Current Concepts and Literature Overview

Riccardo D‘Ambrosi

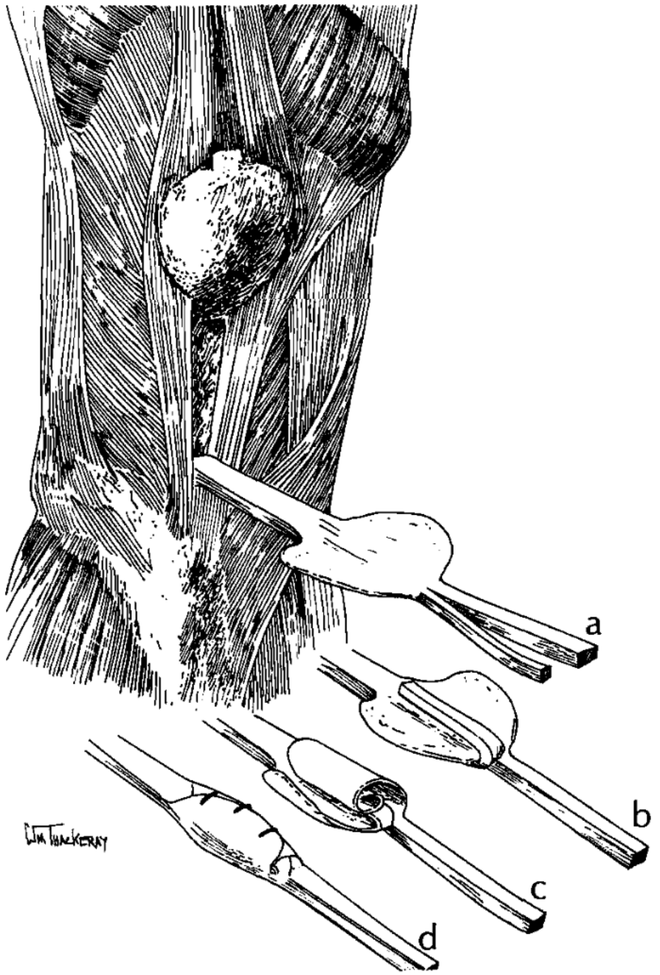
Special thanks to my MENTOR

- Mentor as a concept
  M=manage the relationship
  E=encourages
  N=nurtures
  T=teaches
  O=offers mutual respect
  R=responds to mentee's needs

Once upon a time...

- The QT was initially proposed as a potential graft choice for ACL-R in the late 1970s.

- However, its adoption was limited due to the initial emergence of several postoperative complications



The frog was transformed into a prince.

Contents lists available at ScienceDirect

Journal of ISAKOS

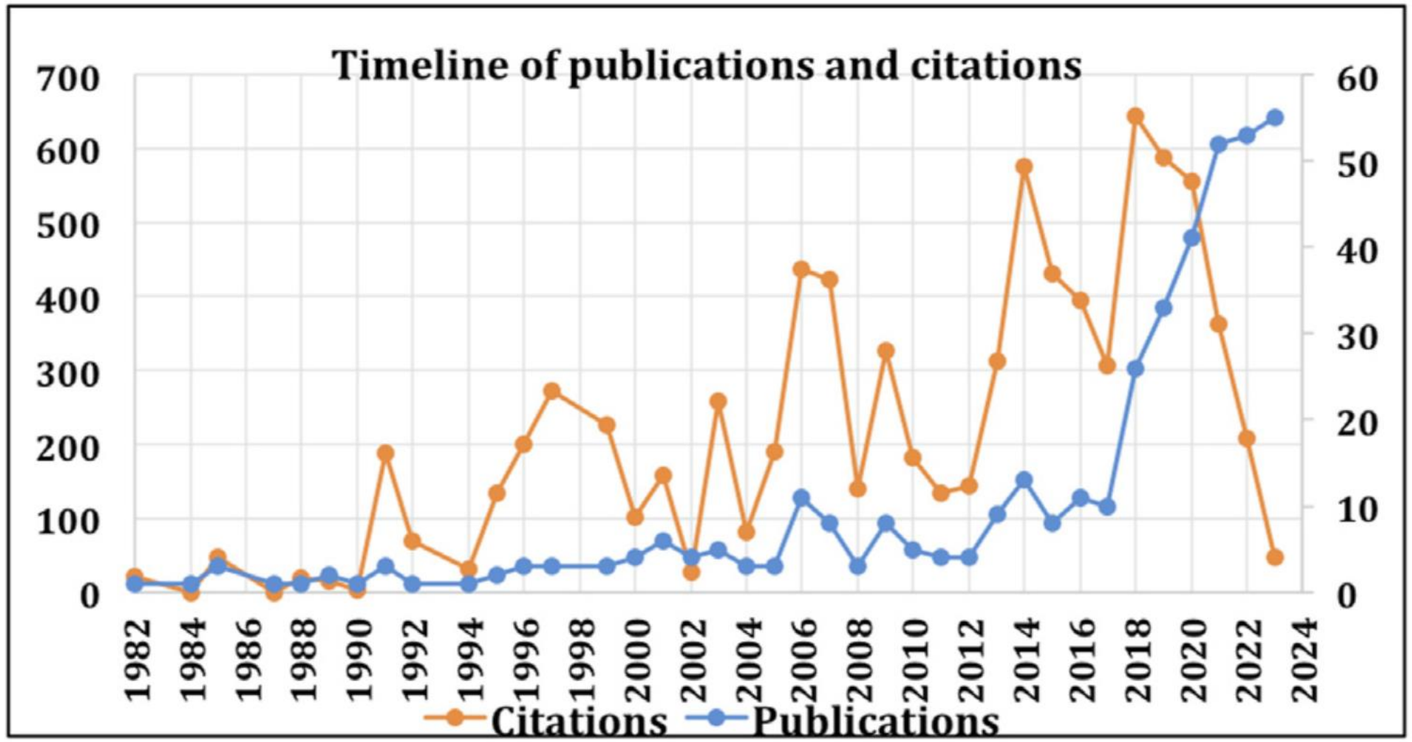
journal homepage: www.elsevier.com/locate/jisakos

Systematic Review

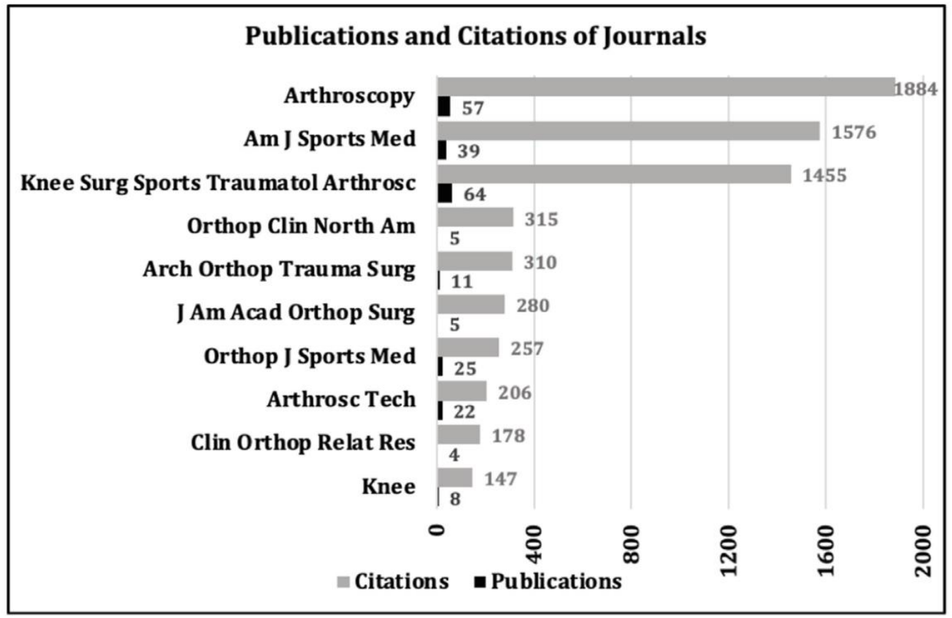
The "Golden Age" of quadriceps tendon grafts for the anterior cruciate ligament: a bibliometric analysis

Literature

- The number of yearly publication averaged 10 or less up to 2018 from 1982 when the first paper on the QT was published.



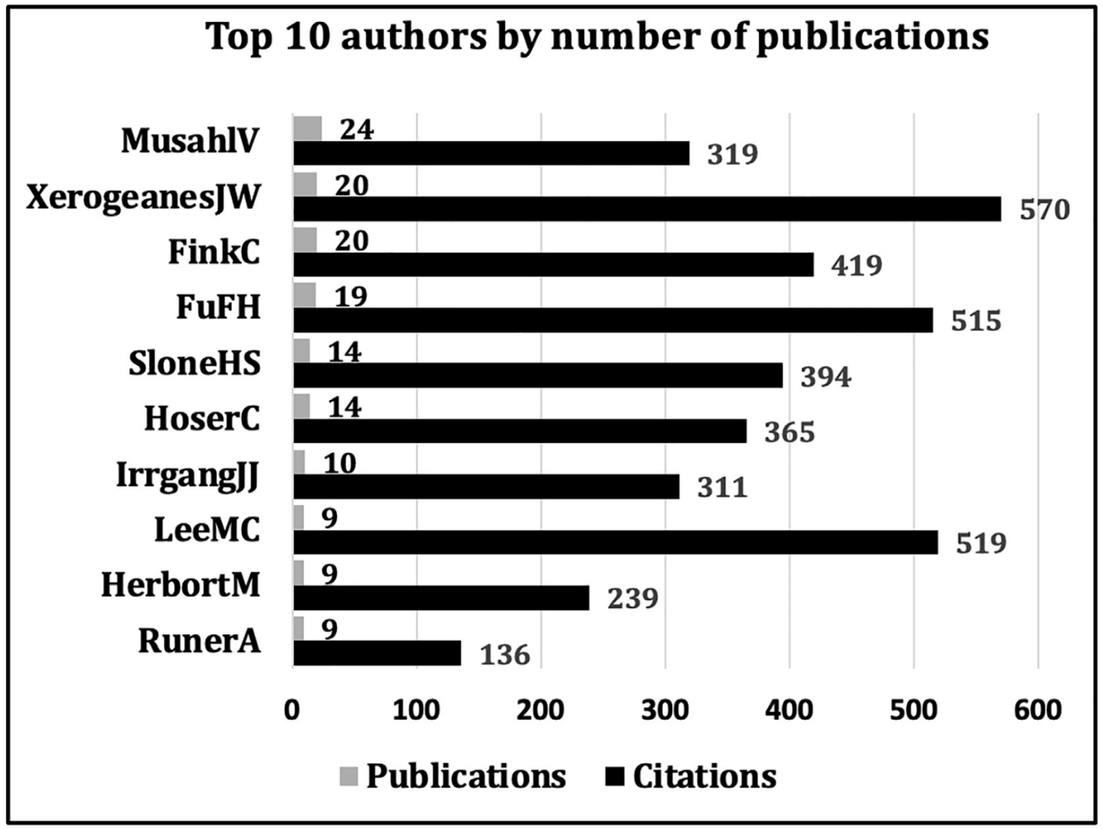
Journals



Top 10 journals arranged as per citations per publication for journals.

Journal	Publications	Citations	Citations/publication
Orthop Clin North Am	5	315	63
J Am Acad Orthop Surg	5	280	56
Br J Sports Med	2	101	50.5
Clin Orthop Relat Res	4	178	44.5
Am J Sports Med	39	1576	40.41
J Bone Joint Surg Am	3	115	38.33
Open Access J Sports Med	1	36	36
J Trauma	2	70	35
Sports Med	2	67	33.5
Arthroscopy	57	1884	33.05

Authors


Top 10 authors by number of publications
MusahlV
XerogeanesJW
FinkC
FuFH
SloneHS
HoserC
IrrgangJJ
LeeMC
HerbortM
RunerA
24
319
20
570
20
419
19
515
14
394
14
365
10
311
9
519
9
239
9
136
0
100
200
300
400
500
600
Publications
Citations

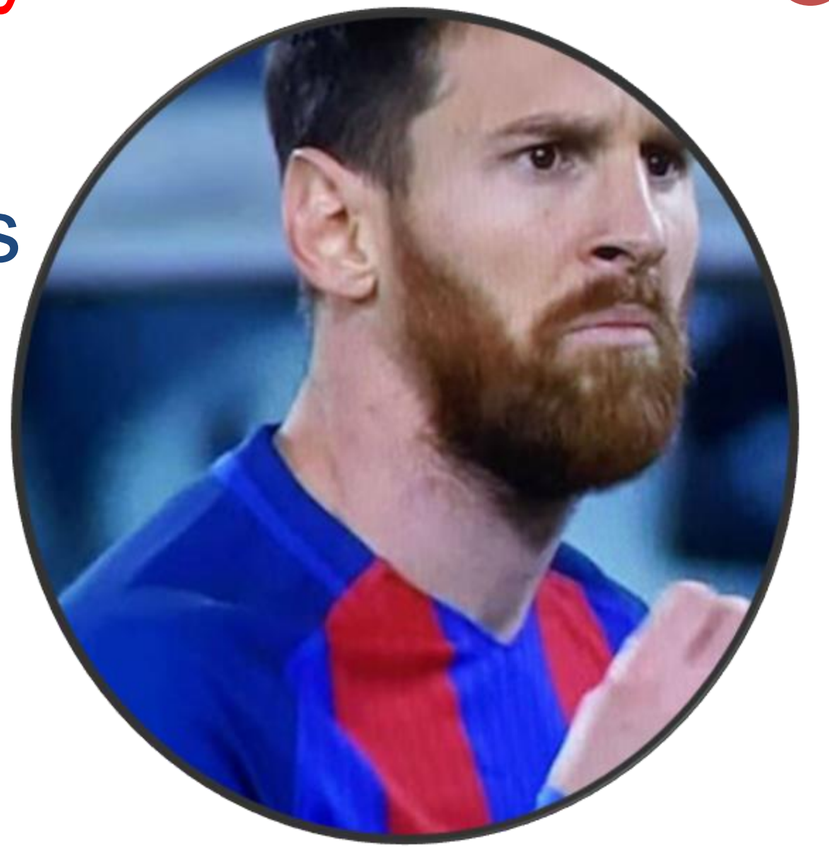

samuelssonk
signorilejf
tummalasv
brinkmanjc
harkeyms
crallts
wijdicksca
wernerbc
anderstw
gottschalkmb
giampetruzzin
kinoshitat
straussmj
johnstonpt
johnsonrj
schlumbergerm
steint
kurodar
moralesm
schulzap
fabricantpd
letterm
kocherms
arroyo
nishinok
zaffagninis
niedererd
gagliardiag
xerogeanesj
guentherd
sheakg
tashiroy
besttm
ettingerm
rabucksj
kanedak
hetsroniigföllerp
lamplotjd
premkumara
cookjl
keelingl
yoshimizur
alguacilji
ohks
kramerde
kumarp
özbekea
onishik
abermanne
cavaignace
websterke
westrv
getgooda
kantor
leetq
woolfsk
akotor
meenaa
herbortm
lesniakbp
ohkoshiy
nakasej
raja
seilr
iidak
nessbm
yanatoriy
hoshinoy
höherj
xerogeanesjw
fulkersonjp
debskire
parrinorl
hurleyet
kimsh
leonen
baragamg
lozano
hanc
lindm
lapraderf
chenwj
mayerp
hartjm
musahlv
irrgangjj
fellerja
gillej
wagalan
singhs
patelnm
tashmans
lees
michelilj
hashr
josb
obiohaoa
martin
albrightjc
maligea
tsuchiyah
nakamurah
slonehs
hanhs
fufh
kimsj
sonnery
richterj
schmidtec
jabera
kayj
kaplanld
csapor
finkc
runera
winklerpw
dadoos
nortege
colebj
hartr
takeuchis
desad
nagaik
cottetb
nielsent
eltoukhym
huberj
wilsonpl
luxenburgd
galet
pascual
greendw
leemc
hoserc
petersenw
manng
mcgarrymh
haleyrm
todora
bouillonb
farinellil
menetreyj
hastmw
zantopt
hunnicuttjl
hughesjd
ganleytj
romandp
albersm
arakgime
kanayamat
engebretsenl
ollivierm
heppergerc
seongsc
gilmerbb
knapikdm
abdelkhalikh
bariéa
hashimotoy
gibbscm
cordascofa
adrianie
baghdadis
adamsongj
eichingerm
sheeana
yasudak
marxrg
mcclellandja
lameiredl
lozanom
herbste
chipmande
kuenzec
stäublihu
pacejl
cognaultj
chahlaj
kanakamedalaac
hidalgopereas
weavera
yamasakis
schusterp
pederzinil
arnerjw
tishermanrt
behringerm
sugimotod
nugrahah
setliffjc
economopouloskj

Still so many doubts

Revision surgery

Graft Harvesting

Biomechanics



Complications

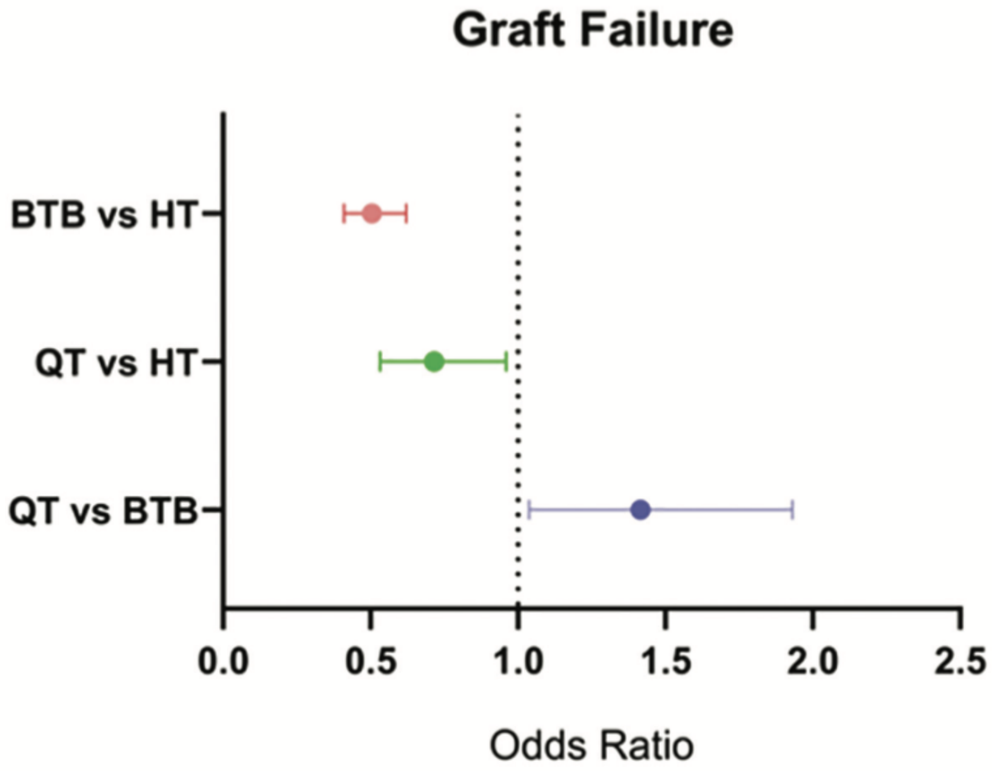
Children

Osteoarthritis

Graft Size

Current evidences

- HT had the highest failure rate (12.7%), followed by QT (9.1%) and BTB (6.4%)
- Odds ratios favored BTB over both QT and HT in terms of failure rate.



Uncovering the State of Current Data on Quadriceps Tendon Autograft Use Versus Bone–Patellar Tendon–Bone and Hamstring Tendon Autografts in Anterior Cruciate Ligament Reconstruction at ≥5 Years After Surgery

A Systematic Review and Meta-analysis

Bone block or not?

