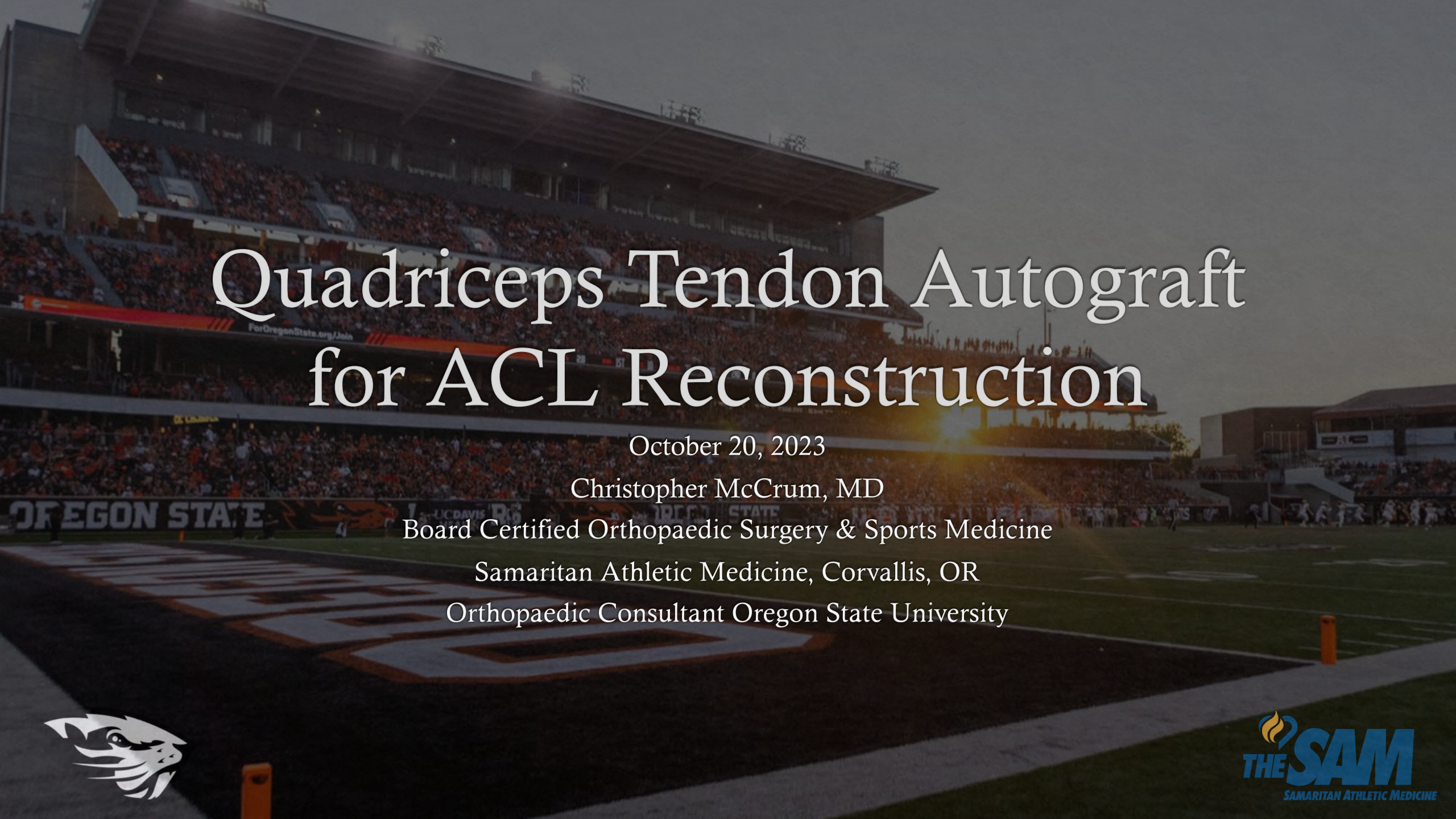

Quadriceps Tendon Autograft for ACL Reconstruction

October 20, 2023

Christopher McCrum, MD
Board Certified Orthopaedic Surgery & Sports Medicine
Samaritan Athletic Medicine, Corvallis, OR
Orthopaedic Consultant Oregon State University

Conflicts of Interest

No conflicts related to this presentation

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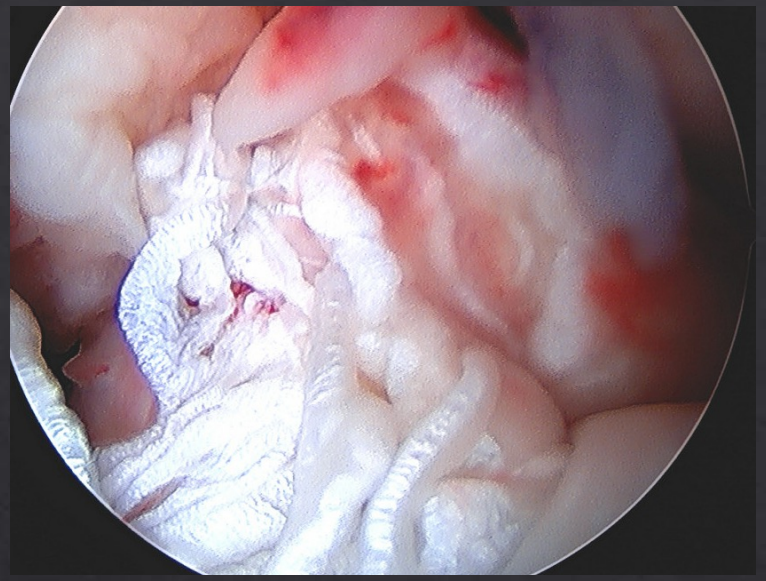
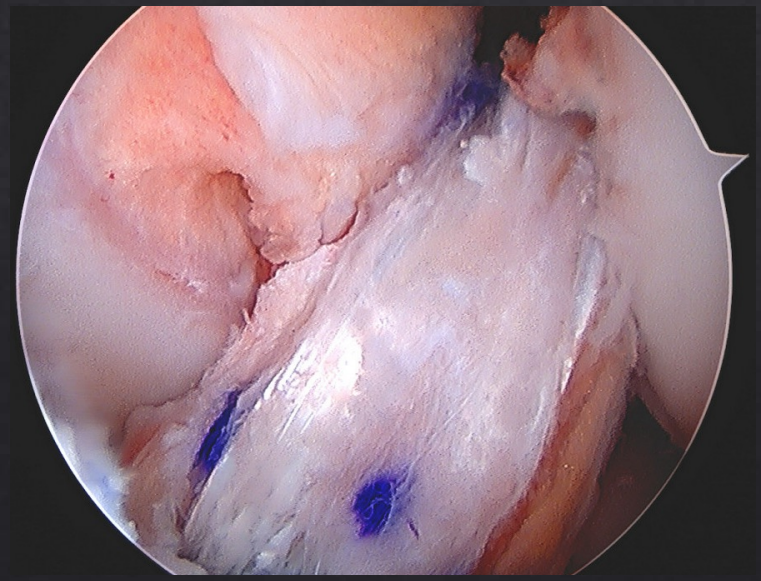