No difference in clinical outcome between quadriceps tendon anterior cruciate ligament reconstruction with and without bone block: Results from the Danish Knee Ligament Registry

Quadriceps tendon autograft with or without bone block have comparable clinical outcomes, complications and revision rate for ACL reconstruction: a systematic review

- ACL with a QT harvested either with a bone block or as a soft tissue exhibited comparable revision rates and knee stability.
- Both grafts are safe and viable with comparable clinical outcomes, complications and revision rates.

Graft Choice

....time to change the literature...

Do not consider QT as first choice

Review

Graft Selection in Anterior Cruciate Ligament Reconstruction: A Comprehensive Review of Current Trends

Marko Ostojic [1,2], Pier Francesco Indelli [3,4], Bruno Lovrekovic [5], Jerome Volcarenghi [6], Doria Juric [7], Hassan Tarek Hakam [8,9], Mikhail Salzmann [8,9], Nikolai Ramadanov [8,9], Aleksandra Królikowska [10,*], Roland Becker [8,9] and Robert Prill [8,9,*]

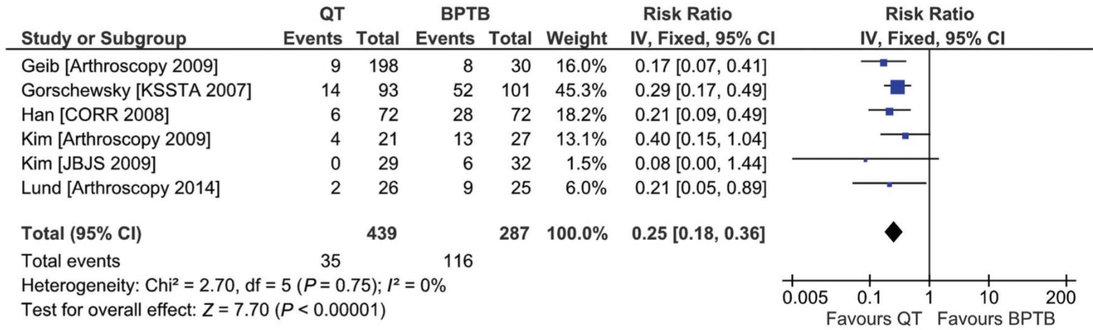
One type of graft for reconstruction of the ACL does not suit all patients based on their characteristics and sports: a scoping review

J. M. Reinerink[1] · T. Vendrig[1] · M. N. J. Keizer[1] · R. A. G. Hoogeslag[2] · R. W. Brouwer[3]

Biomechanics

- QT have been found to exhibit a 1.36-time greater load to failure than BTB of a similar width

- Increased collagen (20% more), larger fibroblast density and increased fibril-interstitial ratio in comparison to BTB



Study or Subgroup	QT Events	QT Total	BPTB Events	BPTB Total	Weight	Risk Ratio IV, Fixed, 95% CI
Geib [Arthroscopy 2009]	9	198	8	30	16.0%	0.17 [0.07, 0.41]
Gorschewsky [KSSTA 2007]	14	93	52	101	45.3%	0.29 [0.17, 0.49]
Han [CORR 2008]	6	72	28	72	18.2%	0.21 [0.09, 0.49]
Kim [Arthroscopy 2009]	4	21	13	27	13.1%	0.40 [0.15, 1.04]
Kim [JBJS 2009]	0	29	6	32	1.5%	0.08 [0.00, 1.44]
Lund [Arthroscopy 2014]	2	26	9	25	6.0%	0.21 [0.05, 0.89]
Total (95% CI)		**439**		**287**	**100.0%**	**0.25 [0.18, 0.36]**
Total events	35		116			

Heterogeneity: Chi² = 2.70, df = 5 (*P* = 0.75); I^2 = 0%

Test for overall effect: *Z* = 7.70 (*P* < 0.00001)

Graft Size

Quadriceps tendon autograft diameters are routinely above 8 mm, and preoperative size estimation before anterior cruciate ligament reconstruction may not be necessary for this graft type: A systematic review

- QT autografts have a mean diameter of 8 mm or greater and are consistently larger than HT.

- Preoperative MRI measurements are better than anthropometric characteristics at predicting QT parameters; however, preoperative prediction may not be necessary.

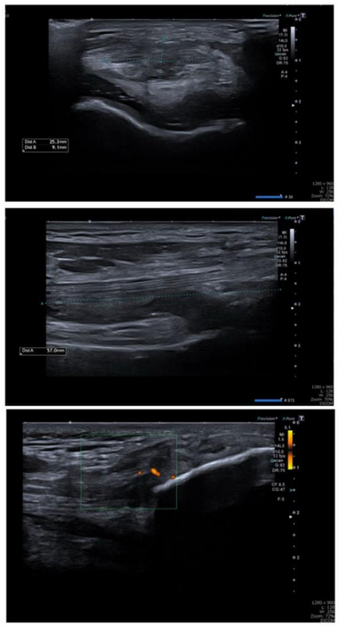
- QT parameters were not found to be significantly associated with any post-operative complication or outcome.

Healing

- At 6 months follow-up, healed by 93 ± 9%.

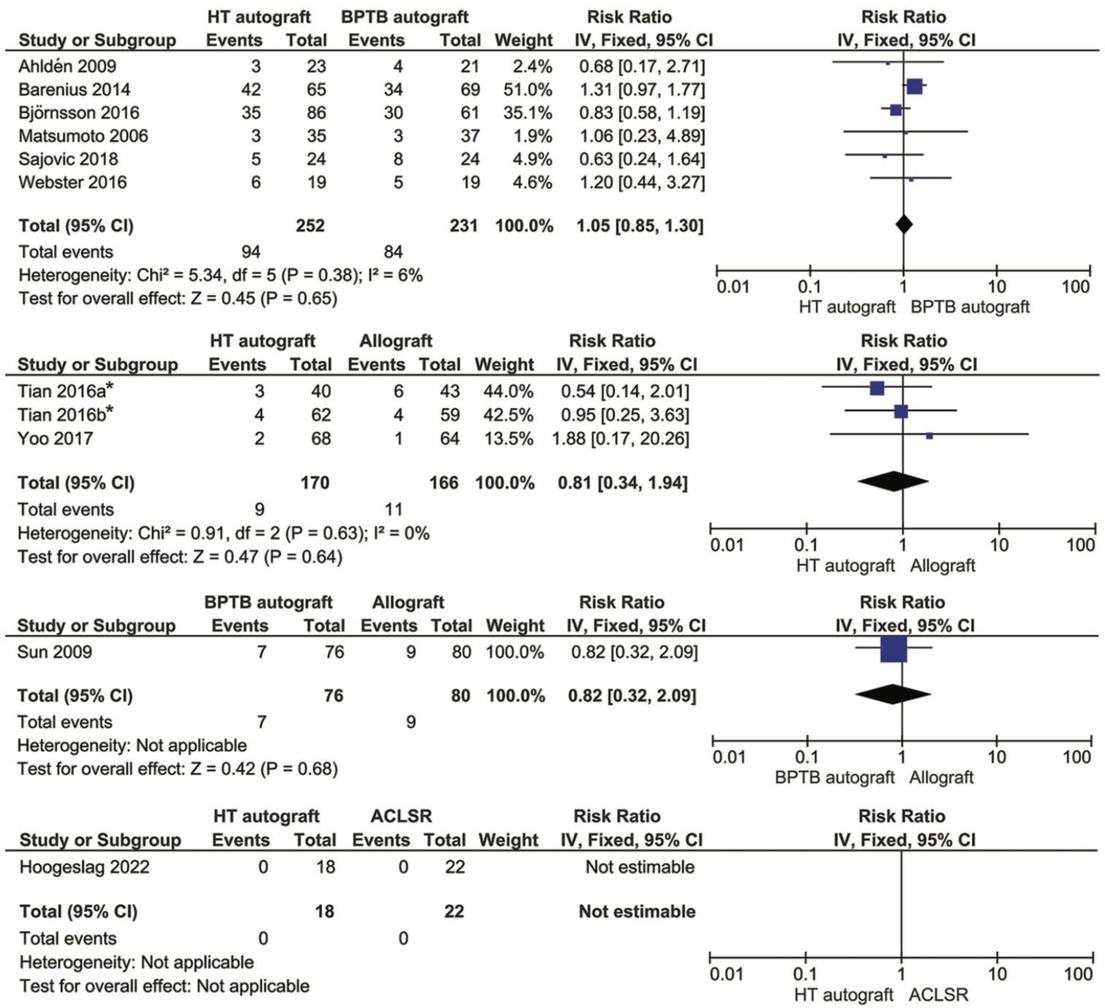
Ipsilateral side

Contralateral side



Osteoarthritis

- No difference in the incidence of OA between graft types used for ACLR



Study or Subgroup	HT autograft Events	Total	BPTB autograft Events	Total	Weight	Risk Ratio IV, Fixed, 95% CI
Ahldén 2009	3	23	4	21	2.4%	0.68 [0.17, 2.71]
Barenius 2014	42	65	34	69	51.0%	1.31 [0.97, 1.77]
Björnsson 2016	35	86	30	61	35.1%	0.83 [0.58, 1.19]
Matsumoto 2006	3	35	3	37	1.9%	1.06 [0.23, 4.89]
Sajovic 2018	5	24	8	24	4.9%	0.63 [0.24, 1.64]
Webster 2016	6	19	5	19	4.6%	1.20 [0.44, 3.27]
Total (95% CI)		**252**		**231**	**100.0%**	**1.05 [0.85, 1.30]**
Total events	94		84			

Heterogeneity: Chi² = 5.34, df = 5 (P = 0.38); I² = 6%
Test for overall effect: Z = 0.45 (P = 0.65)

Risk Ratio IV, Fixed, 95% CI
0.01 0.1 1 10 100
HT autograft BPTB autograft

Study or Subgroup	HT autograft Events	Total	Allograft Events	Total	Weight	Risk Ratio IV, Fixed, 95% CI
Tian 2016a*	3	40	6	43	44.0%	0.54 [0.14, 2.01]
Tian 2016b*	4	62	4	59	42.5%	0.95 [0.25, 3.63]
Yoo 2017	2	68	1	64	13.5%	1.88 [0.17, 20.26]
Total (95% CI)		**170**		**166**	**100.0%**	**0.81 [0.34, 1.94]**
Total events	9		11			

Heterogeneity: Chi² = 0.91, df = 2 (P = 0.63); I² = 0%
Test for overall effect: Z = 0.47 (P = 0.64)

Risk Ratio IV, Fixed, 95% CI
0.01 0.1 1 10 100
HT autograft Allograft

Study or Subgroup	BPTB autograft Events	Total	Allograft Events	Total	Weight	Risk Ratio IV, Fixed, 95% CI
Sun 2009	7	76	9	80	100.0%	0.82 [0.32, 2.09]
Total (95% CI)		**76**		**80**	**100.0%**	**0.82 [0.32, 2.09]**
Total events	7		9			

Heterogeneity: Not applicable
Test for overall effect: Z = 0.42 (P = 0.68)

Risk Ratio IV, Fixed, 95% CI
0.01 0.1 1 10 100
BPTB autograft Allograft

Study or Subgroup	HT autograft Events	Total	ACLSR Events	Total	Weight	Risk Ratio IV, Fixed, 95% CI
Hoogeslag 2022	0	18	0	22		Not estimable
Total (95% CI)		**18**		**22**		**Not estimable**
Total events	0		0			

Heterogeneity: Not applicable
Test for overall effect: Not applicable

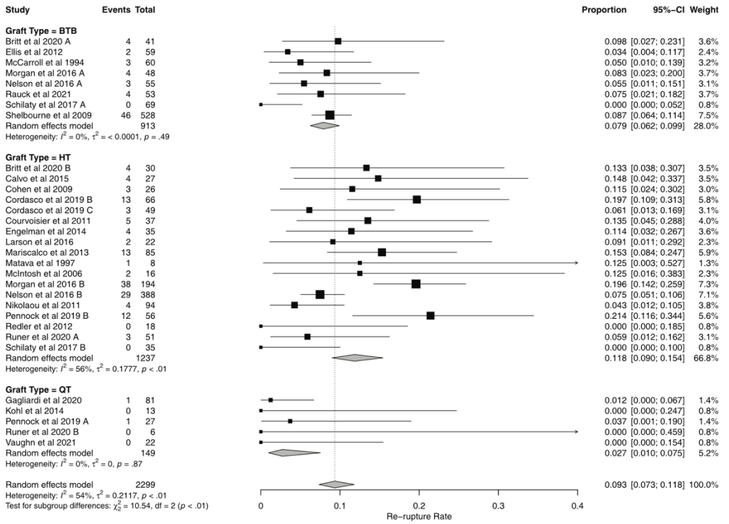
Risk Ratio IV, Fixed, 95% CI
0.01 0.1 1 10 100
HT autograft ACLSR

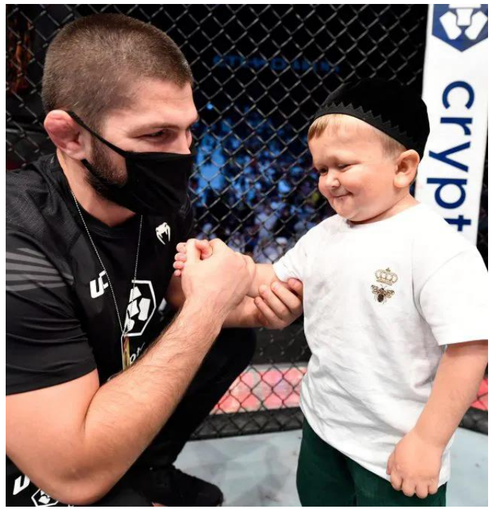
Incidence of Osteoarthritis Between ACL Reconstruction With Different Graft Types and Between ACL Reconstruction and Repair

A Systematic Review and Meta-analysis of Randomized Controlled Trials

Pediatric

- BPTB and QT demonstrated significantly lower failure rates than HT in adolescent athletes 18 years old.
- The QT demonstrated the lowest failure rate in adolescents





…and differently pediatric

- QT in highly active older patients provides satisfactory patient-reported outcomes

- QT autograft is a good graft option in patients older than 50 years.

Variables	Patient numbers = 57 Number (%)
Age, mean (SD)	54.9 (5.2)
Sex	
Female	33 (57.9%)
Male	24 (42.1%)
Days from injury to surgery, mean (SD) [range]	16.6 (12.9) [0–90]
QT autograft without bone block	38 (67%)
QT autograft with bone block	19 (33%)
Isolated ACL reconstruction	16 (28%)
Concomitant (complex) procedures	41 (72%)
Meniscal injuries	36 (63%)
Meniscectomy	
Medial	19 (33%)
Lateral	6 (11%)
Meniscal repair	
Medial	2 (4%)
Lateral	9 (16%)
Cartilage lesions	10 (18%)
MCL injuries	5 (9%)
Summer sport before ACL injury	
Cycling	16 (28%)
Running	15 (26%)
Mountain biking	7 (12%)
Others	13 (23%)
Winter sport before ACL injury	
Ski/Snowboard	52 (91%)
Others	5 (9%)
Sport after ACL injury	
Summer sport at 2-year follow-up	
Running	15 (26%)
Cycling	13 (23%)
Mountain biking	9 (16%)
Others	15 (26%)
Winter sport after ACL injury	
Ski/Snowboard	46 (81%)
Others	11 (19%)
Frequency of sports before ACL injury	
> 5 times by week	15 (26%)
2–3 times by week	36 (63%)
Irregularly	6 (11%)
Frequency of sports at 2-year follow-up	
> 5 times by week	11 (19%)
2–3 times by week	40 (70%)
Irregularly	

QT quadriceps tendon, *SD* standard deviation

Impostazioni c

Quadriceps autograft is a viable graft choice for arthroscopic ACL reconstruction in patients over 50 years of age

Revision Surgery

- HT autografts result in either similar or inferior outcomes in r-ACLR when compared to QT or BPTB autograft options.

Reference	Study design (level of evidence)	Number of patients/knees	Mean follow-up (%) post-r-ACLR (SD) (months)	Lost to follow-up (%)	Female (%)	Mean age at revision (SD) (years	Time between first and r-ACLR (SD) (years)	MINORS/ *Detsky* score
Ahn et al. [2]	Case-control (III)	55/56	48.7 (range: 22.0–120.0)	0.0	21.8	31.6 (range: 21.0–55.0)	4.4 (range: 0.4–18.0)	13/24
Legnani et al. [19]	Retrospective cohort study (III)	44/44	62.4 (range: 24.0–84.1)	0.0	34.1	26.9 (9.3)	NR	16/24
Häner et al. [9]	Prospective comparative study (II)	51/51	24.0	5.5	31.4	35.8 (11.8)	NR	16/24
Barié et al. [3]	Retrospective cohort study (III)	79/79	52.3 (6.9)	39.7	27.8	31.0 (10.0	6.6 (6.8)	16/24
Supreeth et al. [39]	Retrospective observational study (III)	84/84	NR (range: 24–60)	NR	14.3	29.0 (8.4)	4.6 (range: 0.8–19.0)	14/24
Sasaki et al. [33]	Randomized controlled trial (I)	41/41	46.8	0.0	63.4	26.1 (11.5)	8.1 (8.6)	*16/20*
Eggeling et al. [7]	Retrospective cohort study (III)	89/89	26.9 (3.7)	5.2	39.3	30.1 (8.9)	NR	14/24
Meena et al. [24]	Retrospective cohort study (III)	85/85 *90/90 (demographics included lost to follow-up)*	24.0	12.37	38.1	35.6 (9.8)	NR	17/24
Rayes et al. [31]	Retrospective cohort study (III)	72/72	56.5	0.0	14.9	23.3 (4.8)	NR	18/24
Katagiri et al. [14]	Retrospective cohort study (III)	41/41	40.5	31.0	39.0	30.6 (range: 15–54)	7.4 (range: 0.5–22.5)	14/24
Yumashev et al. [44]	Retrospective cohort study (III)	218/218	60.0	NR	19.3	NR	NR	13/24

Hamstring autografts demonstrate either similar or inferior outcomes to quadriceps or bone–patellar tendon–bone autografts in revision anterior cruciate ligament reconstruction: A systematic review of comparative studies

Complications

- 10.5% of knees, with anterior knee pain being the most common.
- No difference with the use of the QT versus QTPB
- Anterior knee pain was 2.7 times greater with use of a soft tissue quadriceps graft

	QT			QTPB			
Complication	Knees, n/N	IR, %	Study Citations	Knees, n/N	IR, %	Study Citations	*P*
Total complications	74/604	12.3	[5,11,13,17,19,45]	120/1254	9.6	‖‖	.08
Failure (total)	9/569	1.6	[5,11,13,17,19,45]	39/1254	3.1	‖‖	.06
Infection	1/124	0.8	[13]	3/162	1.9	[1,15,25,27,46]	.44
Anterior knee pain	38/159	23.9	[13,19]	44/509	8.6	††	**<.001**
Patellar fracture	-	-	-	10/464	2.2	[14,18,23,24,46]	-
Cyclops lesion	18/365	4.9	[5,17]	5/107	4.7	[18,25]	.94
ROM deficit	4/124	3.2	[13]	7/376	1.9	[14,18,23]	.19
Instability	-	-	-	9/206	4.4	[18,22,24,40]	-
Unsatisfactory cosmetic appearance	5/39	12.8	[45]	-	-	-	-
Quadriceps muscle weakness	-	-	-	1/57	1.8	[18]	-
DVT	-	-	-	3/57	5.3	[18]	-
Reoperations	31/528	5.9	[5,13,17,45]	34/1056	3.2	¶¶	**.011**
Revision ACLR	5/528	0.9	[5,13,17,45]	22/1056	2.1	¶¶	.08

dverse Events and Complications After rimary ACL Reconstruction With uadriceps Tendon Autograft