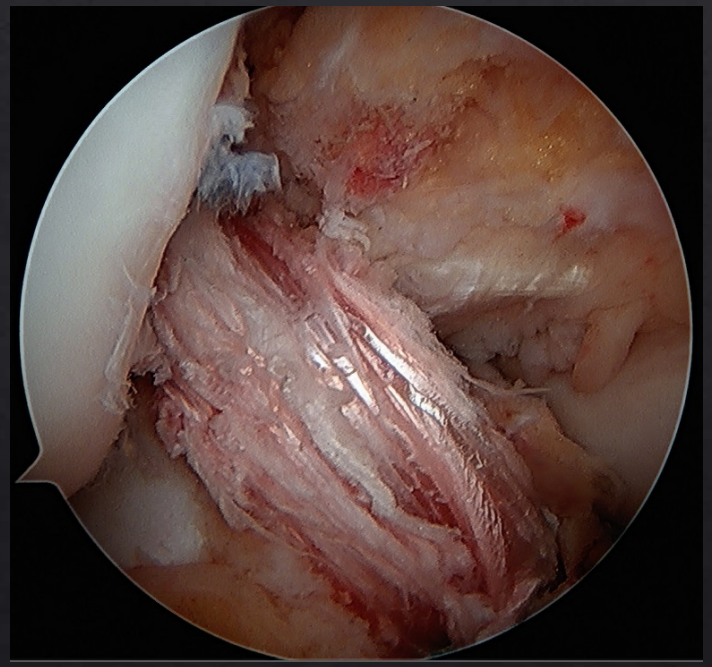


Lecture Outline

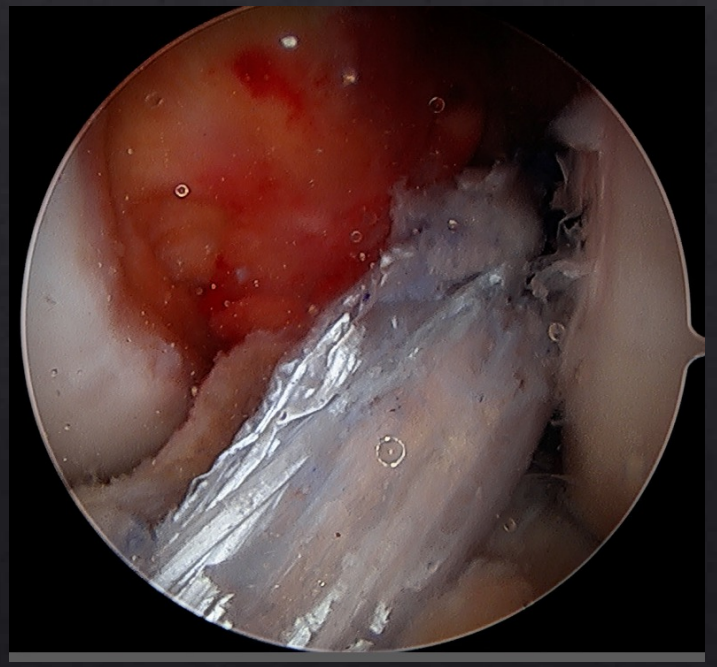
- Quadriceps Tendon for ACL Reconstruction Data
- Harvest Technique

Autograft Choice: Which to Choose?

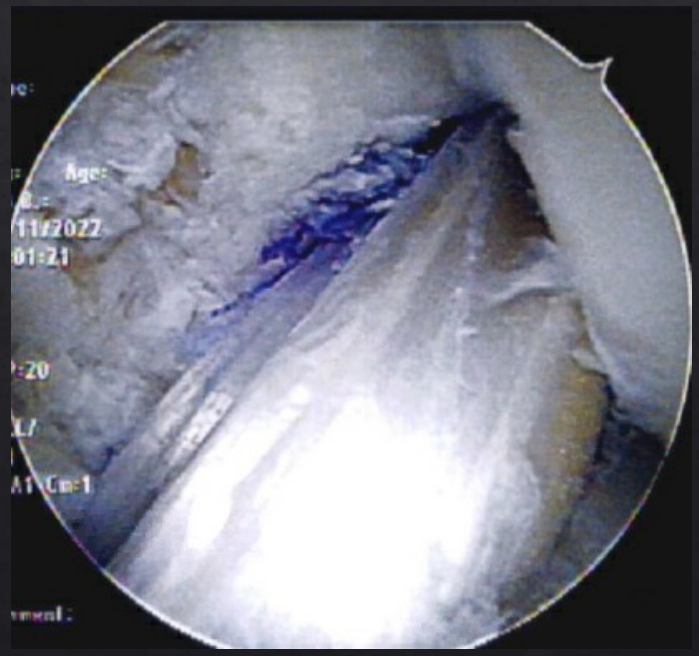
Quadriceps Tendon



Patellar Tendon



Hamstring Tendon



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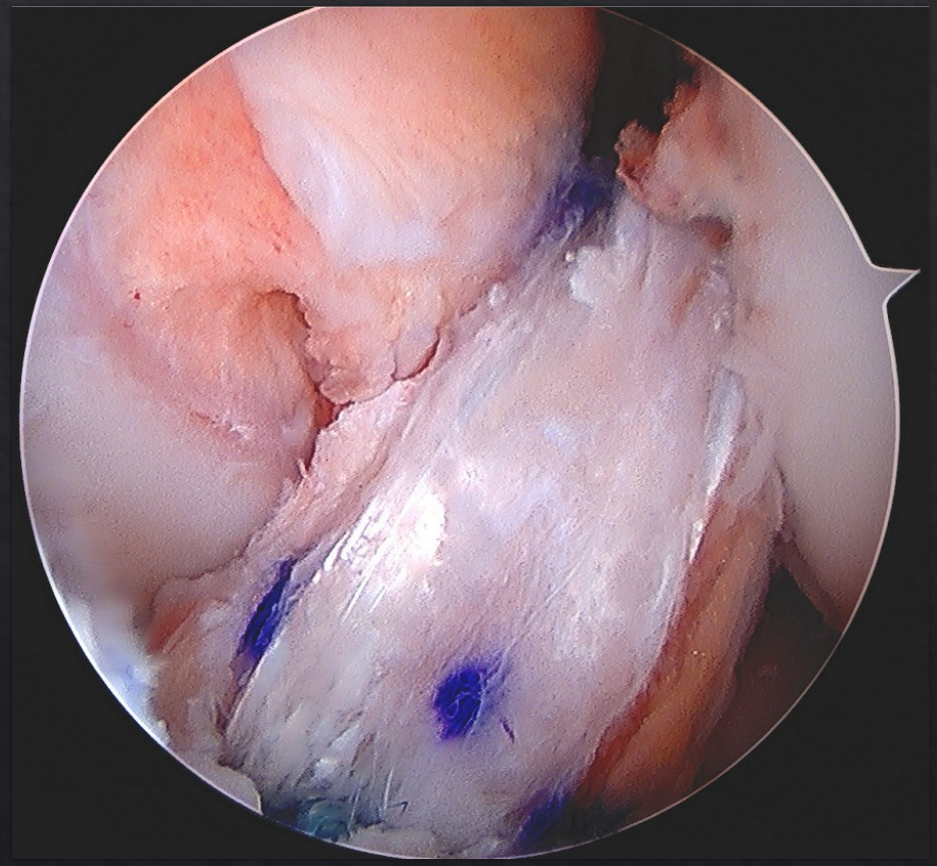
Quadriceps Tendon Autograft: New Kid on the Block