Systematic Review

Take Home Message

- Literature is increasing but still scarce (vs HT and BPTB)
- With or without bone-block results are similar
- Lower failure than HT
- Better biomechanicals properties than BPTB
- High healing rate
- No evidence of OA
- Good to excellent results in pediatric and over 50 patients
- Excellent outcomes in revision surgery

Thank you for your attention!

riccardo.dambrosi@hotmail.it

2nd
IQTI
Meeting

| 7th June 2025 | NH München Messe

IQTI INTERNATIONAL QT INTEREST GROUP

OSMI FOUNDATION

13.00 - 13:15 ANATOMY AND BIOMECHANICS

Dott. Luca Farinelli MD PhD

Assistant Professor Clinica Ortopedica dell'Adulto e Pediatrica

Università Politecnica delle Marche, Ancona

Azienda Ospedaliera Universitaria delle Marche

IRCCS INRCA Ancona Italy

Sport Traumatology and Knee Arthroscopy surgery

Email: l.farinelli@staff.univpm.it

IRCCS INRCA

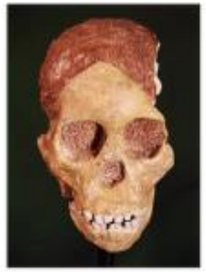
UNIVERSITÀ POLITECNICA DELLE MARCHE

Hominins

7 millions years ago

Gen. Australopithecus

Genus of early hominins that existed in Africa during the Pliocene and Early Pleistocene (5 millions years ago)



Gen. Homo

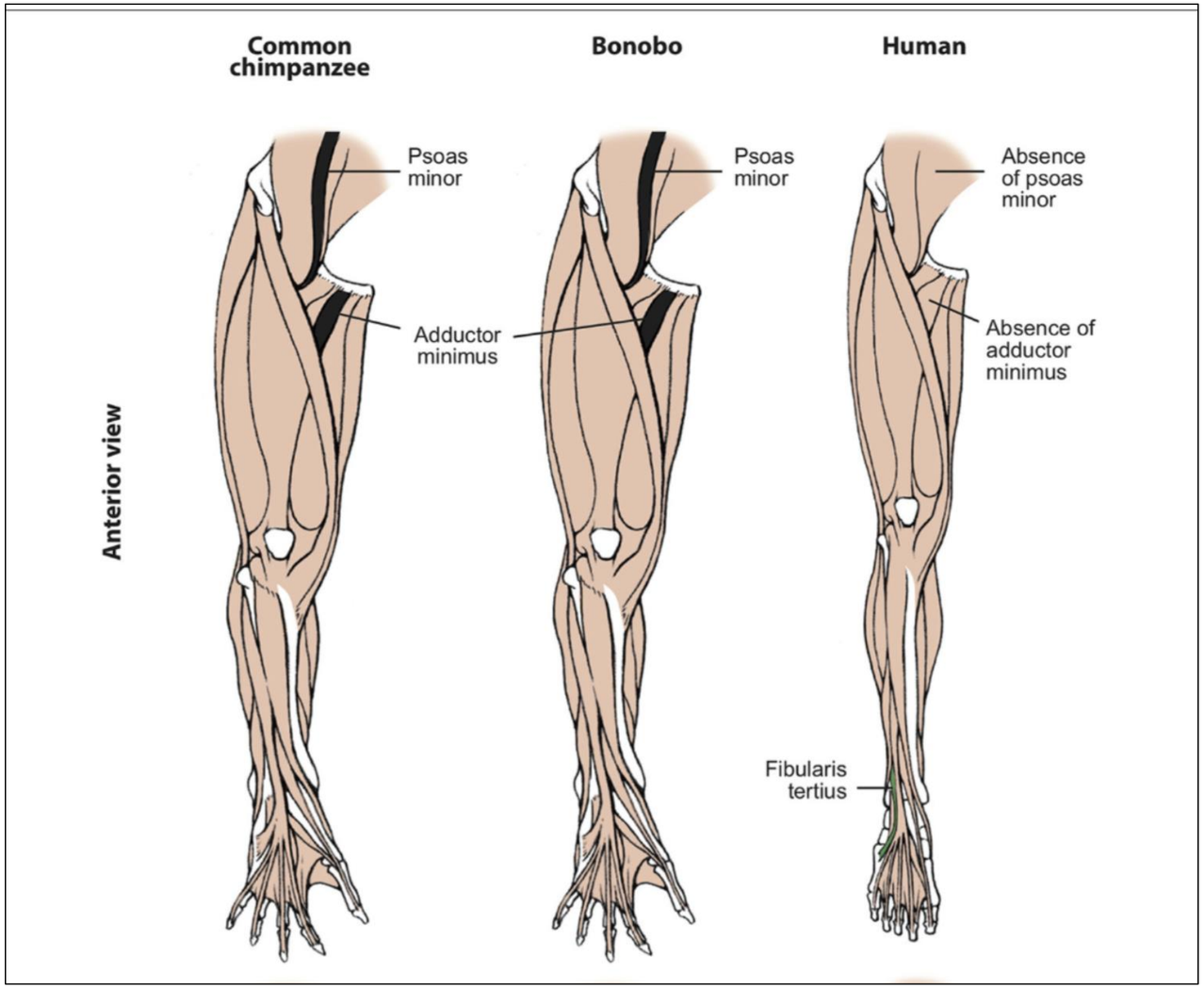
Gen. Pan

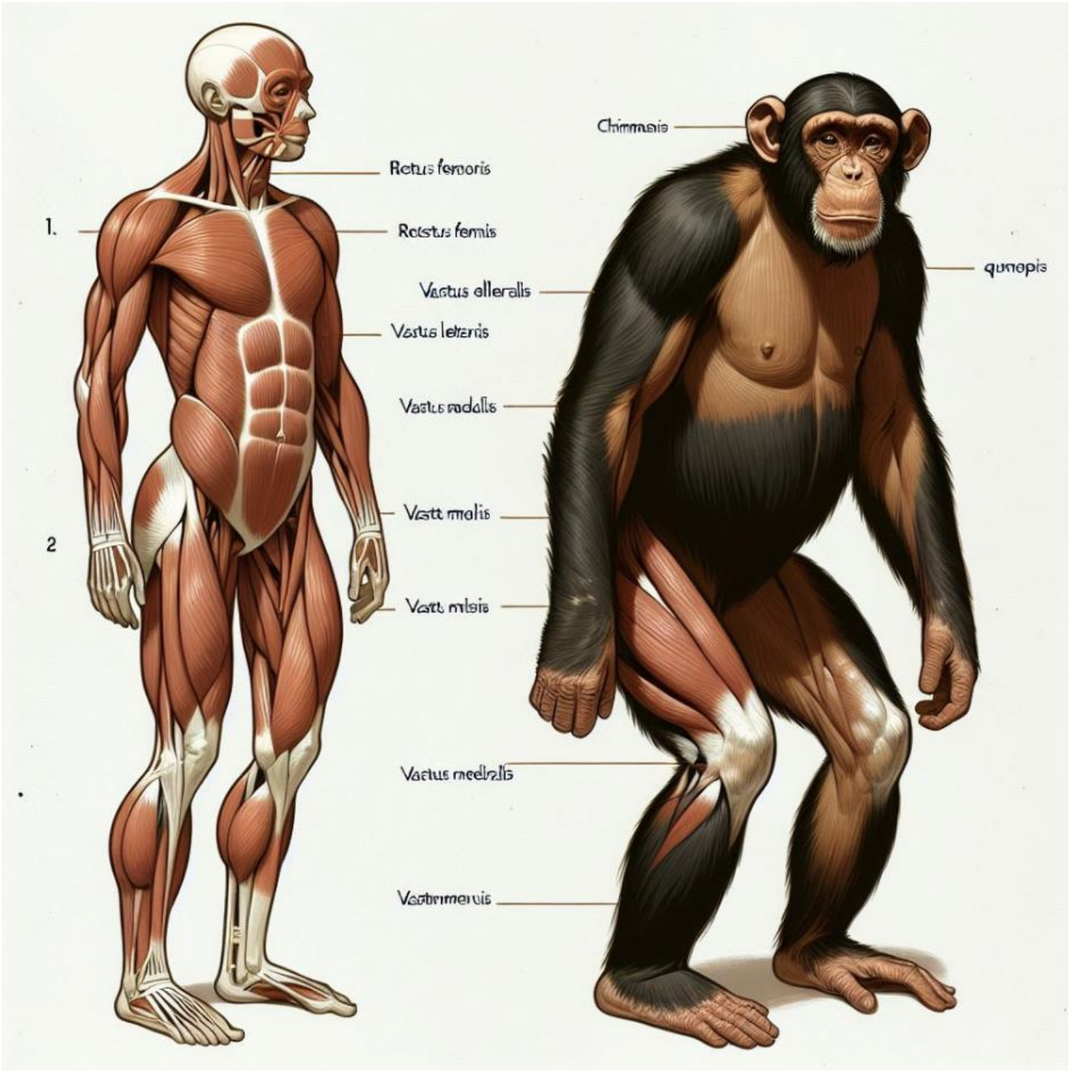
Chimpanzees

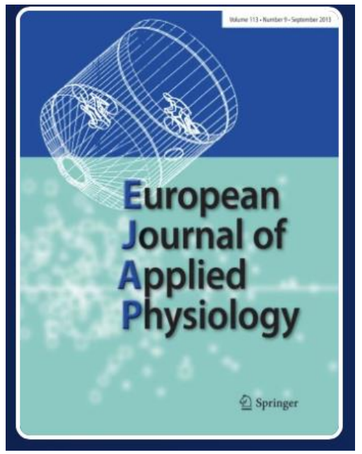
bonobos

Gen Homo

Gen Pan


Common chimpanzee
Bonobo
Human
Anterior view
Psoas minor
Adductor minimus
Psoas minor
Absence of psoas minor
Absence of adductor minimus
Fibularis tertius


1.
2
Rectus femoris
Rectus femoris
Vastus lateralis
Vastus medialis
Vastus medialis
Vastus intermedius
quadriceps



Rectus femuris: the only quadriceps muscle that crosses the hip joint (Flexor of the hip)

Role: fundamental in movements like kicking, running, and climbing stairs.

Medial and lateral vastus: activation for knee extension during different angles of knee flexion, patella stabilizers . At low degrees of flexion (near full extension), **the vastus medialis** is particularly active in stabilizing the patella and guiding it correctly into the femoral groove.

At higher degrees of flexion (above 45°), the **vastus lateralis** provides greater force to support extension and return to standing.

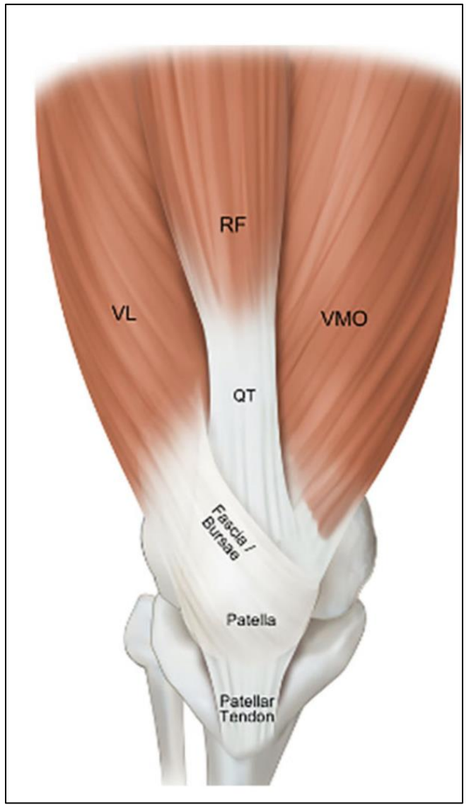
Chan AY, Lee FL, Wong PK, Wong CY, Yeung SS. Effects of knee joint angles and fatigue on the neuromuscular control of vastus medialis oblique and vastus lateralis muscle in humans. Eur J Appl Physiol. 2001 Jan-Feb;84(1-2):36-41. doi: 10.1007/s004210000326.

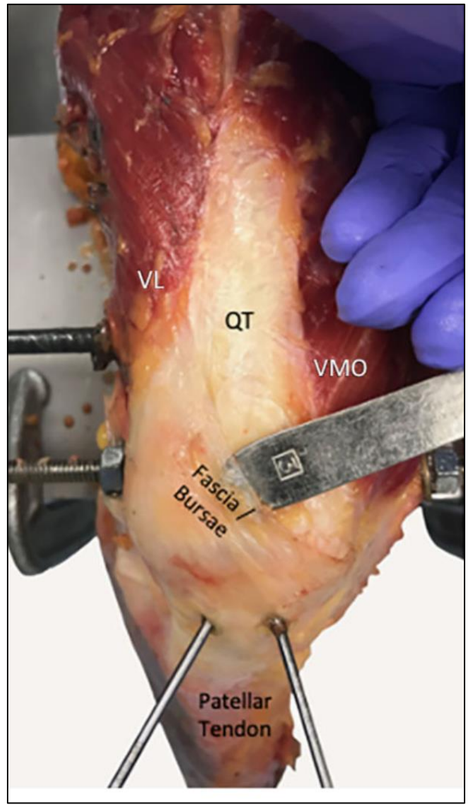
ANALYSIS OF QUAD TENDON IN YOUNG ADULT PATIENT

The QT was identified in all specimens as 3 distinct layers: superficial (first layer), middle (second layer), and deep (third layer).

First Layer (*Rectus femuris)*

RF with a fascia/ bursa structure superficial to the RF, coursing in a diagonal direction from the VL and toward the medial aspect of the patella.



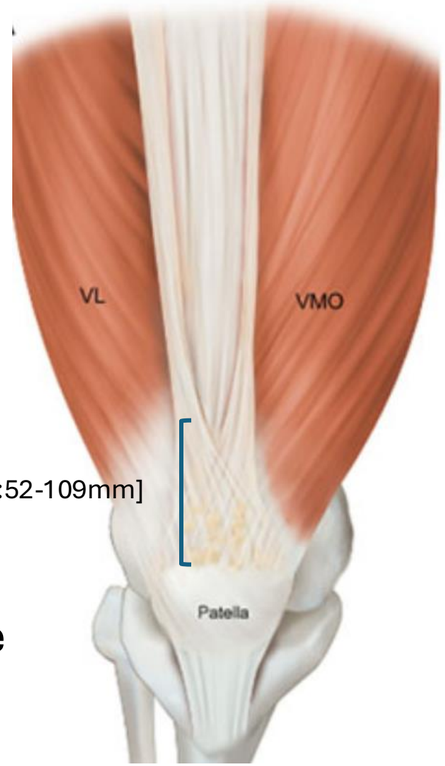


Strauss et al. 2021 OJSM

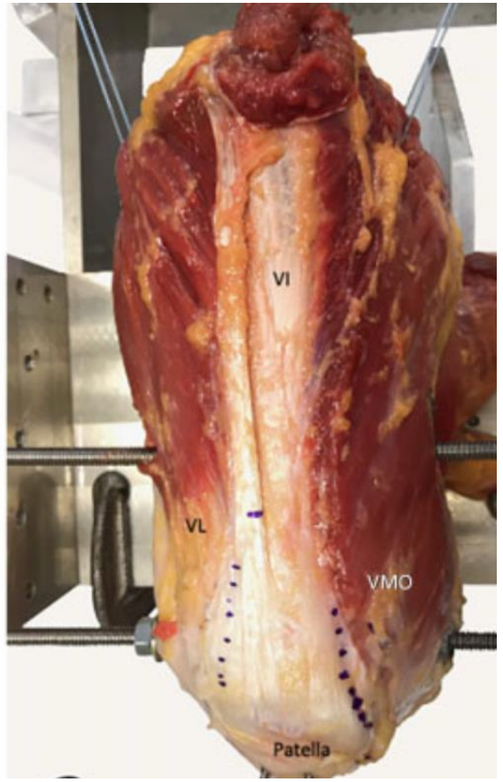
ANALYSIS OF QUAD TENDON IN YOUNG ADULT PATIENT

Second Layer (*Lateral and medial vastus)*

This layer included the VM and VL and was a more complex layer that merged fibers from both muscles and tendons in a crossing pattern and where the fibers of the VM and VL blended as they coursed distally toward the patella



Median 85.5 mm [range:52-109mm]



From the «blended point»
the fiber structures were identifiable but not dissectable

Strauss et al. 2021 OJSM

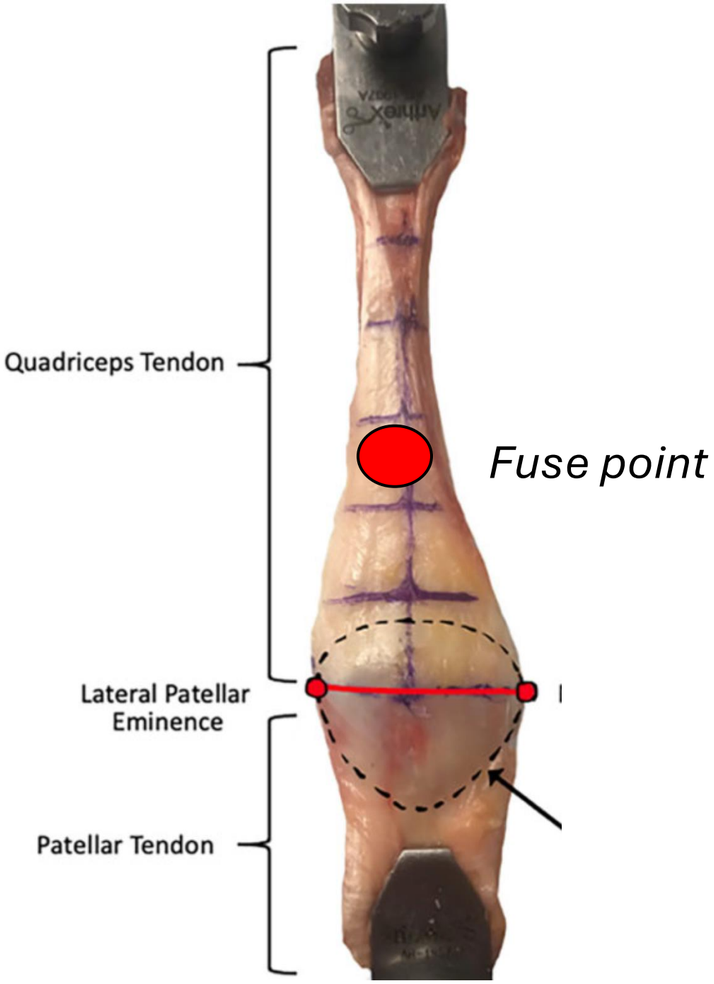
ANALYSIS OF QUAD TENDON IN YOUNG ADULT PATIENT

Dissecting from a proximal-to-distal direction, the proximal part of the RF was not attached to the deeper layer and was separated from the second layer by fatty tissue. In the more distal part, the fatty tissue faded, and the first layer (RF) fused with the second layer (VL and VM)

The «fuse point» is at a median length of 48.7 mm (range, 27.9- 62.6 mm) from the PEL;

From the fuse point and distally to the patella, the first and second layers could easily be separated via simple dissection.