Quadriceps Tendon Autograft: Maybe Not That New Kid on the Block

- First described by Blauth in 1984 and Staubli in 1992
  - Endorsed by Fulkerson in 1995
- However, starting to become much more popular due to favorable morbidity profile and modern harvest techniques

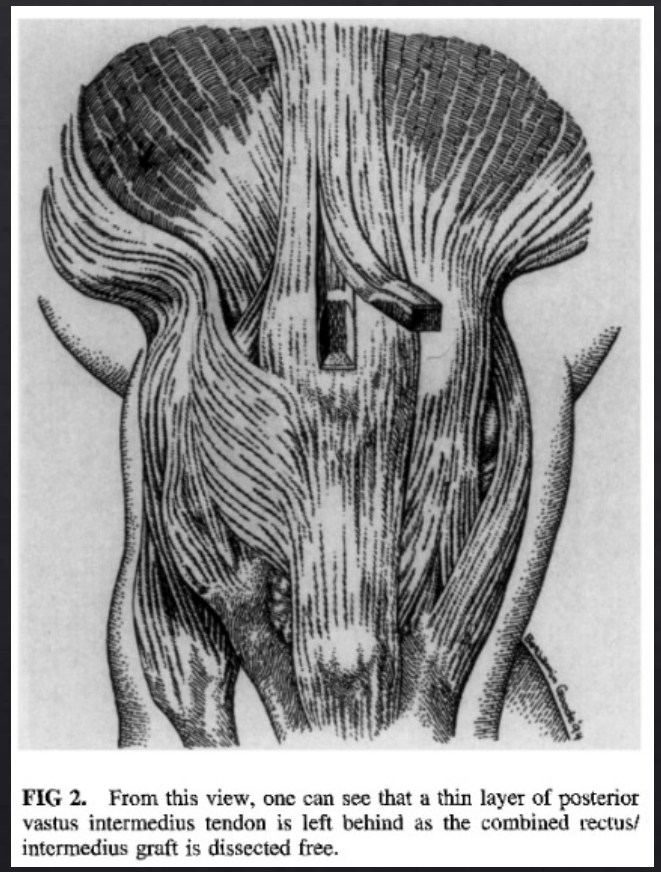


FIG 2. From this view, one can see that a thin layer of posterior vastus intermedius tendon is left behind as the combined rectus/intermedius graft is dissected free.

Blauth W. Die zweizügelige Ersatzplastik des vorderen Kreuzbandes aus der Quadricepssehne [2-strip substitution-plasty of the anterior cruciate ligament with the quadriceps tendon]. Unfallheilkunde. 1984 Feb;87(2):45-51. German. PMID: 6710676.
Fulkerson JP, Langeland R. An alternative cruciate reconstruction graft: the central quadriceps tendon. Arthroscopy. 1995 Apr;11(2):252-4. doi: 10.1016/0749-8063(95)90078-0. PMID: 7794444.
Staubli HU. IN: Jakob R, Staubli HU, eds. *The knee and cruciate ligaments*. New York: Springer-Verlag, 1992:447.

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Quadriceps Tendon Advantages: Anatomy

- Anatomy
  - Compared with BTB, QT is (Fulkerson & Langeland Arthroscopy 1995):
    - Longer & wider
      - Large volume allows for reconstruction of large ACL footprints or revisions
    - Higher tensile strength
    - 50% more mass
  - Cross-sectional area 2x size of BTB (Shani *et al* Arthroscopy 2016)
  - Soft tissue
    - Can use in skeletally immature

Fulkerson JP, Langeland R. An alternative cruciate reconstruction graft: the central quadriceps tendon. Arthroscopy. 1995 Apr;11(2):252-4. doi: 10.1016/0749-8063(95)90078-0. PMID: 7794444.
Shani RH, Umpierez E, Nasert M, Hiza EA, Xerogeanes J. Biomechanical Comparison of Quadriceps and Patellar Tendon Grafts in Anterior Cruciate Ligament Reconstruction. Arthroscopy. 2016 Jan;32(1):71-5. doi: 10.1016/j.arthro.2015.06.051. Epub 2015 Sep 14. PMID: 26382635.

Quadricep Tendon Advantages: Structural

- Laxity
  - No difference in laxity (KT-1000), satisfaction, or outcomes vs BTB (Sloane HS Arthroscopy 2015)
  - Less pivot shift laxity, lower failure compared with hamstring autograft (Nyland J KSSTA 2020)

Slone HS, Romine SE, Premkumar A, Xerogeanes JW. Quadriceps tendon autograft for anterior cruciate ligament reconstruction: a comprehensive review of current literature and systematic review of clinical results. Arthroscopy. 2015 Mar;31(3):541-54. doi: 10.1016/j.arthro.2014.11.010. Epub 2014 Dec 25. PMID: 25543249.
Nyland J, Collis P, Huffstutler A, Sachdeva S, Spears JR, Greene J, Caborn DNM. Quadriceps tendon autograft ACL reconstruction has less pivot shift laxity and lower failure rates than hamstring tendon autografts. Knee Surg Sports Traumatol Arthrosc. 2020 Feb;28(2):509-518. doi: 10.1007/s00167-019-05720-y. Epub 2019 Sep 19. PMID: 31538227.

Quadriceps Tendon Advantages: Outcomes/Complications/Morbidity

- Clinical Outcomes
  - No significant difference in re-tear, functional outcomes, or RTS compared to BTB (Lund Arthroscopy 2014, Slone HS Arthroscopy 2015)
    - Decreased anterior knee pain vs BTB (Mulford KSSTA 2013)
    - Less risk of infrapatellar nerve injury vs BTB (Diermeier KSSTA 2020)
    - Lower failure rate than HS autograft (Nyland *et al* KSSTA 2020, Hurley *et al* J ISAKOS 2022)

Lund B, Nielsen T, Faunø P, Christiansen SE, Lind M. Is quadriceps tendon a better graft choice than patellar tendon? a prospective randomized study. Arthroscopy. 2014 May;30(5):593-8. doi: 10.1016/j.arthro.2014.01.012. Epub 2014 Mar 14. PMID: 24630956.3

Mulford JS, Hutchinson SE, Hang JR. Outcomes for primary anterior cruciate reconstruction with the quadriceps autograft: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2013 Aug;21(8):1882-8. doi: 10.1007/s00167-012-2212-2. Epub 2012 Sep 25. PMID: 23007413.

Diermeier T, Tisherman R, Hughes J, Tulman M, Baum Coffey E, Fink C, Lynch A, Fu FH, Musahl V. Quadriceps tendon anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2020 Aug;28(8):2644-2656. doi: 10.1007/s00167-020-05902-z. Epub 2020 Feb 18. PMID: 32072203.

Nyland J, Collis P, Huffstutler A, Sachdeva S, Spears JR, Greene J, Caborn DNM. Quadriceps tendon autograft ACL reconstruction has less pivot shift laxity and lower failure rates than hamstring tendon autografts. Knee Surg Sports Traumatol Arthrosc. 2020 Feb;28(2):509-518. doi: 10.1007/s00167-019-05720-y. Epub 2019 Sep 19. PMID: 31538227.

But what about the Danish Registry Study?

- "Quadriceps tendon autografts for ACLR was associated with higher revision rates than HT and PT grafts. QT graft was also associated with small increased objective knee laxity and more positive pivot shift than HT and PT grafts."
- Limitations
  - Statistics
    - 31 QT, 14,213 HT and 1835 PT ACLR
  - Selection Bias
    - Significantly younger, higher rate of meniscus injury, and more frequent significant pivot shift in the quadriceps group
    - Risk factors for failure

Knee Surgery, Sports Traumatology, Arthroscopy (2020) 28:2163–2169
https://doi.org/10.1007/s00167-019-05751-5

KNEE

Quadriceps tendon autograft for anterior cruciate ligament reconstruction is associated with high revision rates: results from the Danish Knee Ligament Registry

Martin Lind[1] · Marc J. Strauss[2] · Torsten Nielsen[1] · Lars Engebretsen[2]

Lind M, Strauss MJ, Nielsen T, Engebretsen L. Quadriceps tendon autograft for anterior cruciate ligament reconstruction is associated with high revision rates: results from the Danish Knee Ligament Registry. Knee Surg Sports Traumatol Arthrosc. 2020 Jul;28(7):2163-2169. doi: 10.1007/s00167-019-05751-5. Epub 2019 Oct 22. PMID: 31641810.

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Strength After Autograft ACL

- Main Findings
  - QT
    - Peak extensor torque did not reach 85% LSI until ***>15 months***
      - Significantly less than HT at 5-8 months, but not different to PT
      - No differences between grafts after 8 months
    - Peak flexor torque exceeded 85% LSI 5-8 months, >90% at 9-15 months
      - Significantly higher than HT
- Limitations
  - Sample size
    - 952 QT, 245 HT, 143 PT, 45 QT allo, 21 TA allo
  - Level IV evidence, needs work!
    - Particularly little data after 8 months

Knee muscle strength after quadriceps tendon autograft anterior cruciate ligament reconstruction: systematic review and meta-analysis

Peta T. Johnston[1] · Jodie A. McClelland[1] · Julian A. Feller[1,2] · Kate E. Webster[1]

Received: 30 June 2020 / Accepted: 28 September 2020 / Published online: 7 October 2020

Peak knee extensor torque	Limb symmetry index		
	5–8 months	9–15 months	24 months
Isokinetic (slow speed)	76.3 (68.7 to 83.8)	76.7 (64.2 to 89.1)	81.1 (64.7 to 97.5)
Isokinetic (medium speed)	59.8 (45.0 to 74.5)	81.3 (70.9 to 91.8)	88.1 (77.9 to 98.4)
Isometric	75.5 (54.3 to 96.7)	84.6 (63.5 to 105.7)	N/A

Values are reported as mean (95% CI) unless noted otherwise

Table 4 Summary meta-analyses for knee extensor torque LSI following QT ACL reconstruction

Johnston PT, McClelland JA, Feller JA, Webster KE. Knee muscle strength after quadriceps tendon autograft anterior cruciate ligament reconstruction: systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2021 Sep;29(9):2918-2933. doi: 10.1007/s00167-020-06311-y. Epub 2020 Oct 7. PMID: 33026536.