Strauss et al. 2021 OJSM

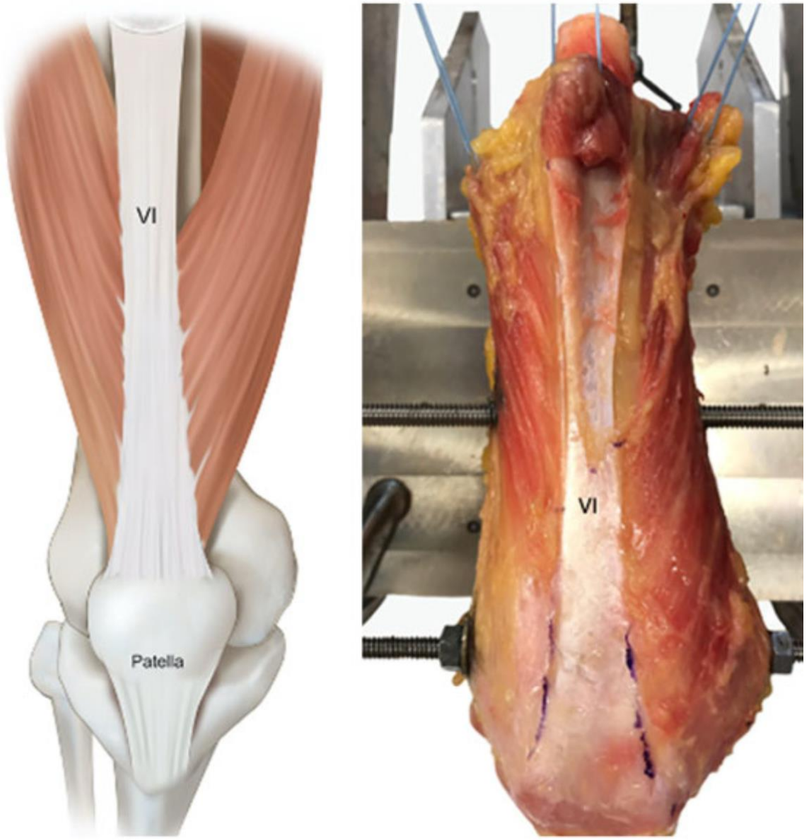


Third Layer (*Intermedius vastus)*

The deep layer, consisting of the VI a homogenous structure with fibers coursing in a parallel direction to the tendon.

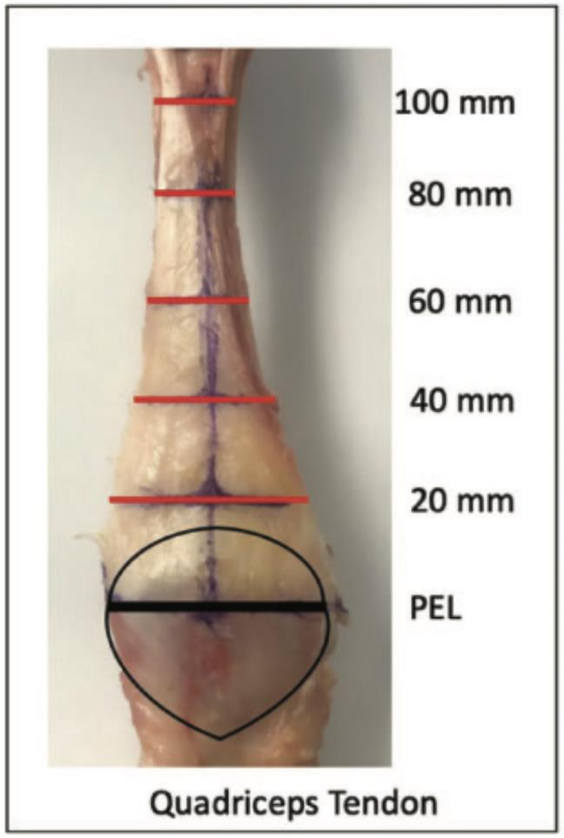
Measures:

- median thickness of 7.5 mm (range, 4.3-9.9 mm),
- median width of 34.9 mm (range, 23.2-38.8 mm), and
- median attachment area of 211.2 mm2 (range, 157.9-349.6 mm2)



Strauss et al. 2021 OJSM

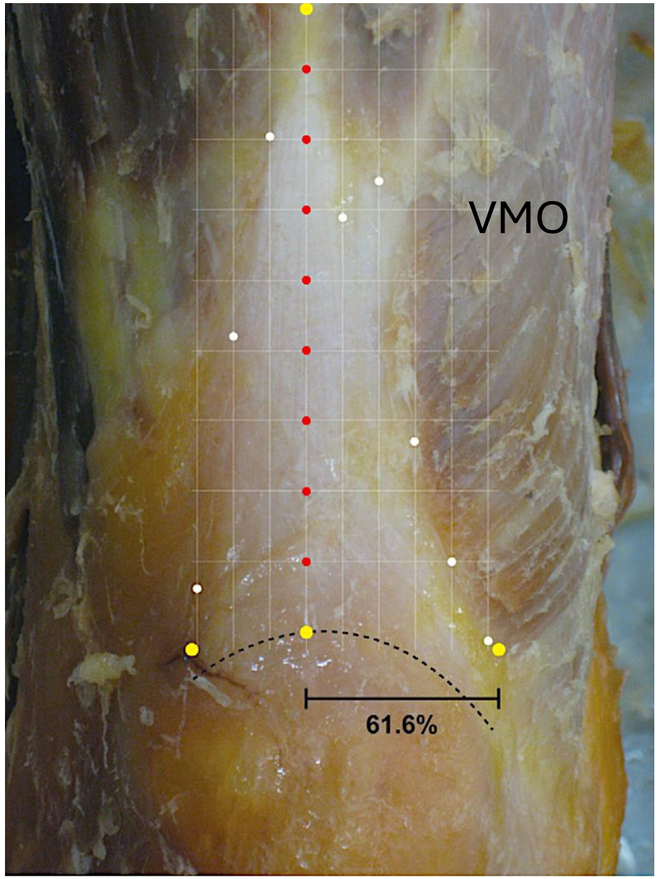
ANALYSIS OF QUAD TENDON IN YOUNG ADULT PATIENT



Distance from PEL	Thickness, median (range), mm		
	Lateral	Central	Medial
100 mm	5.5 (3.2-6.8)	5.4 (3.2-7.3)	4.8 (3.2-5.7)
80 mm	5.5 (3.2-8.0)	6.5 (3.2-8.1)	5.2 (3.8-5.9)
60 mm	4.0 (3.4-6.7)	7.5 (4.6-8.3)	5.8 (3.6-8.1)
40 mm	3.7 (2.9-5.4)	7.2 (4.8-9.9)	5.4 (4.8-8.4)
20 mm	6.7 (4.3-7.5)	8.5 (6.0-10.8)	6.1 (4.9-10.2)

Strauss et al. 2021 OJSM

ANALYSIS OF QUAD TENDON IN AGED PATIENTS



Concerning the QT graft for ACL reconstruction, authors recommended harvesting the graft slightly lateral to the midline of the QT insertion on the patella, as this is the thickest part of the tendon.

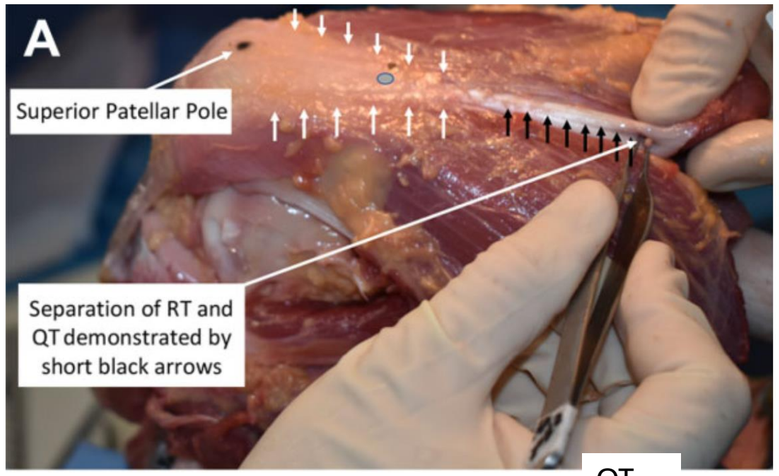
Limit of study by Lippe et al.

They used 11 specimen with mean age of 78 years old (not patient eligible for ACL reconstruction

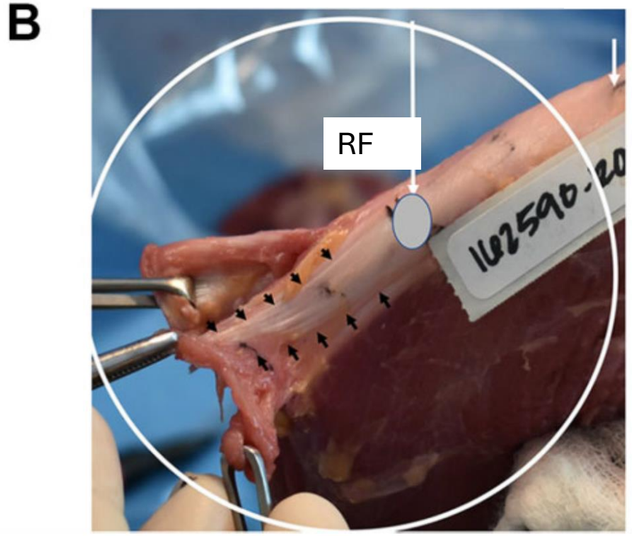
Lippe et al. 2012 Arthroscopy

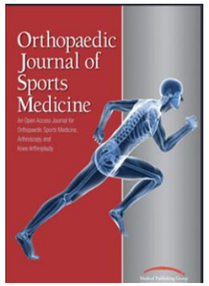
Nine knee specimens *(aged 4-11 years)*

QT



QT





The median distance from the superior pole of the patella to the point of divergence of the RT from the QT complex was 36 mm (IQR, 29-41 mm) (Adult 48.6 mm)

ACL RECONSTRUCTION IN IMMATURE PATIENT:

During QT graft harvest for ACL reconstruction, it is possible to separate the RT from the QT. The point of separation between RF and QT is less than half the length of the graft that would be selected for ACL reconstruction (generally more than 60 mm).

Shea et al. 2019 OJSM doi: 10.1177/2325967119856578

Nine knee specimens *(aged 4-11 years)*

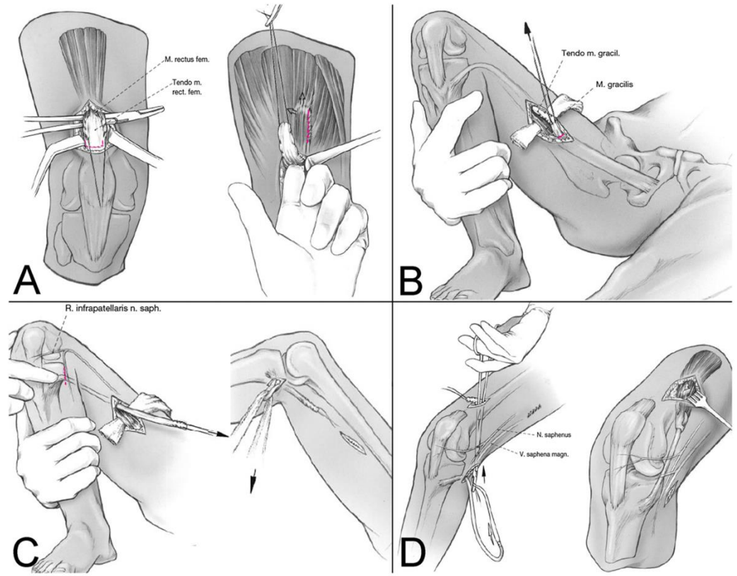
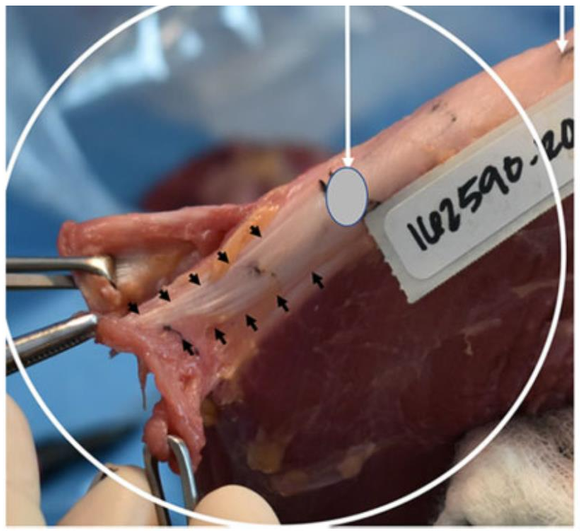
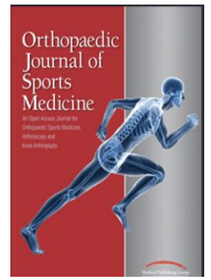


Fig. 2





Celebral palsy → rectus femor trasfer → RF retraction and QT weakness

Careful closure and visualization of the graft harvest interval that includes repair of the RT to the surrounding deep (vastus intermedius), medial (vastus medialis), and lateral (vastus lateralis) components of the QT may be advantageous to avoid secondary RT retraction and QT weakness. An incision allowing adequate exposure for visualization of this proximal graft harvest zone and consideration of this repair may be warranted in the immature population.

Shea et al. 2019 OJSM doi: 10.1177/2325967119856578

2007

TABLE 1. *Morphometric Data of Comparative Analysis of Structure of Quadriceps and Patellar Tendons*

Investigated Parameters	Mean (Range)		*P* Value
	Patellar Tendon	Quadriceps Tendon	
Thickness of collagen fibrils (nm)	103.75 ± 64.45 (41.2-172)	106.50 ± 59.02 (42.14-178.41)	>.99
Density of blood vessels (per 1 mm^2 of collagen fibrils)	1.17 ± 0.23 (0.98-1.49)	1.21 ± 0.34 (1.3-1.76)	>.99
Fibril-interstitium ratio on histologic sections (%)	64.54 ± 7.78 (58.3-74.20)	80.22 ± 6.07 (73.91-86.7)	.0004
Density of fibroblasts (per 1 mm^2 of collagen fibrils)	10.65 ± 2.48 (8.9-14.1)	17.4 ± 3.25 (13.2-21.0)	.0011

The mean patient age was 56.6 years (range, 43 to 78 years).

Arthroscopy
The Journal of Arthroscopic and Related Surgery

Hadjicostas PT, Soucacos PN, Berger I, Koleganova N, Paessler HH. Comparative analysis of the morphologic structure of quadriceps and patellar tendon: a descriptive laboratory study. Arthroscopy. 2007 Jul;23(7):744-50. doi: 10.1016/j.arthro.2007.01.032. PMID: 17637410.

IRCCS INRCA
UNIVERSITÀ POLITECNICA DELLE MARCHE
IQTI INTERNATIONAL QT INTEREST GROUP

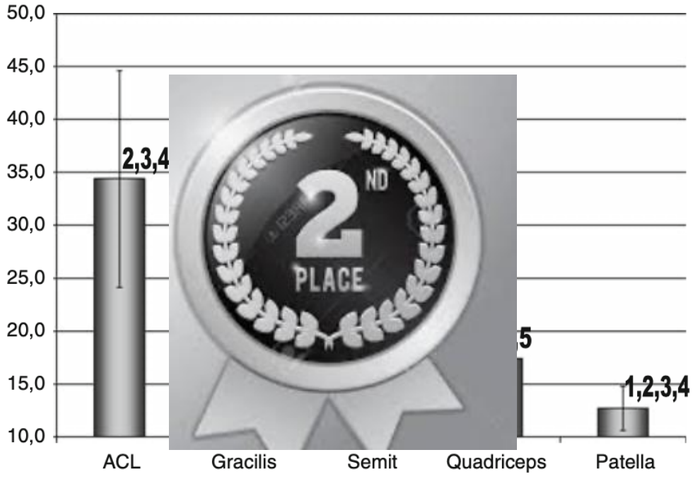
Comparative and morphological analysis of commonly used autografts for anterior cruciate ligament reconstruction with the native ACL: an electron, microscopic and morphologic study

Panayiotis T. Hadjicostas · Panayotis N. Soucacos · Nadezda Koleganova · Gerhard Krohmer · Irina Berger

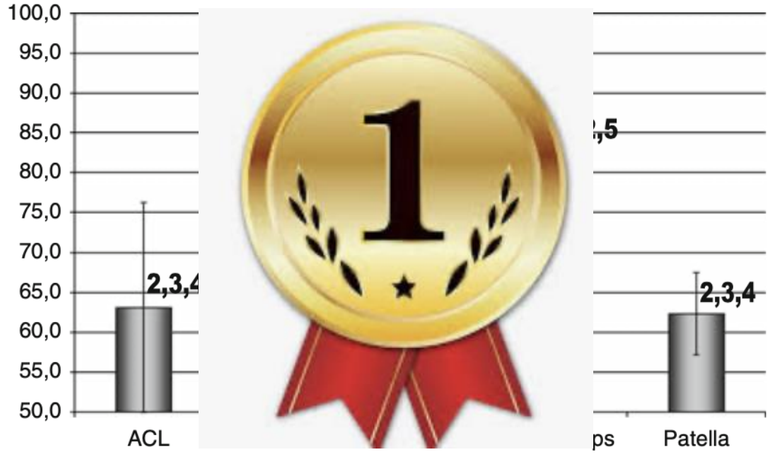
2008

Methods: 20 specimen, mean age **36.4 years (range 24–54 years).**

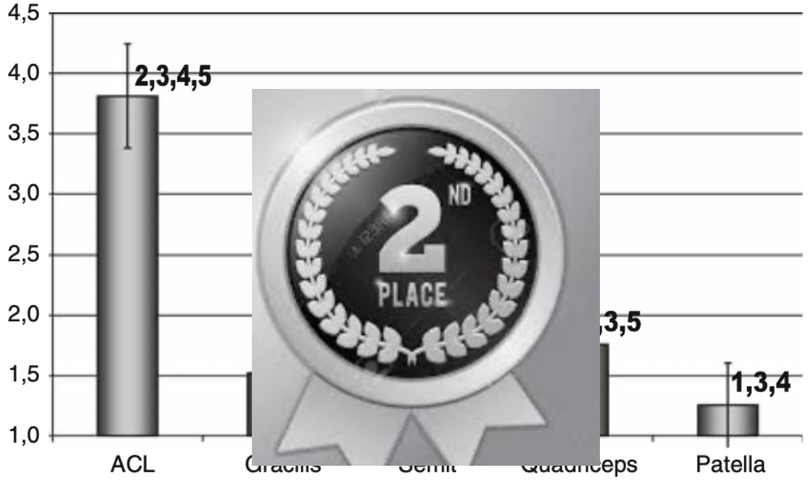
Density of Fibroblast



Fibril / interstitio ratio

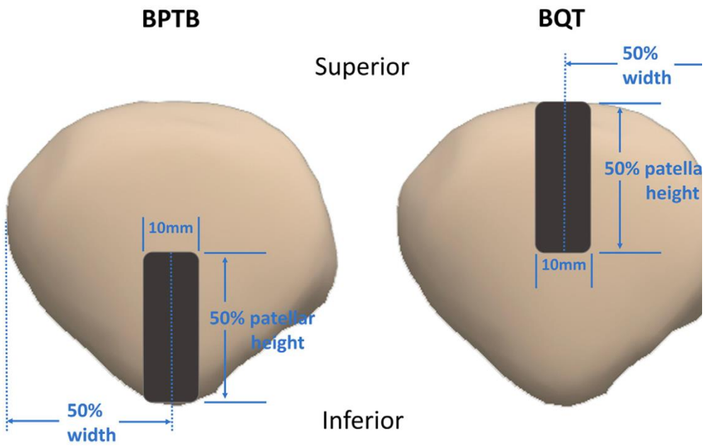


Density of blood vessel



Buza et al. assessed the risk of patella fractures after bone harvest (QT VS BTP) in experimental setting