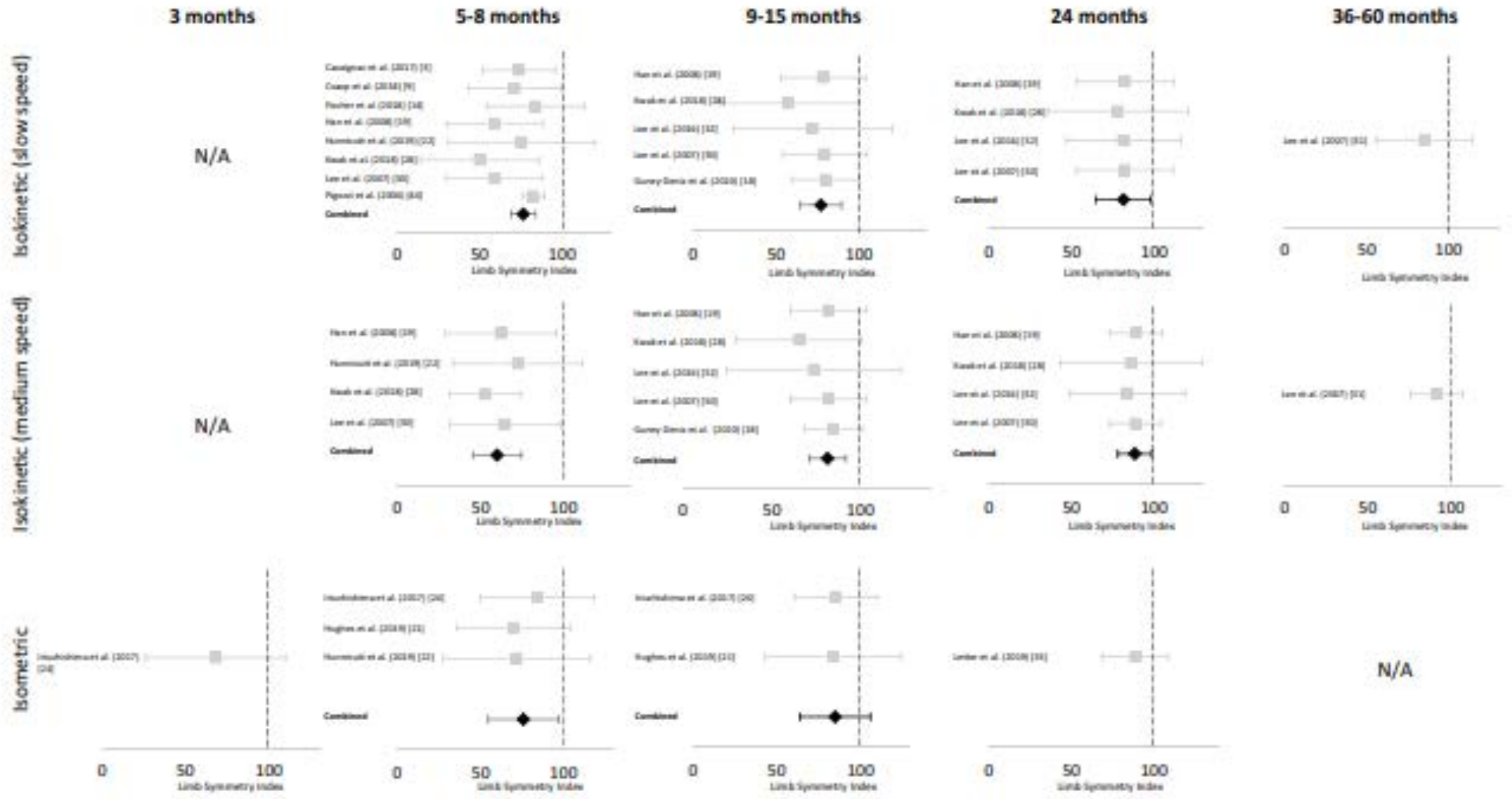


Fig. 2 Recovery of peak knee extensor strength following QT ACL reconstruction compared to non-reconstructed limb

Johnston PT, McClelland JA, Feller JA, Webster KE. Knee muscle strength after quadriceps tendon autograft anterior cruciate ligament reconstruction: systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2021 Sep;29(9):2918-2933. doi: 10.1007/s00167-020-06311-y. Epub 2020 Oct 7. PMID: 33026536.

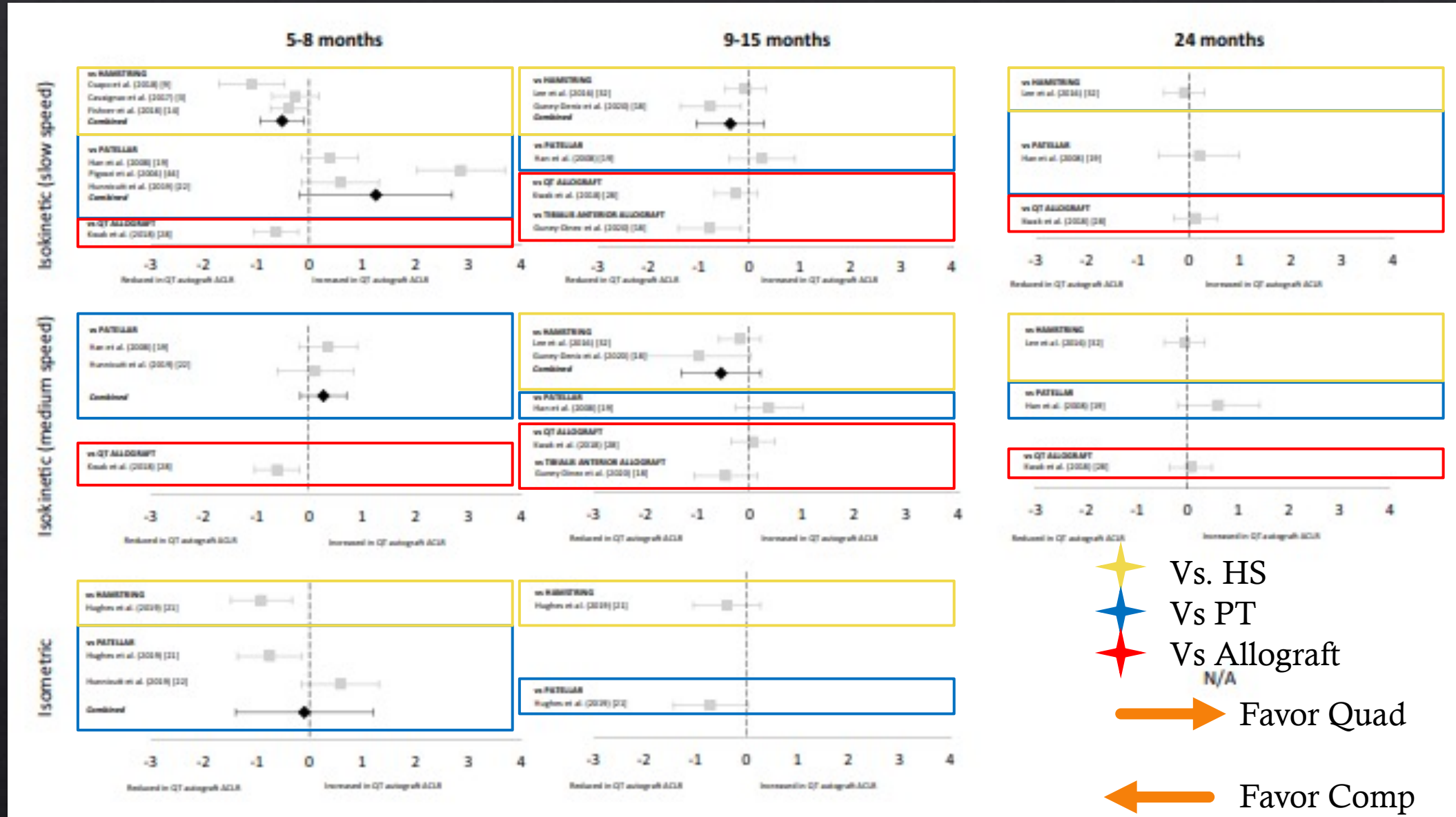
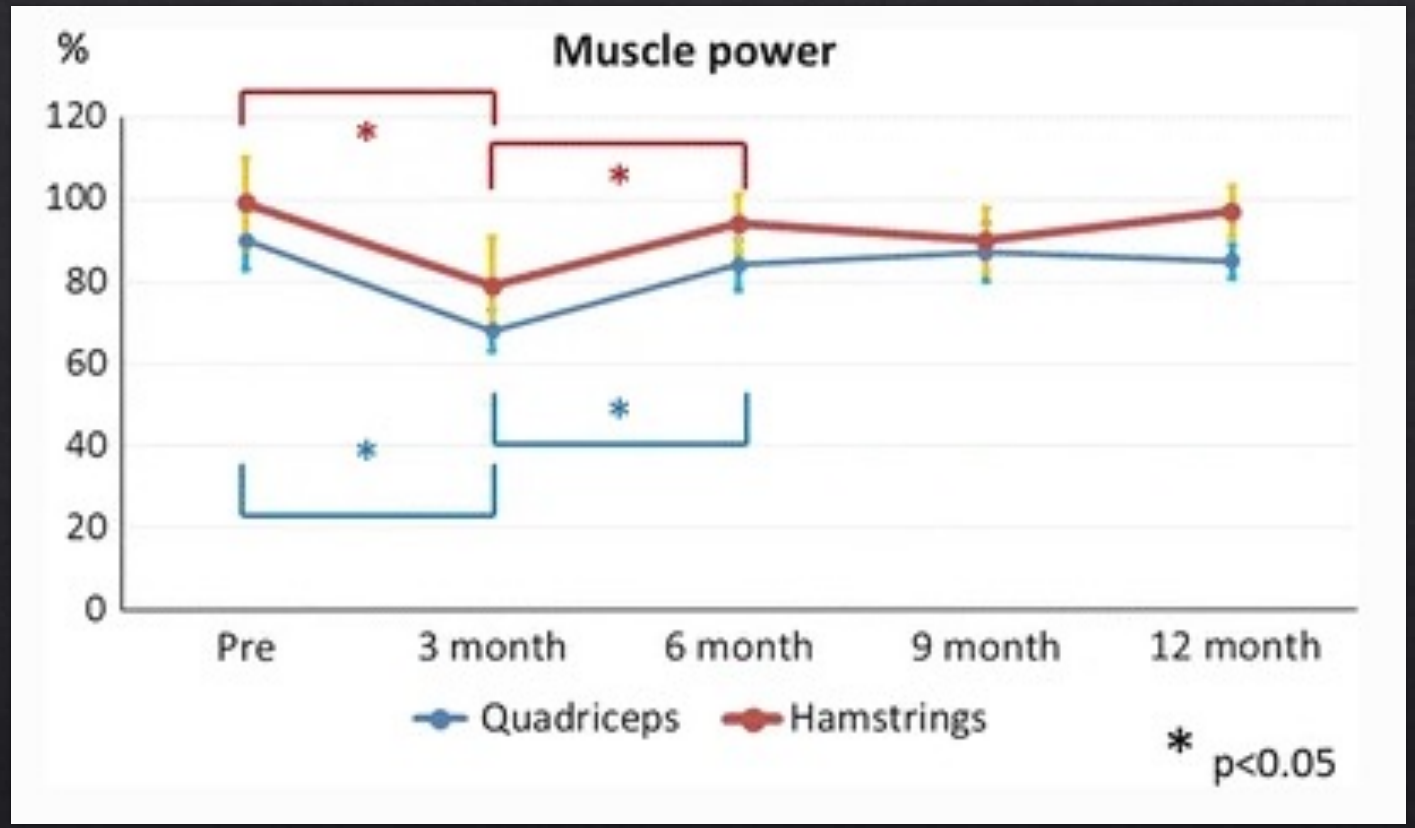