2024



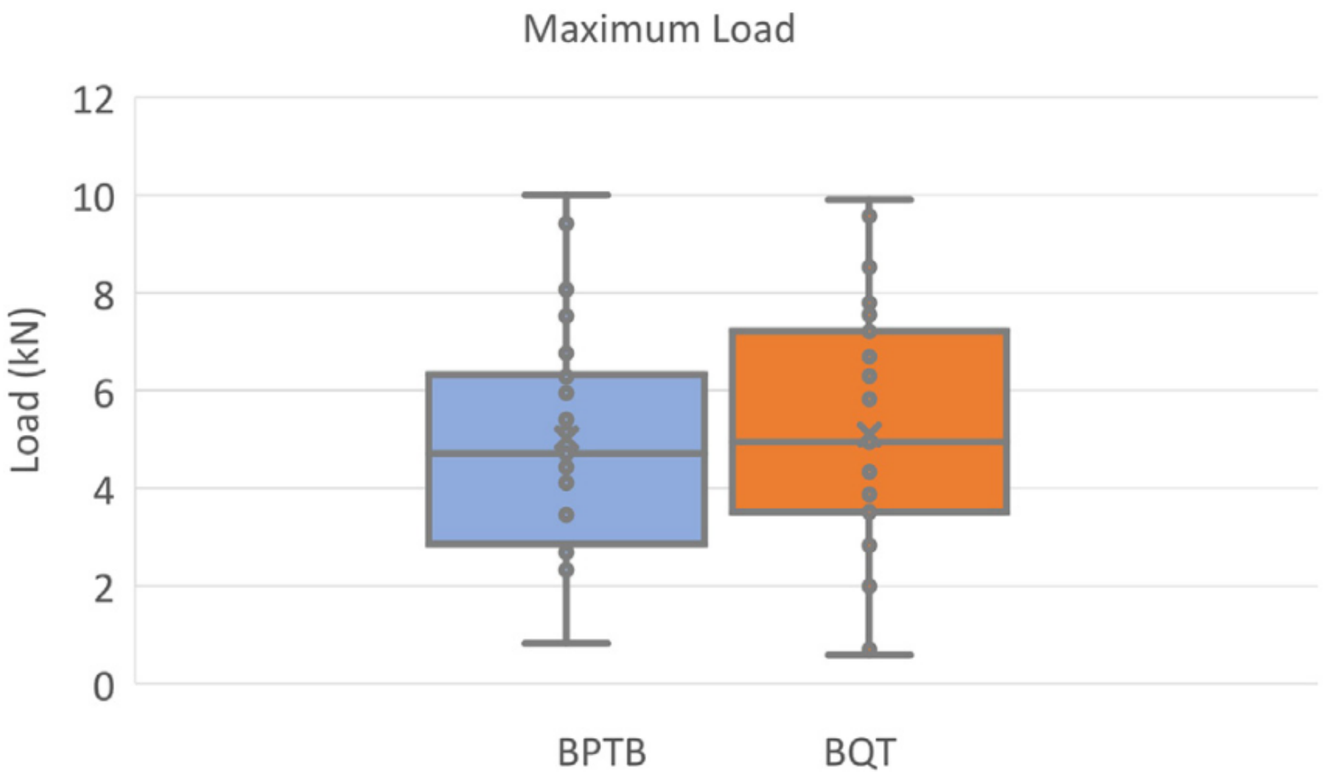


Fig 4. Maximum load to fracture. No significant difference was observed between the 2 groups.

Limit of the study:

- Cadaveric model
- aged 65 $\pm$ 16 years;

What about free hand of QT graft??

Which suture?

Which suture type? (Locking or whipstitch suture)

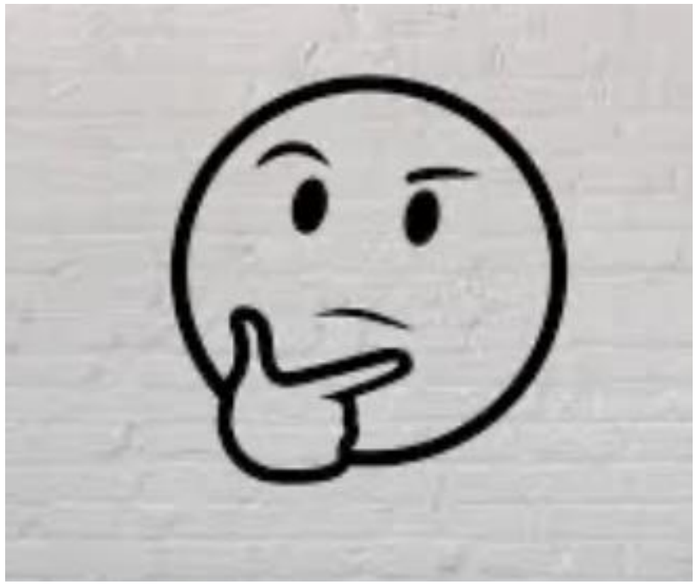
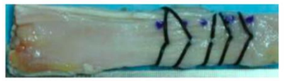
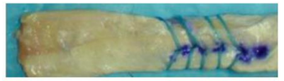
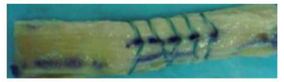


Table 1. Testing Groups

Group	Sample Size	Method	Representative image
1 Winter Innovations	8	WS EasyWhip	
	8	LS EasyWhip	
2 Arthrex	8	WS FiberLoop	
	8	LS FiberWire	
3 CONMED	8	WS SutureLoop Hi-Fi Suture	
	8	LS Hi-Fi Suture	
Total	48		

LS, locking stitch; WS, whipstitch.

Failure assessment:

- Suture breaking
- Suture pull through
- Tendon tear

2024

Conclusion: Locking stich may be preferred over Whipstich due to lower mean elongation and failure displacement

Table 3. Failure Modes by Test Group

		Failure Modes, %		
Study Group	Construct	Suture Pull-Through	Suture Breaking	Tendon Tear, Then Suture Breaking
Group 1	Locking stitch	—	100	—
	Whipstitch	—	100	—
Group 2	Locking stitch	—	100	—
	Whipstitch	12.5	75	12.5
Group 3	Locking stitch	—	100	—
	Whipstitch	—	75	25

Diaz MA, et al. Whipstitch and Locking Stitch Show Equivalent Elongation and Load to Failure Across 3 Suture Systems in a Biomechanical Model of Quadriceps Tendon Grafts for Anterior Cruciate Ligament Reconstruction. Arthrosc Sports Med Rehabil. 2024 Jul 1;6(5):100968. doi: 10.1016/j.asmr.2024.100968.

Smaller Width Quadriceps Tendon Grafts Maintain Advantageous Biomechanical Properties for ACL Reconstruction

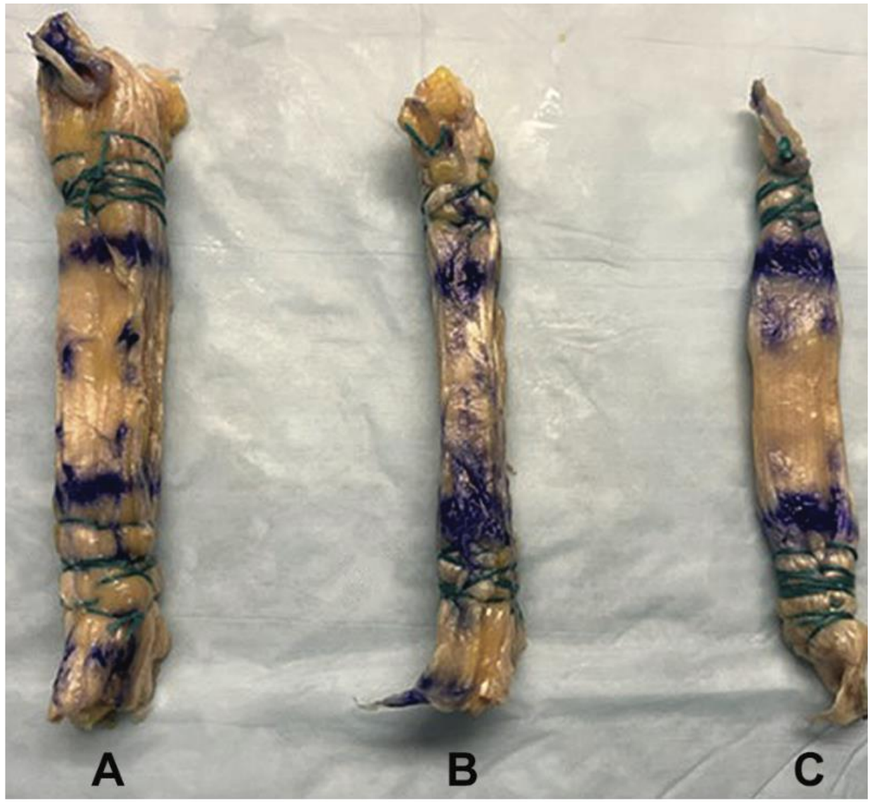
2025

Richard C. Lee,*† MD, Steven D. Voinier,‡§ PhD, Conor F. McCarthy,† MD, Donald F. Colantonio,‖ MD, Shawn M. Gee,‖ MD, Christopher J. Tucker,† MD, Melvin D. Helgeson,† MD, and Nicholas P. Lopreiato,† MD
Investigation performed at the Department of Orthopedic Surgery, Walter Reed National Military Medical Center, Bethesda, Maryland, USA

TABLE 2
Mechanical Properties According to Tendon Group[a]

Mechanical Property	10-mm QT	8-mm QT	6-mm QT	10-mm PT
Failure load, N	1286 ± 237.3	1056 ± 226.7	935.1 ± 283.8	816 ± 192.7
Stiffness, N/mm	201.2 ± 52.13	205.4 ± 21.69	199.6 ± 49.51	239.2 ± 57.72
Time constant, sec	476.4 ± 116.1	453.4 ± 61.06	407.2 ± 49.24	366.1 ± 87.58
Creep strain, mm/mm	0.050 ± 0.020	0.048 ± 0.012	0.041 ± 0.016	0.046 ± 0.018
Failure strain, mm/mm	0.275 ± 0.090	0.214 ± 0.069	0.192 ± 0.023	0.163 ± 0.048
Young modulus, MPa	62.10 ± 21.36	79.52 ± 27.98	104.3 ± 39.86	116.7 ± 38.24

[a]Data are presented as mean ± SD. PT, patellar tendon; QT, quadriceps tendon.



Conclusion: The 8-mm QT graft had higher ultimate tensile strength than the 10-mm PT graft, and the 6-mm QT graft was comparable to the 10-mm PT graft. Given these biomechanical properties, smaller QT graft sizes may be advantageous in minimizing arthrofibrosis risk while maintaining graft strength.

Full thickeness QT vs BPT vs 4-Strand semitendinosus

2022

(1) FT QT *with* bone

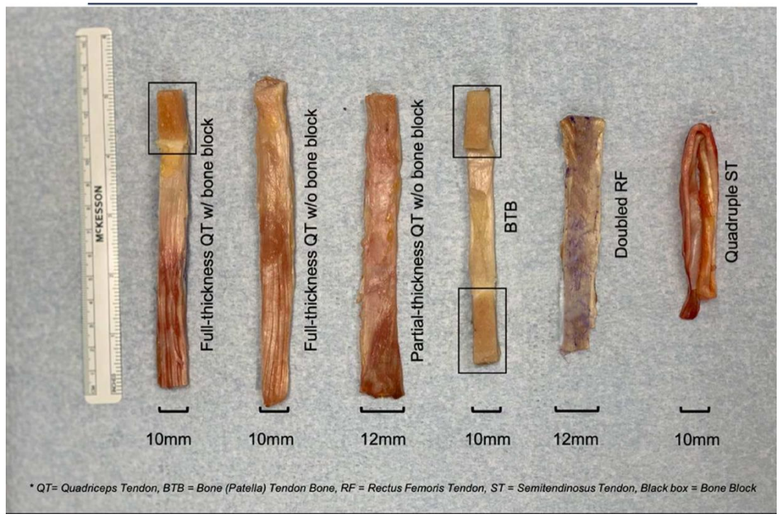
(2) FT QT *without* bone

(3) PT QT *without* bone

(4) BTB

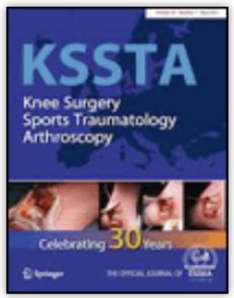
(5) RF

(6) 4-SST.



Strenght: young cadaveric grafts (mean age 32 ± 6 years)

Allograft	Ultimate load (N) (Mean ± SD)
BTB	1810 ± 397
FT QT no bone	1260 ± 264
FT QT with bone	1450 ± 362
PT QT no bone	972 ± 372
2-stranded RF	1160 ± 308
4-SST	1750 ± 316



Conclusions

Full thickness QT grafts with bone had similar material properties to BTB and a 4-SST grafts, while Partial thickness QT graft without bone had significantly lower material properties than BTB and 4-SST, in a biomechanical setting.

Strauss MJ, et al. Knee Surg Sports Traumatol Arthrosc. 2022 May;30(5):1786-1794. doi: 10.1007/s00167-021-06738-x.

BONE-PATELLAR TENDON-BONE (BTB) vs **4-STRAND HAMSTRING tendons (HT)** vs **QUADRICEPS** tendon (QT)

2023

75.2 years (range 53-85 years).

Property	QT ($n=7$)	HT ($n=8$)	BTB ($n=7$)	P value
Cyclic Elongation (mm)	1.0 ± 0.6	0.6 ± 0.3	0.8 ± 0.7	0.370
Linear stiffness (N/mm)	**672 ± 210****	397 ± 91	543 ± 73	**0.004**
Ultimate load (N)	2,097 ± 567	2,046 ± 455	2,129 ± 521	0.951
Ultimate stress (N/mm^2)	26.5 ± 8.6	**44.3 ± 16.8**‡**	34.6 ± 8.2	**0.036**
Ultimate strain (%)	13.7 ± 1.7	11.4 ± 3.0	15.1 ± 4.9	0.139
Elastic modulus (MPa)	269 ± 72	**557 ± 305**†**	297 ± 65	**0.016**
Cross-sectional area (mm^2)	**81.4 ± 19.2***	49.1 ± 12.2	61.8 ± 8.3	**0.001**

BTB Bone–patellar tendon–bone, *HT* Hamstring tendon, *QT* Quadriceps tendon

*Denotes statistical significance when compared to HT and BTB

**Denotes statistical significance when compared to HT but not BTB

†Denotes statistical significance when compared to both QT and BTB

‡Denotes statistical significance when compared to QT but not BTB

CONCLUSION:

All three grafts had similar loads to failure with a significant increase in stiffness when compared to the native ACL. Furthermore, QT demonstrated favourable structural properties to HT and BTB with an **increased cross-sectional area to both HT and BTB along with increased stiffness compared to HT.**

Hart D et al. Biomechanics of hamstring tendon, quadriceps tendon, and bone-patellar tendon-bone grafts for anterior cruciate ligament reconstruction: a cadaveric study. Eur J Orthop Surg Traumatol. 2023 May;33(4):1067-1074. doi: 10.1007/s00590-022-03247-6. Epub 2022 Apr 1. PMID: 35362777.

2nd
IQTI
Meeting

| 7th June 2025 | NH München Messe

IQTI INTERNATIONAL QT INTEREST GROUP

OSMI FOUNDATION

13.00 - 13:15 ANATOMY AND BIOMECHANICS

Dott. Luca Farinelli MD PhD

Assistant Professor Clinica Ortopedica dell'Adulto e Pediatrica

Università Politecnica delle Marche, Ancona

Azienda Ospedaliera Universitaria delle Marche

IRCCS INRCA Ancona Italy

Sport Traumatology and Knee Arthroscopy surgery

Email: l.farinelli@staff.univpm.it

IRCCS INRCA

UNIVERSITÀ POLITECNICA DELLE MARCHE

KNEECARES
The Superspeciality Knee Clinic

QT Autograft for Revision ACLR

Dr Amit Meena

MBBS, MS, DNB, MNAMS

Consultant Knee Surgeon

Shalby Hospital, Jaipur, India

ISAKOS Global Travelling Fellow 2023-2025

Background

- Revision ACLR rates have been noted to be as high as 10 % after a primary ACL reconstruction.

- Revision ACLR technically more demanding than primary cases,

  - Previous autograft use,
  - existing hardware,
  - tunnel position, tunnel size, bone loss,
  - muscle weakness and concomitant injuries that may be associated with graft failure complicating this procedure.

Background

- QT autograft is becoming an increasingly popular graft option in revision ACLR over recent years
  - ➢favorable biomechanical properties and
  - ➢comparable clinical and functional outcomes
  - ➢comparable graft survival

KSSTA Knee Surgery Sports Traumatology Arthroscopy
THE OFFICIAL CLINICAL JOURNAL OF ESSKA

Knee | Open Access

Revision ACL reconstruction using quadriceps, hamstring and patellar tendon autografts leads to similar functional outcomes but hamstring graft has a higher tendency of graft failure

Amit Meena, Luca Farinelli, Christian Hoser, Elisabeth Abermann, Akshya Raj, Caroline Hepperger, Mirco Herbort, Christian Fink

First published: 20 October 2022 | https://doi.org/10.1007/s00167-022-07200-2 | Citations: 34

KSSTA Knee Surgery Sports Traumatology Arthroscopy
THE OFFICIAL CLINICAL JOURNAL OF ESSKA

Knee | Open Access

No difference in patient reported outcomes, laxity, and failure rate after revision ACL reconstruction with quadriceps tendon compared to hamstring tendon graft: a systematic review and meta-analysis

Amit Meena, Stefano Di Paolo, Alberto Grassi, Akshya Raj, Luca Farinelli, Christian Hoser, Sachin Tapasvi, Stefano Zaffagnini, Christian Fink

First published: 24 March 2023 | https://doi.org/10.1007/s00167-023-07380-5 | Citations: 17

Orthop J Sports Med. 2024 Feb 1;12(2):23259671231224501. doi: 10.1177/23259671231224501. eCollection 2024 Feb.

Primary Versus Revision ACL Reconstruction Using Quadriceps Autograft: A Matched-Control Cohort Study

Amit Meena [1 2], Luca Farinelli [3], Christian Hoser [1 2], Elisabeth Abermann [1 2], Caroline Hepperger [1], Mohit Kumar Patralekh [4], Mirco Herbort [2 5], Christian Fink [1 2]

Background

- The size and thickness of the QT graft creates a more robust graft, intra-articular volume of QT graft > 87.5% of harvested patellar tendon
- cross-sectional area is approximately 2 times more than that of the patellar tendon
- The QT allows surgeons to be flexible with their graft size and reconstruction technique because the unique anatomy of the QT allows for significant variation in graft size and thickness

Review > J Am Acad Orthop Surg. 2020 Jan 15;28(2):45-52.
doi: 10.5435/JAAOS-D-19-00032.

Quadriceps Tendon Autograft in Anterior Cruciate Ligament Reconstruction

Nima Mehran [1], Dhanur Damodar, Justin Shu Yang

Comparative Study > Arthroscopy. 2016 Jan;32(1):71-5. doi: 10.1016/j.arthro.2015.06.051.
Epub 2015 Sep 14.

Biomechanical Comparison of Quadriceps and Patellar Tendon Grafts in Anterior Cruciate Ligament Reconstruction

Raj H Shani [1], Erica Umpierez [2], Michael Nasert [3], Elise A Hiza [4], John Xerogeanes [5]

Background

- Extensor mechanism strength is greater post-harvest in patients undergoing QT ACLR compared to those who underwent BTB ACLR

› Arthroscopy. 2006 Jan;22(1):76-9. doi: 10.1016/j.arthro.2005.10.015.

Residual strength of the quadriceps versus patellar tendon after harvesting a central free tendon graft

Douglas J Adams [1], Augustus D Mazzocca, John P Fulkerson

Affiliations + expand

PMID: 16399465 DOI: 10.1016/j.arthro.2005.10.015

Background

- There is some concern regarding a secondary insult to the extensor mechanism if previous ipsilateral BTB was performed for the index procedure

- Revision ACLR with a second extensor mechanism autograft were comparable to those seen for patients who underwent revision ACLR with extensor mechanism autograft after primary ACL reconstruction with hamstring autograft.

Editorial > Arthroscopy. 2021 Sep;37(9):2858-2859. doi: 10.1016/j.arthro.2021.05.011.

Editorial Commentary: Revision Anterior Cruciate Ligament Using Soft Tissue Autograft Quadriceps Is Effective but Not Recommended for All Comers

Sarav S Shah

PMID: 34481626 DOI: 10.1016/j.arthro.2021.05.011

> Knee Surg Sports Traumatol Arthrosc. 2023 Jul;31(7):2828-2835.
doi: 10.1007/s00167-022-07242-6. Epub 2022 Nov 25.

Harvesting a second graft from the extensor mechanism for revision ACL reconstruction does not delay return of quadriceps function

Joshua C Setliff [1], Christopher M Gibbs [2], Volker Musahl [2], Bryson P Lesniak [2], Jonathan D Hughes [2 3], Stephen J Rabuck [2]

Affiliations + expand

PMID: 36434264 DOI: 10.1007/s00167-022-07242-6

Evidence??

- No systematic review or meta-analysis was available in the literature on the QT autograft used in revision ACL reconstruction.
- We aim to synthesize and qualitatively assess the evidence available currently in the literature on the QT graft for revision ACL reconstruction.
- We hypothesize that better functional outcomes and lesser graft failure will be found in the QT group compared to HT graft for revision ACL reconstruction.

Methodology – Search Strategy

- Adheres to PRISMA 2020 guidelines
- Databases: PubMed, EMBASE, Scopus, Cochrane
- Timeframe: 1990–2023
- Registered in PROSPERO (ID: CRD42022308299)

Methodology – Search Strategy

Inclusion Criteria

- Clinical studies reporting on outcomes following revision ACLR with QT autograft were considered for inclusion.
- Minimum follow-up period of 2-year.

Exclusion Criteria

- review articles, non-peer-reviewed studies, surgical techniques, case reports, conference abstracts, biomechanical studies, primary ACL reconstruction, use of graft other than QT autograft, sample size less than 15 patients were excluded

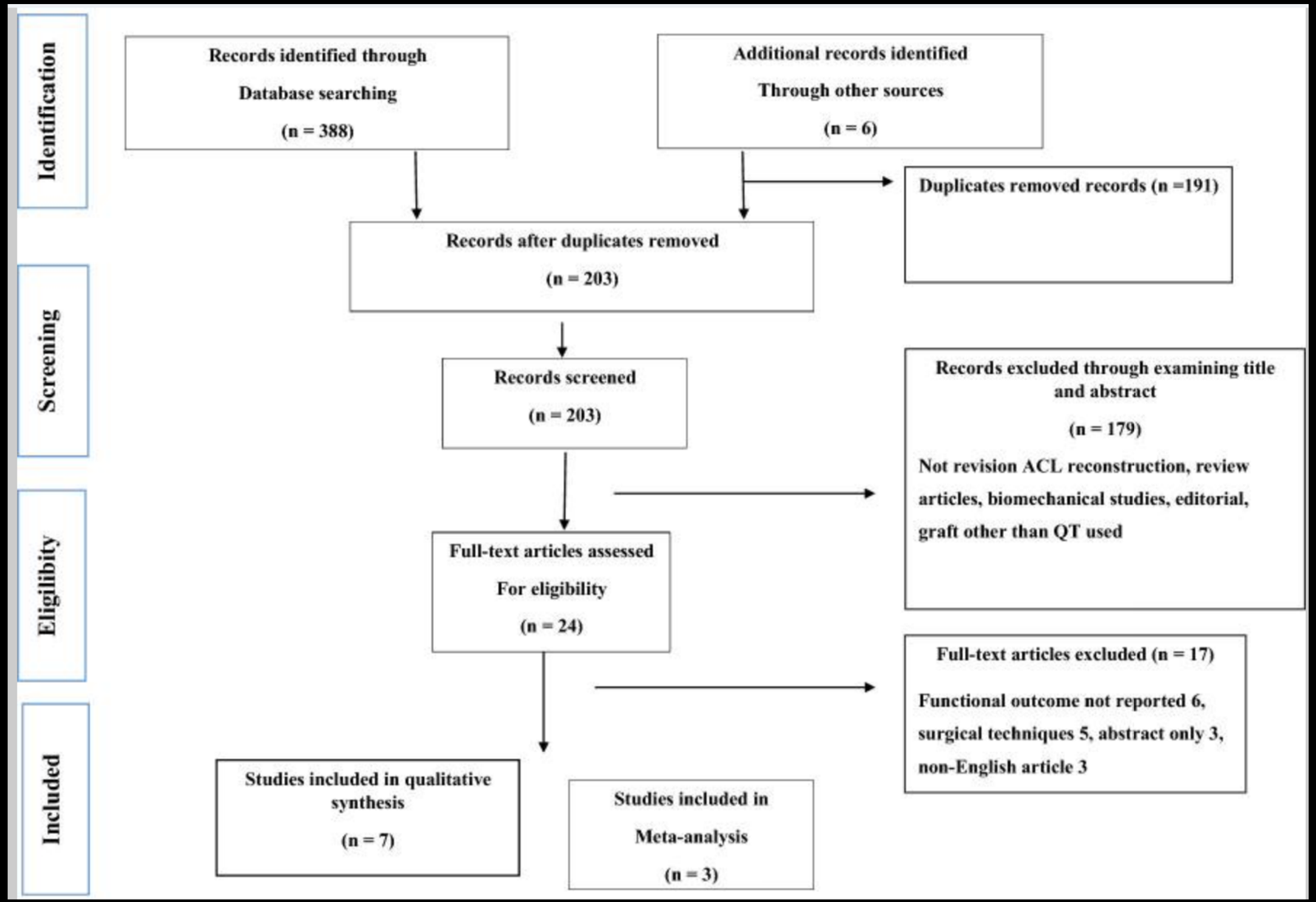
Methodology – Search Strategy

- The search terms used were (ACL OR “anterior cruciate ligament”) AND (“quad*” OR “QT”) AND (“revision“Z” OR “reoperation”)."

- MINORS score was employed to assess the quality of the selected studies.

PRISMA Flow Diagram

- A total of 388 studies were identified.
- After removal of duplications, Following the inclusion and exclusion criteria, A total of seven studies for qualitative synthesis and 3 for meta analysis



Study Characteristics

- A total of 277 patients with Mean age of 30.6 ± 7.1 and Mean postoperative follow-up of 40.2 months underwent ACL Revision with QT and were included in the quantitative synthesis.

- For meta analysis: A total of 109 patients with a mean age at surgery of 34.3 years underwent Revision ACL with QT

- While 109 patients with a mean age at surgery of 30.1 years underwent Revision ACL with HT.

Outcome Measures

- Subjective Scores: Lysholm, IKDC, KOOS, Tegner, VAS for Pain

- Objective tests: KT-1000 SSD , Pivot-shift test , Rolimeter SSD, Single-leg-triple-hop-test (SLTH)

- Return to sports activity

Key Findings

- Lysholm knee score
  - higher score with QT (86.1) than with HT (82.2) grafts postoperatively.
- Tegner activity level
  - higher for QT than for HT (5.9 vs 5.6, n.s.)
- The KOOS scale
  - Among the five subscales of the KOOS, pooled average scores were higher for the QT graft for QoL (Quality of life), Sport and Symptom subscales.
- Vas for Pain score
  - VAS score for pain significantly improved in the QT group compared to the HT group

Key Findings

- KT-1000 SSD measurement was 1.8 mm for QT and 2.4 mm for HT grafts, and thus, QT grafts showed lesser laxity. (ns)
- Lower laxity was found in Rollimeter SSD in the QT group compared to the HT group(ns)
- Lower pivoting was reported in the QT group compared to the HT group (ns)
- In the QT group, graft failure was 12 (9.8%) compared to 8 (17.4%) in the HT group.

Interpretation & Clinical Relevance

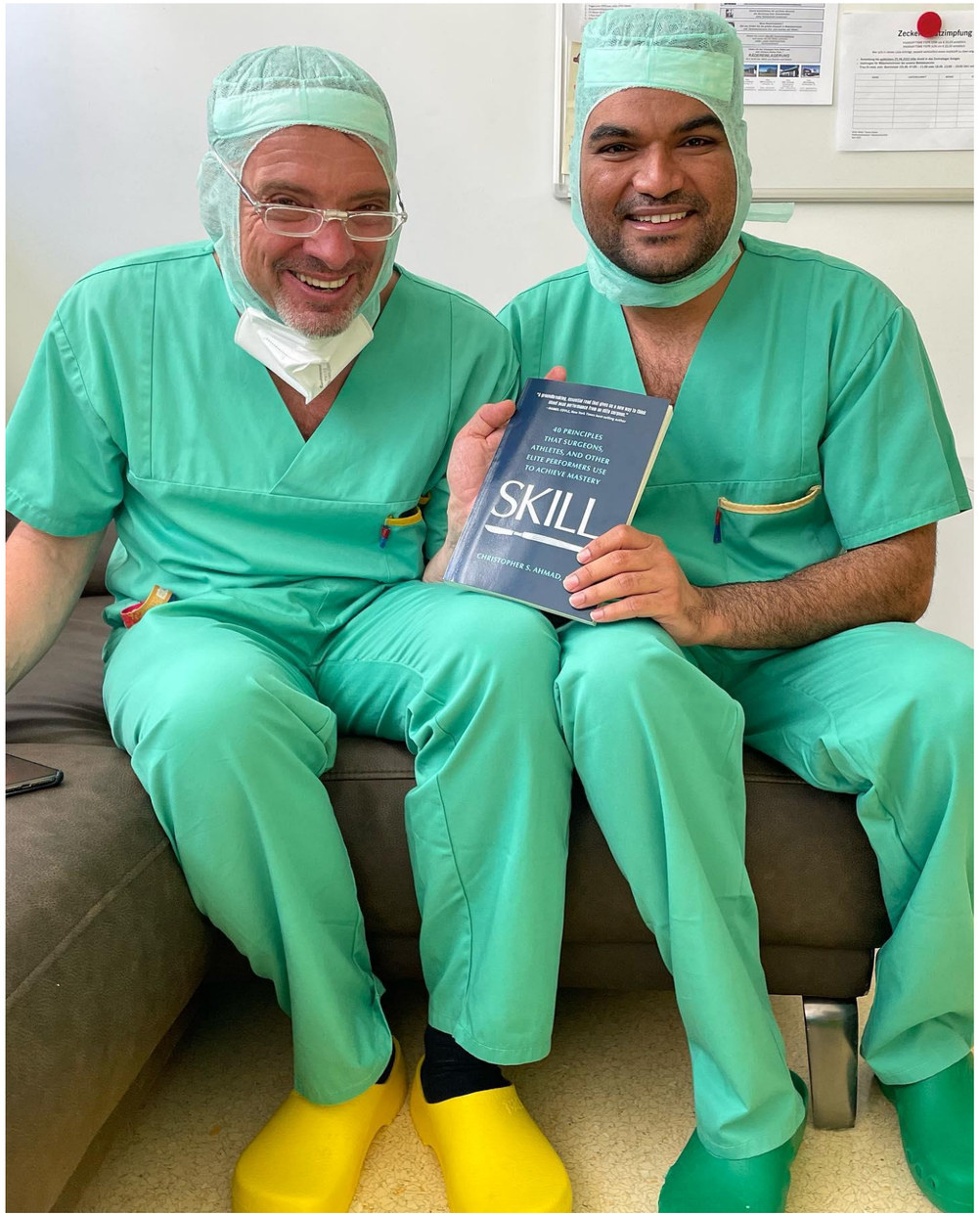
- QT autograft is the least studied and least used graft compared to other grafts, especially for revision ACL reconstruction.
- Many surgeons do not even consider the QT as a possible graft option when discussing with the patients.
- However, it is a very suitable and versatile graft option for revision ACL reconstruction with distinct advantages.

Limitations

- Small cohorts
- Non-uniformity of the techniques used
- Heterogeneous nature of the tools and scores used for reporting outcomes.

Conclusion

- The QT autograft was associated with an improved trend of rotatory laxity, PROMs, and failure rate compared to HT autograft after revision ACL reconstruction.
- The QT autograft for revision ACL reconstruction is supported by the current literature.
- It is a viable graft that should be considered for both primary and revision ACL reconstruction.



Thank you !!

KSSTA Knee Surgery Sports Traumatology Arthroscopy
THE OFFICIAL CLINICAL JOURNAL OF ESSKA
esska.org

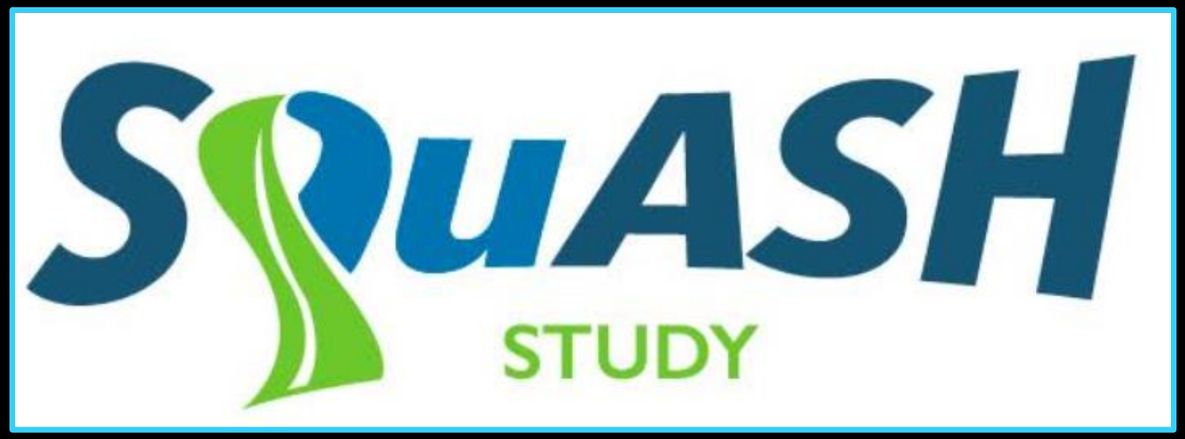
Knee | Open Access

No difference in patient reported outcomes, laxity, and failure rate after revision ACL reconstruction with quadriceps tendon compared to hamstring tendon graft: a systematic review and meta-analysis

Amit Meena, Stefano Di Paolo, Alberto Grassi, Akshya Raj, Luca Farinelli, Christian Hoser, Sachin Tapasvi, Stefano Zaffagnini, Christian Fink

First published: 24 March 2023 | https://doi.org/10.1007/s00167-023-07380-5 | Citations: 17

QT IN PRIMARY PEDS ACLR:



MacOrtho

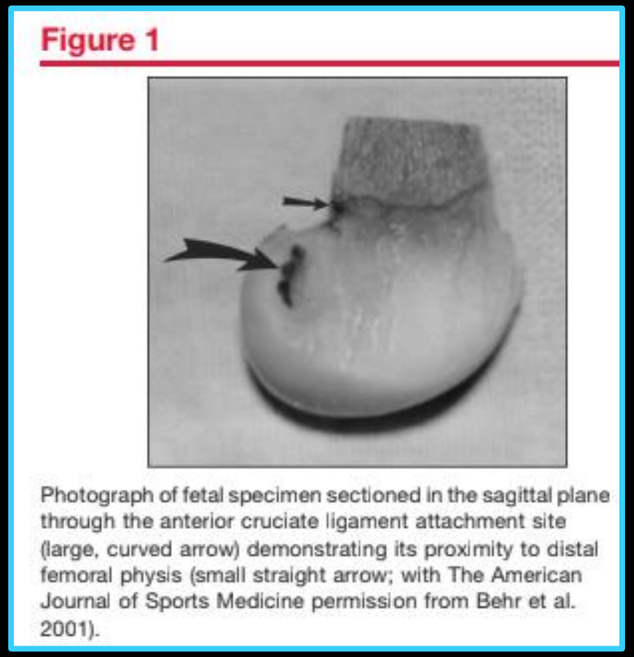
Darren de SA MD MBA FRCSC
Assistant Professor
June 7, 2025

McMaster University

IQTI INTERNATIONAL QT INTEREST GROUP

PROBLEMS with PED-ACLR

- **DELAY** = risk of meniscal/cartilage damage, lower RTP; HIGHER FAILURE (~25% Females)
- physiologic laxity
- **PHYSIS (3 mm F; 1.6 cm tibia) + tibial slope**
- postoperative rehabilitation, RTP testing and clearance protocols +/- compliance
- longer to reach LSI > 90% (1.5 years or more)

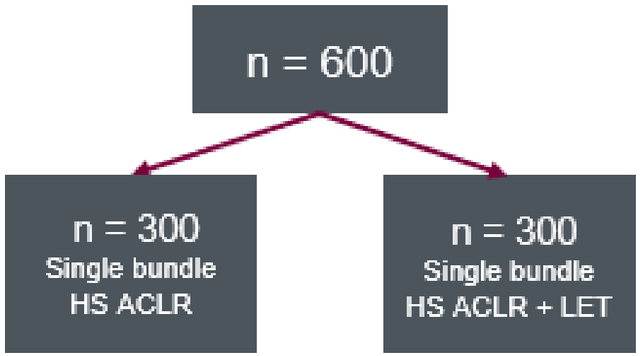


MacOrtho

GRAFT? STABILITY 1…*in skeletal MATURE*

Study Design

RCT



Inclusion Criteria (2 of 3)

1) Grade 2 pivot shift or greater
2) Returning to high risk cutting or pivoting sports
3) Generalized ligamentous laxity

Key Outcome

Failure rates:

Isolate HS – 41%

vs.

HS + LET – 25%

(RR=0.61, 95%CI 0.47 to 0.79, p<0.0001)

MacOrtho

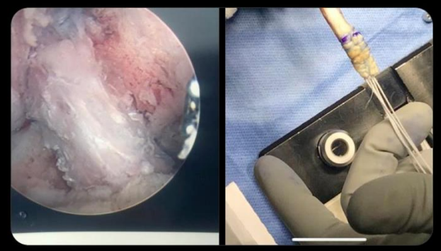
RISE OF THE QUAD TENDON!

Volker Musahl @VolkerMusahl

QT autograft for knee ligament reconstruction: use it now, use it often | British Journal of Sports Medicine #rehabtroubleismyth #anatomicistheonlyway

Harris Slone @harriss... · 2020-09-03
Got to love a juicy quad tendon #ACL graft. Bye bye hamstring. **#laudthequad**

KnesekSportsMD @... · 2020-03-12
Here is a look at a quadriceps tendon graft for all inside ACL reconstruction! It is a very reproducible and robust graft #acl **#laudthequad** #sportsmedicine



Lee Pace, MD @LeeP... · 2021-06-03
Huge fan of all inside and especially **#laudthequad**. I think all inside creates best biology and best fixation construct. Have been doing that along with basically 100% quad since 2016.

Dr. Dan Fuentes @Fix... · 2020-01-04
Auto QT has completely eliminated HS grafts in my practice, as I have increased its use overall. Love the QT, but still for my cutting/pivoting athletes & population, I'm auto BTB for now. That's my last hurdle despite some great data results w/QT comparisons.