Fig. 4 Peak knee extensor torque LSI following QT ACL reconstruction versus alternative ACL grafts

Johnston PT, McClelland JA, Feller JA, Webster KE. Knee muscle strength after quadriceps tendon autograft anterior cruciate ligament reconstruction: systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2021 Sep;29(9):2918-2933. doi: 10.1007/s00167-020-06311-y. Epub 2020 Oct 7. PMID: 33026536.

Strength Recovery for Quadriceps Autograft

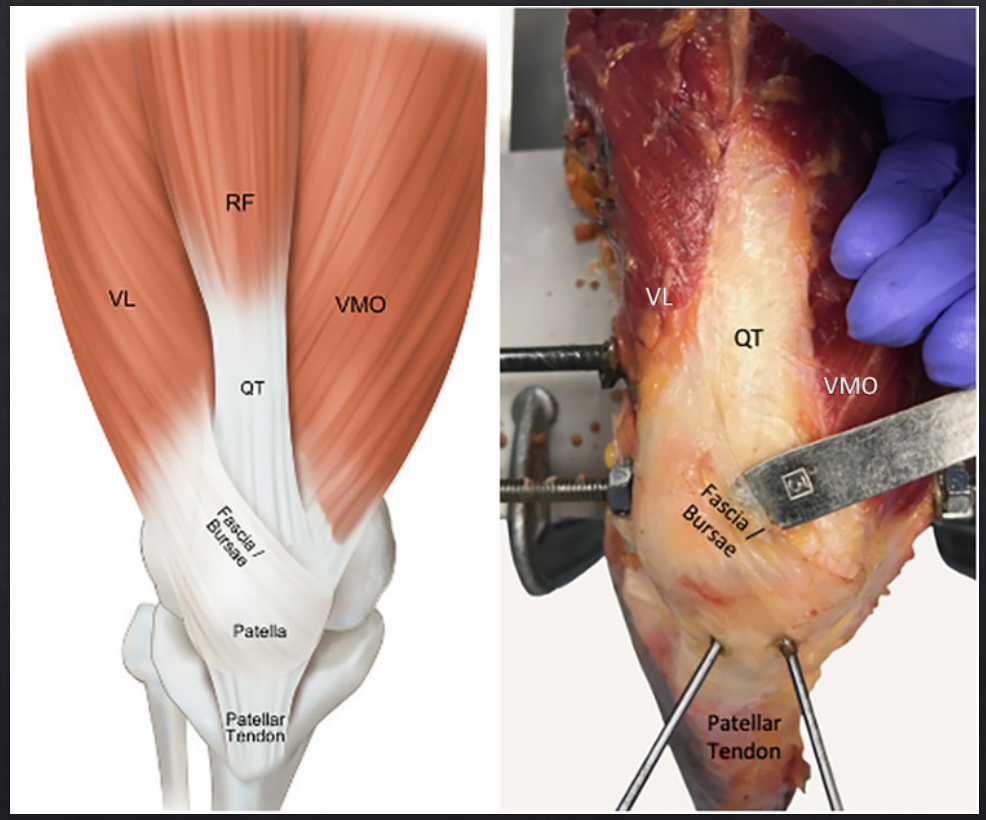
- Patients tend to still be quite weak at 3 months
- Big jump with months 4-6



Iriuchishima T, Ryu K, Okano T, Suruga M, Aizawa S, Fu FH. The evaluation of muscle recovery after anatomical single-bundle ACL reconstruction using a quadriceps autograft. Knee Surg Sports Traumatol Arthrosc. 2017 May;25(5):1449-1453. doi: 10.1007/s00167-016-4124-z. Epub 2016 Apr 7. PMID: 27056694.

Harvest Technique: Anatomy

- Three Layers
  - Superficial
    - Rectus femoris with a superficial bursal/fascial layer
    - Separated from 2nd layer by fatty tissue proximally
      - Fuses to middle layer 48.7 mm (range, 27.9-62.6 mm) from superior patella
  - Middle Layer
    - Vastus Lateralis and Vastus Medialis
    - VM and VL blended together at a median distance of 85.5 mm (range, 52.0-109.0 mm) from superior patella
  - Deep Layer
    - Vastus Intermedius
    - Thickest layer



Strauss M, Kennedy ML, Brady A, Moatshe G, Chahla J, LaPrade RF, Lind M, Engebretsen L. Qualitative and Quantitative Anatomy of the Human Quadriceps Tendon in Young Cadaveric Specimens. Orthop J Sports Med. 2021 Sep 14;9(9):23259671211037305. doi: 10.1177/23259671211037305. PMID: 34541017; PMCID: PMC8445542.

Incision Technique

- ~2 cm incision
  - Longitudinal
    - Easy to visualize, extend, even in larger patients
    - Scar may widen
  - Horizontal
    - Cosmetically favorable
      - Langer Lines
    - Limited ability to extend visualization
- Excise subcutaneous tissue/fat
  - Will hamper visualization

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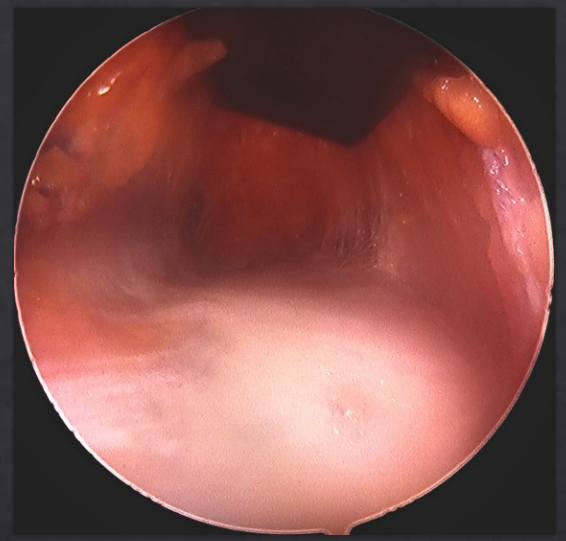
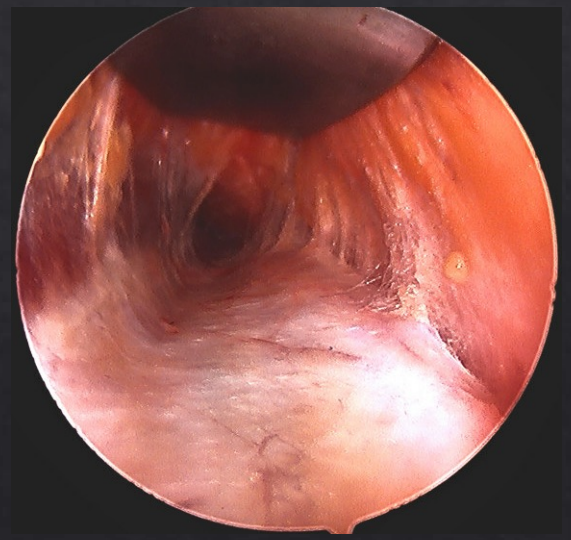
Quadriceps Exposure

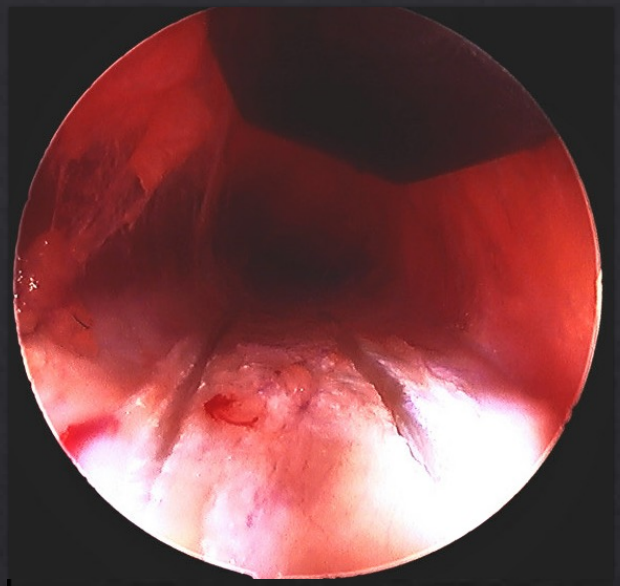
- Separate quadriceps tendon from overlying soft tissues
  - Cobb elevator with Raytec sponge to bluntly dissect layer
  - Army-Navy retractor in line
  - Beware perforating vessels adjacent to VMO
- Visualize up to confluence of tendons
  - Variable anatomy, avoid risk of rectus tear





Quadriceps Tendon Harvest

- Harvest adjacent to VMO
  - Beware perforating vessels → hematoma
- Partial Thickness vs. Full Thickness
  - No difference in complications, clinical outcome, or graft thickness[1]
- 8-10mm width
  - Graft size can vary based on harvest depth
  - Graft diameter can be reliably predicted based on MRI[2]



1. Kanakamedala AC, de Sa D, Obioha OA, Arakgi ME, Schmidt PB, Lesniak BP, Musahl V. No difference between full thickness and partial thickness quadriceps tendon autografts in anterior cruciate ligament reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2019 Jan;27(1):105-116. doi: 10.1007/s00167-018-5042-z. Epub 2018 Jul 4. PMID: 29974173.
2. Takeuchi S, Rothrauff BB, Taguchi M, Kanto R, Onishi K, Fu FH. In situ cross-sectional area of the quadriceps tendon using preoperative magnetic resonance imaging significantly correlates with the intraoperative diameter of the quadriceps tendon autograft. Knee Surg Sports Traumatol Arthrosc. 2021 Mar;29(3):742-749. doi: 10.1007/s00167-020-05993-8. Epub 2020 Apr 24. PMID: 32333056.