#laudthequad

Ryan Hess, MD @Rya... · 2019-03-03
When I use QT I make it about 70mm and use adjustable loop on both sides- all-inside technique. Works well for me. **#LaudTheQuad**

3

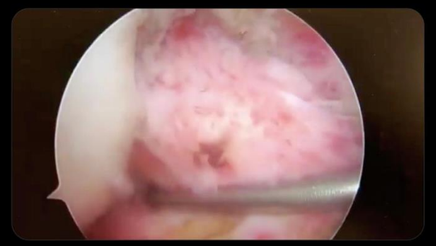
Dr. Jayesh K. Patel.... · 2020-08-25
Don't use hamstring use quad tendon. **#laudthequad**

3 14

Mary Mulcahey @mar... · 2020-12-05
Awesome! I love quad autograft. Very robust, reliable graft! Great work.

#laudthequad #acl

Clayton Nuelle, MD, F... · 2020-07-17
This is an autograft quad #ACL 2.5 months after reconstruction. Note the amount of re-vascularity present. #knee #laudthequad



Neel Kushare @Neel... · 2020-09-03
Replying to @harrisslone
Agree ! I haven't done a single hamstring since the day I did my first Quad ! **#laudthequad**

MacOrtho

MY INTEREST…

Review > Knee Surg Sports Traumatol Arthrosc. 2024 Dec 17. doi: 10.1002/ksa.12558. Online ahead of print.

Quadriceps tendon autograft diameters are routinely above 8 mm, and preoperative size estimation before anterior cruciate ligament reconstruction may not be necessary for this graft type: A systematic review

> Knee Surg Sports Traumatol Arthrosc. 2024 Nov 4. doi: 10.1002/ksa.12535. Online ahead of print.

How statistically fragile are randomized controlled trials comparing quadriceps tendon autografts with hamstring or bone–patellar tendon–bone autografts in anterior cruciate ligament reconstruction?

> Curr Rev Musculoskelet Med. 2021 Dec;14(6):462-474. doi: 10.1007/s12178-021-09726-3. Epub 2021 Nov 10.

Quadricep ACL Reconstruction Techniques and Outcomes: an Updated Scoping Review of the Quadricep Tendon

Dan Cohen [1], David Slawaska-Eng [1], Mahmoud Almasri [2], Andrew Sheean [3], Darren de Sa [4 5]

Knee Surgery, Sports Traumatology, Arthroscopy (2019) 27:105–116
https://doi.org/10.1007/s00167-018-5042-z

Review > Knee Surg Sports Traumatol Arthrosc. 2025 Feb;33(2):567-580. doi: 10.1002/ksa.12395. Epub 2024 Jul 31.

Femoral tunnel length does not impact outcomes following ACL reconstruction using a single-bundle quadriceps tendon autograft: A systematic review

Tess Bracken [1], Alexandre Veilleux [1], Hassaan Abdel Khalik [2], Jansen Johnson [2], Darren de Sa [2]

Review > Knee Surg Sports Traumatol Arthrosc. 2022 Nov;30(11):3659-3672. doi: 10.1007/s00167-022-06930-7. Epub 2022 Apr 20.

Quadriceps tendon autograft for pediatric anterior cruciate ligament reconstruction results in promising postoperative function and rates of return to sports: A systematic review

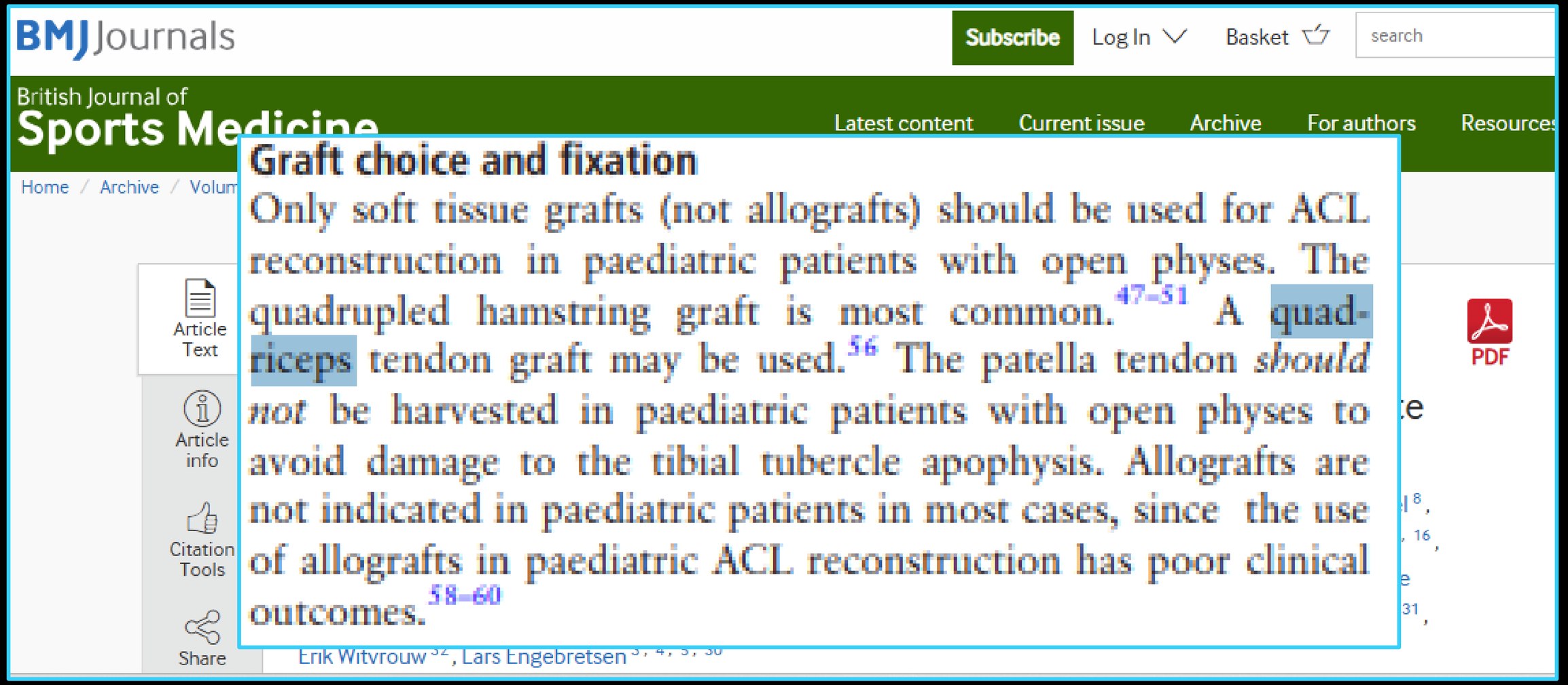
Alexander Zakharia [1], Darius L Lameire [2], Hassaan Abdel Khalik [3], Jeffrey Kay [3], Abhilash Uddandam [1], Kanto Nagai [4], Yuichi Hoshino [4], Darren de Sa [5]

Less than 1% risk of donor-site quadriceps tendon rupture post-ACL reconstruction with quadriceps tendon autograft: a systematic review

Harasees Singh[1] · Isaac Glassman[1] · Andrew Sheean[2] · Yuichi Hoshino[3] · Kanto Nagai[4] · Darren de SA[5]

Received: 21 June 2022 / Accepted: 15 September 2022

What is the Consensus?



MacOrtho

THE PROBLEM: *"LACK OF DATA"*

TABLE IV Review of the Literature on Surgical Outcomes Following Pediatric ACL Reconstruction: Study Demographics and Complications*

First Author	No. of Patients	Mean Age *(yr)*	Mean Follow-up *(mo)*	Graft	Recurrent Instability	Reinjury
All-e (phy						
Extr (phy						
Part						
Tran						
Kocher[38], 2007	59	14.7	43.2	Hamstring	NR	NR
Liddle[50], 2008	17	12.0	44.0	Hamstring	NR	5.9%
Cohen[35], 2009	26	13.3	45.0	Hamstring	NR	6.7%
Courvoisier[48], 2011	37	14.0	36.0 (median)	Hamstring	NR	8.1%

*LLD = limb-length discrepancy, NR = not reported, ITB = iliotibial band, BTB = bone-tendon-bone, and FL = fascia lata.

Review > J Bone Joint Surg Am. 2017 Dec 20;99(24):2062-2068. doi: 10.2106/JBJS.16.01408.

A Historical Analysis of Randomized Controlled Trials in Anterior Cruciate Ligament Surgery

Jeffrey Kay [1], Muzammil Memon [1], Darren de Sa [1], Nicole Simunovic [1], Volker Musahl [2], Freddie H Fu [2], Jon Karlsson [3], Olufemi R Ayeni [1 3]

EVIDENCE? *"Kids are NOT small adults!"*

Transphyseal Anterior Cruciate Ligament Reconstruction in the Skeletally Immature

Quadriceps Tendon Autograft Versus Hamstring Tendon Autograft

Andrew T. Pennock,*†‡ MD, Kristina P. Johnson,† ATC, OPA-C, Robby D. Turk,† BA, Tracey P. Bastrom,† MA, Henry G. Chambers,†‡ MD, Kelly E. Boutelle,† BS, and Eric W. Edmonds,†‡ MD

Investigation performed at Rady Children's Hospital, San Diego, California, USA

TABLE 2
Outcomes and Complications for 83 Patients Undergoing Transphyseal ACL Reconstruction Who Had a Minimum Follow-up of 2 Years or Had Documented Graft Failure Before 2 Years[a]

	Hamstring Tendon (n = 56)	Quadriceps Tendon (n = 27)	*P* Value
Lysholm score	94 ± 6	96 ± 8	.095
Satisfaction (0-10)	9.2 ± 1.2	9.6 ± 0.8	.096
SANE score (0-100)	89 ± 11	93 ± 9	.227
Pain score (0-10)	0.9 ± 1.5	0.6 ± 1.4	.163
Tegner activity score	7.1 ± 2.0	6.6 ± 1.6	.229
Graft failure, n (%)	12 (21)	1 (4)	**.037**
Time to graft failure, y	1.5 ± 0.9	2.5 ± 0.0	.900
Growth abnormality, n (%)	0 (0)	0 (0)	N/A
Contralateral ACL tear, n (%)	5 (9)	5 (19)	.270

[a]Values are reported as mean ± SD unless otherwise specified. Bolded values indicate significance ($P < .05$). ACL, anterior cruciate ligament; N/A, not applicable; SANE, Single Assessment Numeric Evaluation.

QT in SKELETAL IMMATURE:

Quadriceps Tendon Anterior Cruciate Ligament Reconstruction in Skeletally Immature Patients

3-Year Clinical and Patient-Reported Outcomes

Frank A. Cordasco,*† MD, MS, Sofia Hidalgo Perea,‡ BS, Tyler J. Uppstrom,* MD, Danielle E. Chipman,‡ BS, Nicolas Pascual-Leone,‡ MD, Alexandra Hunter Aitchison,‡ BS, Emilie Lijesen,‡ BS, Lori Ann Asaro,*† PA-C, MS, and Daniel W. Green,*‡§ MD, MS
Investigation performed at Hospital for Special Surgery, New York, New York, USA

- Case Series: skeletal immature; full-thickness ST-QT; AE vs CT techniques; mean FU 3.7 years
- N = 83 pt; aged ~11-17; AE (31%) vs. CT (69%); 58% had concomitant LET
- 24% needed second surgery:
    - 6 pt meniscus, 5 LoA, 4 suture removal; 3 I&D, 2 LLD, 3 pt revisions due to graft failure
- **no differences in reoperation b/w technique or concomitant LET**

MacOrtho

THE LITERATURE…

Knee Surgery, Sports Traumatology, Arthroscopy (2022) 30:3659–3672
https://doi.org/10.1007/s00167-022-06930-7

KNEE

Check for updates

Quadriceps tendon autograft for pediatric anterior cruciate ligament reconstruction results in promising postoperative function and rates of return to sports: A systematic review

Alexander Zakharia[1] · Darius L. Lameire[2] · Hassaan Abdel Khalik[3] · Jeffrey Kay[3] · Abhilash Uddandam[1] · Kanto Nagai[4] · Yuichi Hoshino[4] · Darren de SA[3]

Received: 18 November 2021 / Accepted: 3 March 2022 / Published online: 20 April 2022

Study Design
• 14 published/grey lit studies examining 596 patients – growing interest • Underwent ACLR with QT autograft

Graft Rupture Rate:
2.5%

Return to Sports Rate:
88.9% – 100%

MacOrtho

THE LITERATURE…

Review > J Orthop. 2023 Dec 22:49:156-166. doi: 10.1016/j.jor.2023.12.014. eCollection 2024 Mar.

Quadriceps tendon autograft is promising with lower graft rupture rates and better functional Lysholm scores than hamstring tendon autograft in pediatric ACL reconstruction. A systematic review and meta-analysis

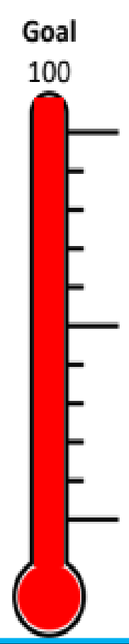
Karthick Rangasamy [1] [2], Vishnu Baburaj [2], Nirmal Raj Gopinathan [2], Mandeep Singh Dhillon [2], Shital N Parikh [3]

MacOrtho

Quest for “Best Available Evidence”…

SQuASH STUDY

CIHR IRSC
Canadian Institutes of Health Research | Instituts de recherche en santé du Canada



Site Status Update

Site Name	Participants Enrolled to Date	Participants Withdrawn	Total Active/Completed Participants	Current Follow-Up Rate
Hamilton Health Sciences, Canada	35	1	34	**97%**
Shriners Hospital for Children, Canada	16	5	11	**69%**
Kobe University, Japan	15	0	15	**100%**
CHEO, University of Ottawa, Canada	14	3	11	**79%**
Michael Garron Hospital, Canada	13	1	12	**92%**
CHU Sainte-Justine, Canada	7	2	5	**71%**
TOTAL:	100	12	88	**88%**

- ~ $920,000 CDN
- 64% Male / 54% R knee
- mean 14.5 years
- 89% traumatic injuries
- 90% FU
- 94% case-report completion
- 1% cross-over rate
- 100% recruitment rate
- DSMB – no concerns

MacOrtho

Thank You

@darrendesa

darren.desa@medportal.ca

ISAKOS
International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine

2025 Travelling Fellow

MacOrtho

MPFL reconstruction with Quadriceps Tendon Autograft

Danko D. Milinkovic

Center for Musculoskeletal Surgery

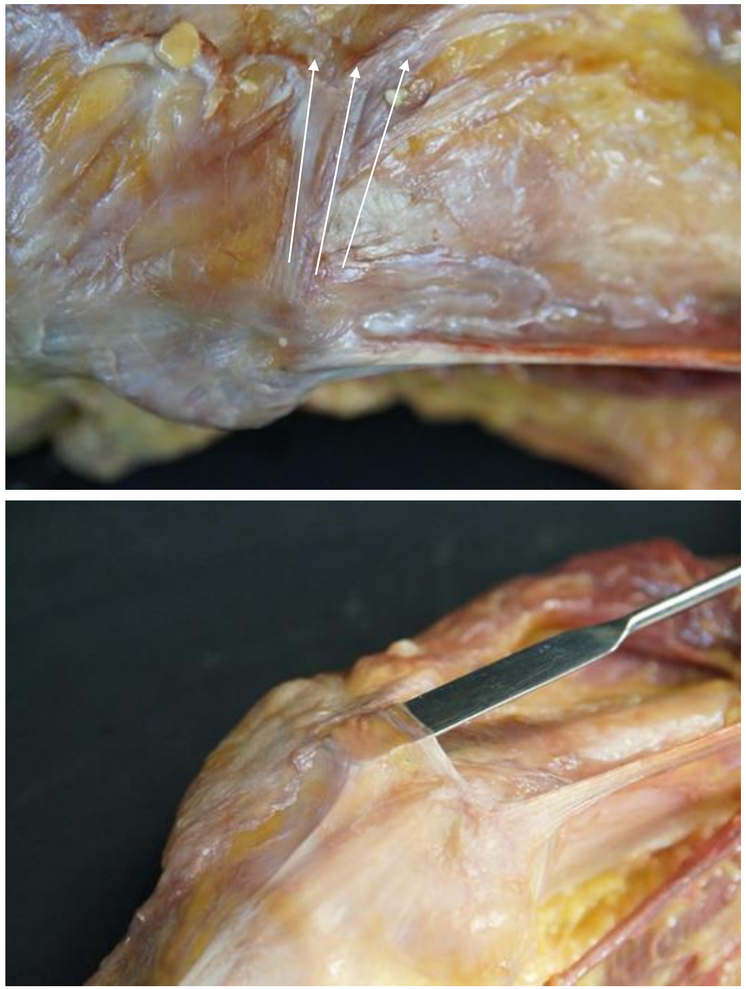
Charité - University Medicine

Berlin

No conflict of interest

Medial patellofemoral ligament – MPFL

- Main passive soft-tissue stabilizer up to 30° of flexion
- Originates from prox. 2/3 of medial patellar margin
- Inserts between Add. Tubercle and med. Epicondyle
- In 2nd of the three soft-tissue medial layers



First time luxation

Adolescent and young active population

> 90% of first time luxation

MPFL injury → „Essential lesion“

Keppler et al., 2011 AJSM
Elias et al., 2002 Radiology
Balcarek et al. 2010, Eur J Radiology
Seeley et al., 2012 J Pediatr Orthop
Sillanpää et al.,2009 AJSM

Risk stratification

Main factors that predispose recurrence:

- Young age/open physis
- Trochlear dysplasia
- Patella alta
- Distal malalignment and
- (Contralateral instability)

TABLE 3
Studies Reporting Risk of Recurrence With Multiple Concurrent Risk Factors[a]

	No. of Risk Factors				
First Author (Year)	0	1	2	3	4
Lewallen[18] (2015)	8.6%	11.1%-26.6%[b]	29.6%-60.2%[b]	70.4%	—
Arendt[1] (2018)	7.7%	22.7%	50.9% (42.8%-54.8%)[b]	78.5%	—
Jaquith[15] (2017)	13.8%	30.1%	53.6%	74.8%	88.4%

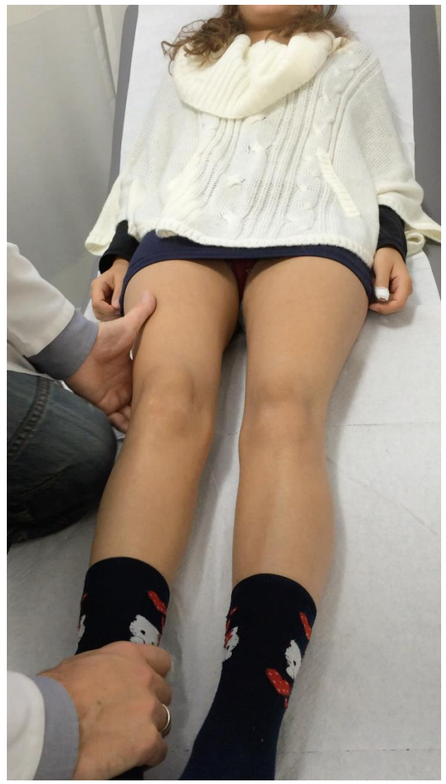
Lewallen LW et al. 2013 Am J Sports Med.
Arendt EA et al. 2018 Am J Sports Med.
Hiemstra LA et al. 2017 KSSTA
Jaquith BP, Parikh SN. 2017 J of ped orthoped..