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MRI to Predict Graft Size

Table 2 In situ quadriceps tendon measurements with preoperative MRI and the intraoperative diameter of the quadriceps tendon autograft

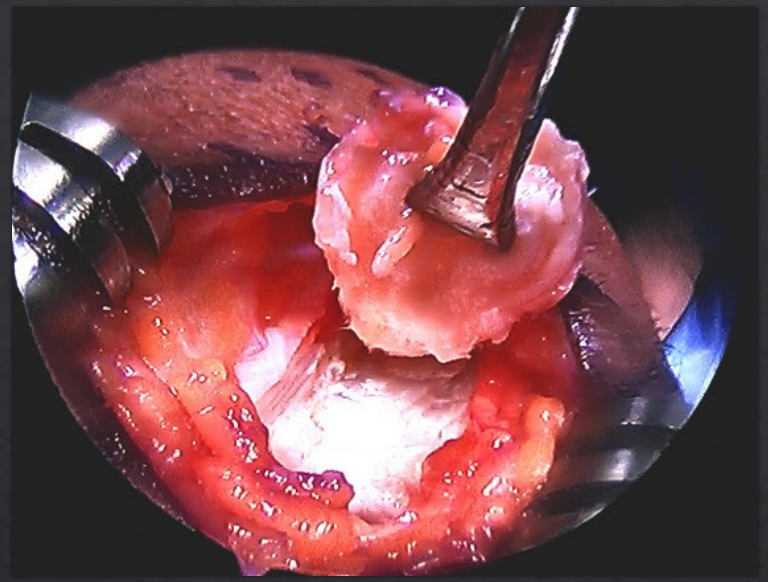
From: In situ cross-sectional area of the quadriceps tendon using preoperative magnetic resonance imaging significantly correlates with the intraoperative diameter of the quadriceps tendon autograft

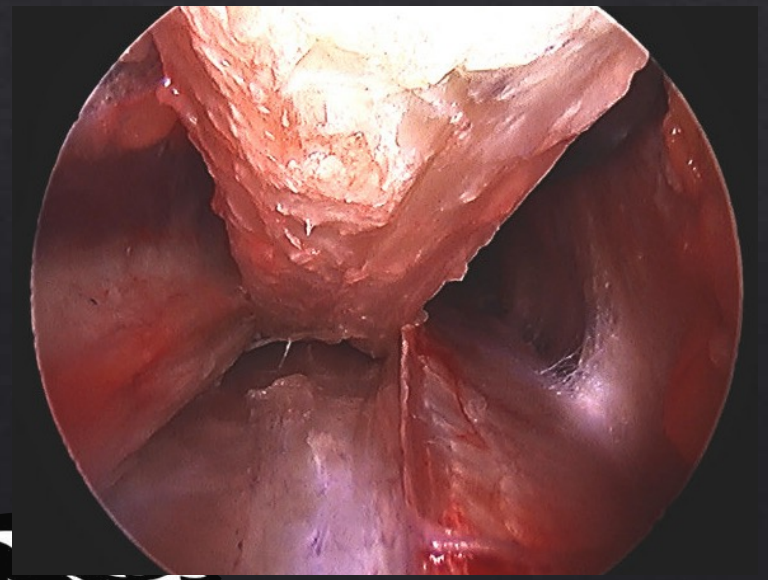
Variable	
Preoperative measurement using MRI	
Thickness, mm	8.3 ± 0.9
CSA, mm^2	84.9 ± 10.0
Adjusted CSA, mm^2	81.7 ± 10.6
Intraoperative measurement	
QT autograft diameter, mm	10.0 ± 1.0

Continuous data are shown as the mean ± standard deviation

MRI magnetic resonance imaging, *CSA* cross-sectional area, *QT* quadriceps tendon

Takeuchi S, Rothrauff BB, Taguchi M, Kanto R, Onishi K, Fu FH. In situ cross-sectional area of the quadriceps tendon using preoperative magnetic resonance imaging significantly correlates with the intraoperative diameter of the quadriceps tendon autograft. Knee Surg Sports Traumatol Arthrosc. 2021 Mar;29(3):742-749. doi: 10.1007/s00167-020-05993-8. Epub 2020 Apr 24. PMID: 32333056.



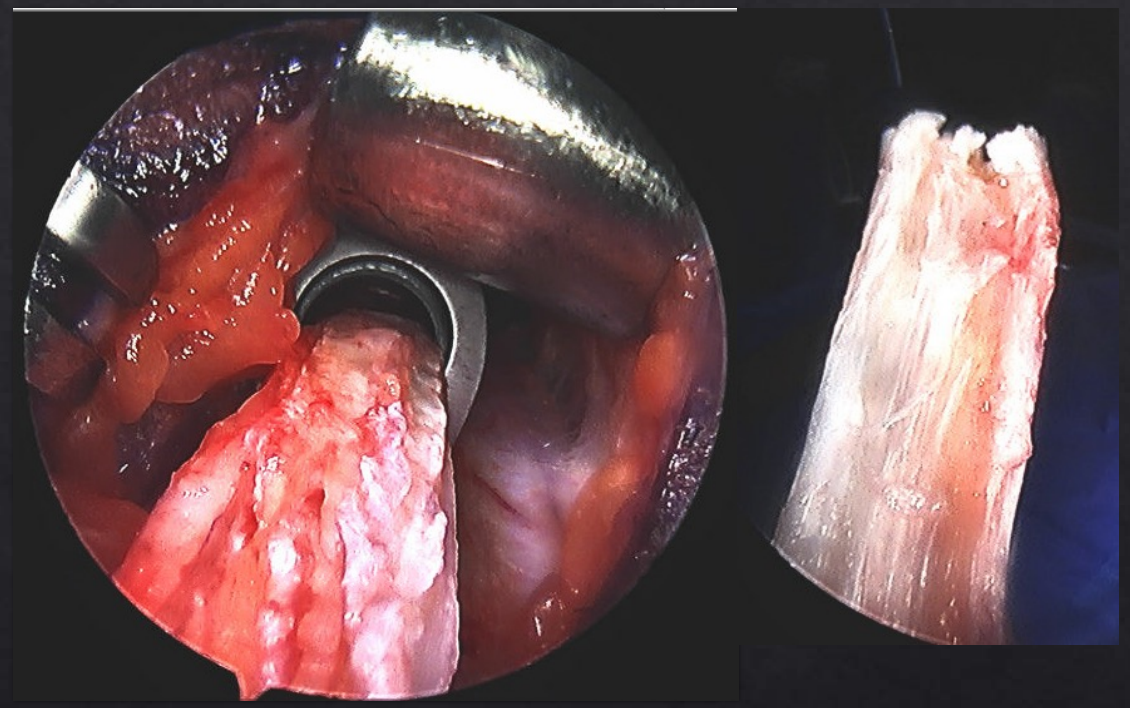


Distal Harvest

- May elevate subperiosteal sleeve
  - Increase length
- Partial Thickness vs. Full Thickness
  - May bluntly dissect below selected layer of graft to assure smooth harvest

Proximal Harvest

- Several proprietary harvest devices allow for minimally invasive harvest
  - Beware anatomy, particularly "Fuse Points"
  - Initial incision may not lacerate all traversing/oblique fibers or device may skive to miss vastus intermedius layer
    - Consider slightly longer graft → fold over for bulk
- Beware graft length to avoid rectus tear
  - Median length of the QT was 86.9 mm (range, 68.4-98.9 mm)[1]



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Harvest Site Repair

- Paucity of data on benefits/necessity of harvest site repair
- Techniques
  - Open with standard suture
  - Minimally invasive with suture passing device (such as for RCR)

Thank you!

Christopher McCrum, MD

cmccrum@samhealth.org