Risk stratification

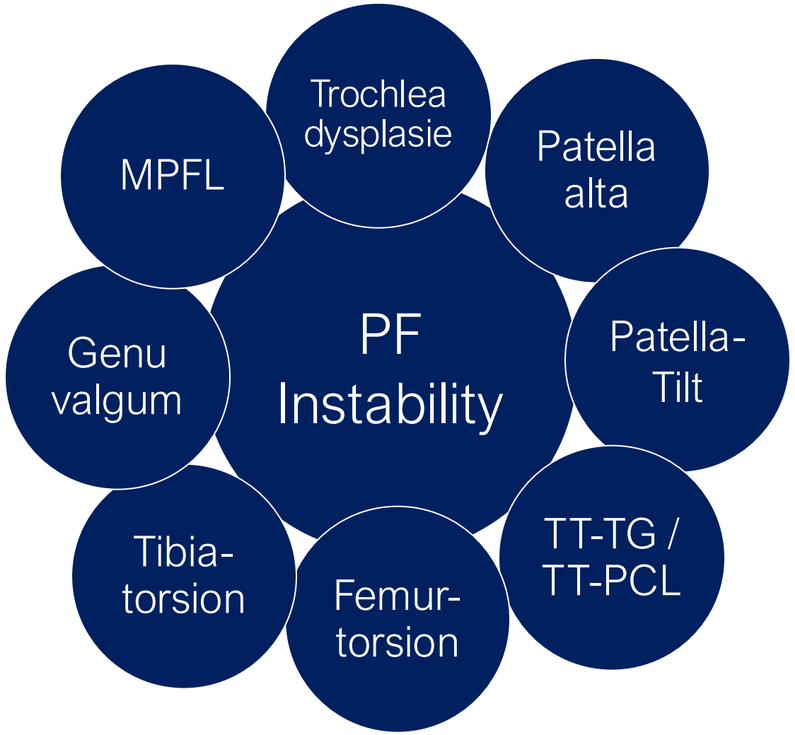
Main factors that predispose recurrence:

- Young age/open physis
- Trochlear dysplasia
- Patella alta
- Distal malalignment and
- (Contralateral instability)

Various clinical manifestations



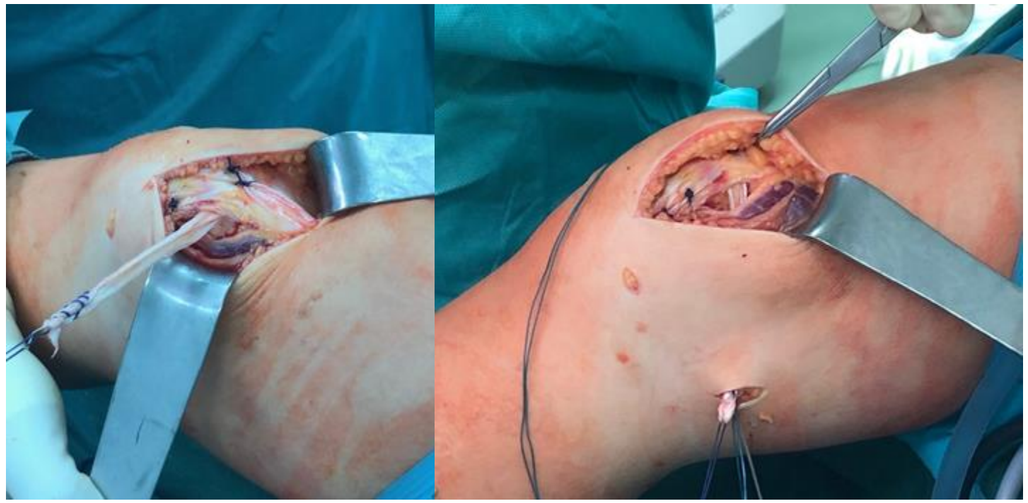
Risk stratification



Steensen et al., 2015 AJSM

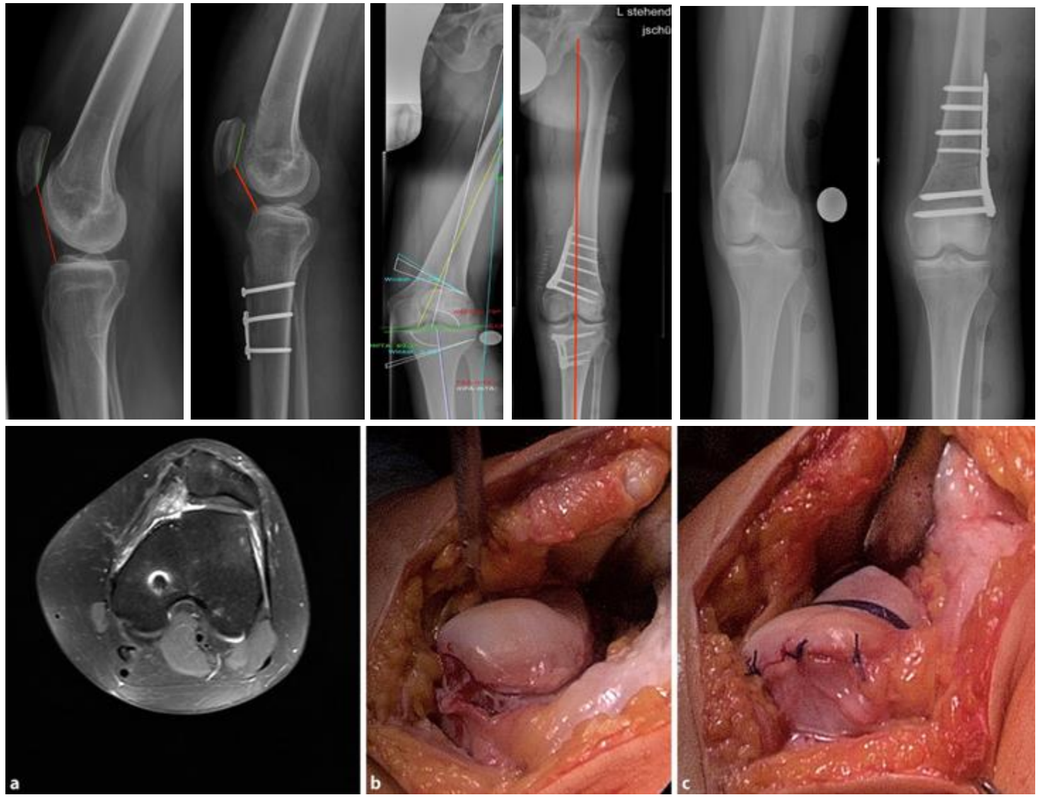
Various clinical manifestations

MPFL- Reconstruction



- Gold standard
- Multiple techniques
- Various graft and fixation options

Often with concomitant procedures



Medial Patellofemoral Ligament Reconstruction for Patellar Dislocation

A Systematic Review

Nicola D. Mackay,*† MBChB, BMSc, MRCS, Nicholas A. Smith,‡ MBChB, MRCS, Nick Parsons,‡ MSc, PhD, Tim Spalding,† MBChB, FRCS, Peter Thompson,† MBChB, FRCS, and Andrew P. Sprowson,‡ MD, FRCS

Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-015-3698-1

KNEE

Surgical treatment of patellofemoral instability using trochleoplasty or MPFL reconstruction: a systematic review

Enrique Adrian Testa[1] · Carlo Camathias[2] · Felix Amsler[3] · Philipp Henle[4] · Niklaus F. Friederich[5] · Michael Tobias Hirschmann[1]

Outcomes of MPFL-R

- significant improvements of PROMs
- low Re-luxation rates (1-5%)
- **when performed technically well and with proper indication**

Balcarek P et al. 2014 KSSTA
Milinkovic et al. 2023 KSSTA
Milinkovic et al. 2025 KSSTA
Hevesi M et al. 2019 Arthroscopy. 35:537-43.

A Systematic Review of Complications and Failures Associated With Medial Patellofemoral Ligament Reconstruction for Recurrent Patellar Dislocation

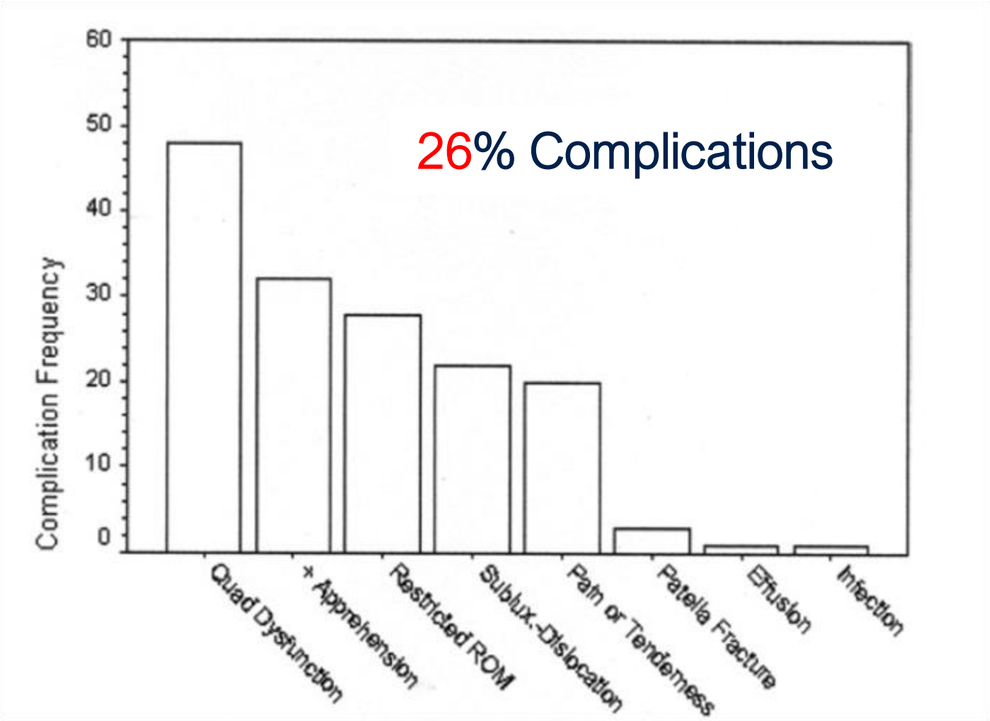
CME

Jay N. Shah,* MD, MS, Jennifer S. Howard,† PhD, ATC, David C. Flanigan,‡ MD, Robert H. Brophy,§ MD, James L. Carey,‖ MD, MPH, and Christian Lattermann,*¶ MD

Systematic Review

Medial Patellofemoral Ligament Reconstruction for Recurrent Patellar Dislocation: A Systematic Review Including Rehabilitation and Return-to-Sports Efficacy

Brent Fisher, M.D., John Nyland, Ed.D., Emily Brand, B.A., and Brian Curtin, M.D.



Patient-Reported Outcomes After Revision Surgery for Failed Medial Patellofemoral Ligament Reconstruction

A Matched-Pair Analysis Including Correction of Predisposing Factors

Felix Zimmermann,*† MD, Juliane Börtlein,* PA, Danko Dan Milinkovic,* MD, and Peter Balcarek,*‡ MD
Investigation performed at the Arcus Sportklinik, Pforzheim, Germany

Failure Analysis in Patients With Patellar Redislocation After Primary Isolated Medial Patellofemoral Ligament Reconstruction

Matthias J. Feucht,*†‡ MD, Julian Mehl,† MD, Philipp Forkel,† MD, Andrea Achtnich,† MD, Andreas Schmitt,† MD, Kaywan Izadpanah,‡ MD, Andreas B. Imhoff,† MD, and Daniel P. Berthold,† MD
Investigation performed at the Department for Orthopaedic Sports Medicine, Technical University Munich, Germany

KNEE

Femoral tunnel malposition is the most common indication for revision medial patellofemoral ligament reconstruction with promising early outcomes following revision reconstruction: a systematic review

Madison Walker[1] · Larissa Maini[1] · Jeffrey Kay[2] · Ali Siddiqui[3] · Mahmoud Almasri[2,4] · Darren de SA[2]

Most common reasons for failure

- femoral tunnel malpositioning
- not addressing the underlying pathology
- hardware problems
- patella fracture/breach of anterior surface

Technical Note

A Simple Technique for Reconstruction of the Medial Patellofemoral Ligament Using a Quadriceps Tendon Graft

Robert N. Steensen, M.D., Ryan M. Dopirak, M.D., and Peter B. Maurus, M.D.

"The Superficial Quad Technique" for Medial Patellofemoral Ligament Reconstruction: The Surgical Video Technique

Deepak Goyal, M.B.B.S., M.S.(Orthop), D.N.B.(Orthop), M.N.A.M.S.

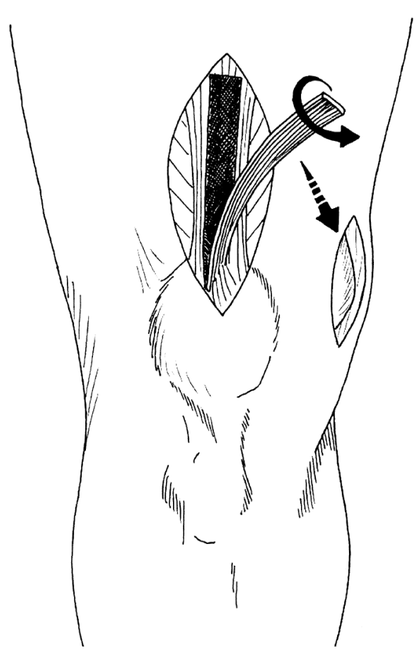
Technical Note

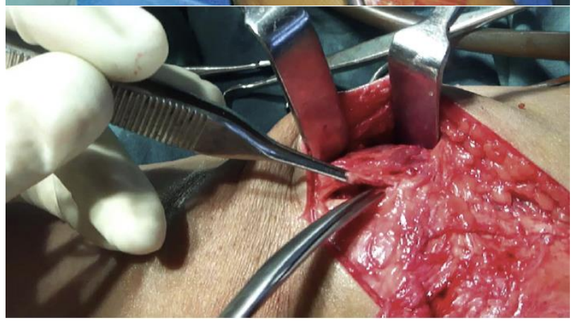
Reconstruction of the Medial Patellofemoral Ligament With Autologous Quadriceps Tendon

Frank R. Noyes, M.D., and Jay C. Albright, M.D.

Historical introduction

- approach: open or MIS
- graft harvest location: central or medial graft
- graft routing: subcutaneous; sub-retinacular, or sub-periosteal
- femoral fix: suturing to bone, or soft tissue, interference screws and anchors

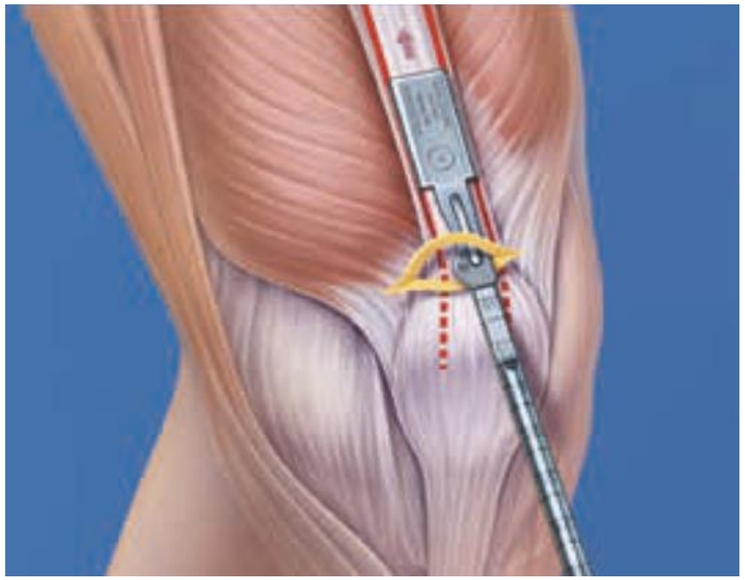




MPFL with pedicle QT graft – Fink et al

Minimally Invasive Reconstruction of the Medial Patellofemoral Ligament Using Quadriceps Tendon

Christian Fink, M.D., Matjaz Veselko, M.D., Mirco Herbort, M.D., and Christian Hoser, M.D.



Minimal invasive approach

Perpendicular short incision 2-3 cm

8/10-mm width double edge knife

Lenght of the graft marked on the holder

3/5 mm depth tendon separator

Allows for precise thickness harvesting

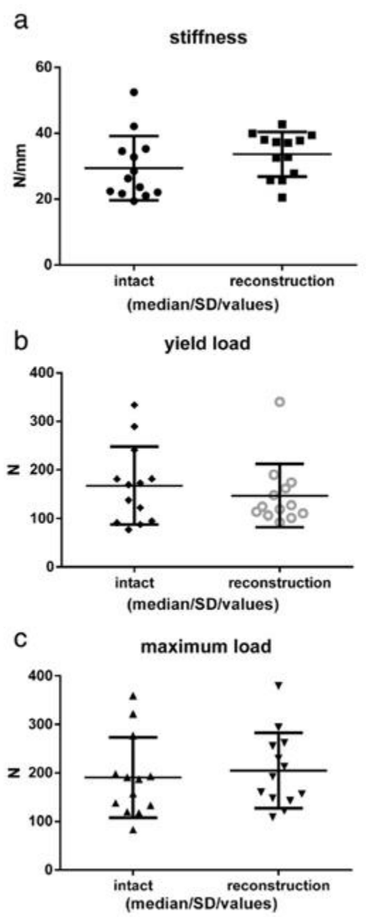
MPFL reconstruction using a quadriceps tendon graft
Part 1: Biomechanical properties of quadriceps tendon MPFL reconstruction in comparison to the Intact MPFL. A human cadaveric study

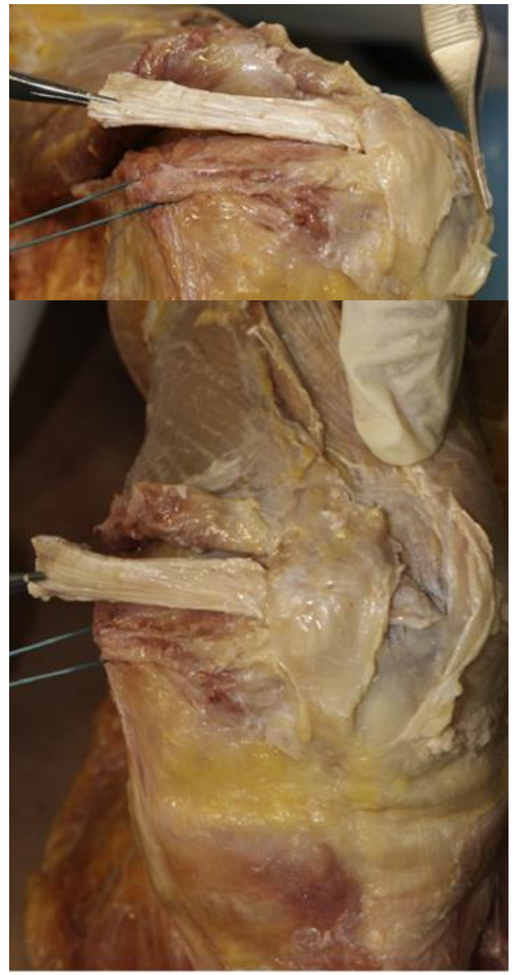
Mirco Herbort [a,*], Christian Hoser [b], Christoph Domnick [a], Michael J. Raschke [a], Simon Lenschow [a], Andre Weimann [a], Clemens Kösters [a], Christian Fink [b]

[a] Department of Trauma-, Hand- and Reconstructive Surgery, Westfaelian–Wilhelms University of Muenster, Muenster, Germany
[b] Sportsclinic Austria, Innsbruck, Austria

Biomechanical properties

- ultimate failure load: 205 ± 58.5 N
- stiffness: 33.6 ± 9.3 N/mm
- length change during knee flexion: 1.9 ± 0.9 mm
- **equivalent to native MPFL**





QT vs HT

- similar load to failure to MPFL
- lower stiffness than HT
- same mesenchymal origin as MPFL
- resembling the native MPFL → flat

No drill holes

Round

Flat

Herbort et al. 2018 Arthroscopy.
Milinkovic et al. 2022 AJSM
Arendt et al 2005, Tech Chirurg in Ortopedia,
Moutney et al. 2005 JBJS

Surgical Set-up

Case 1

16-year old girl
First-time dislocation during dancing

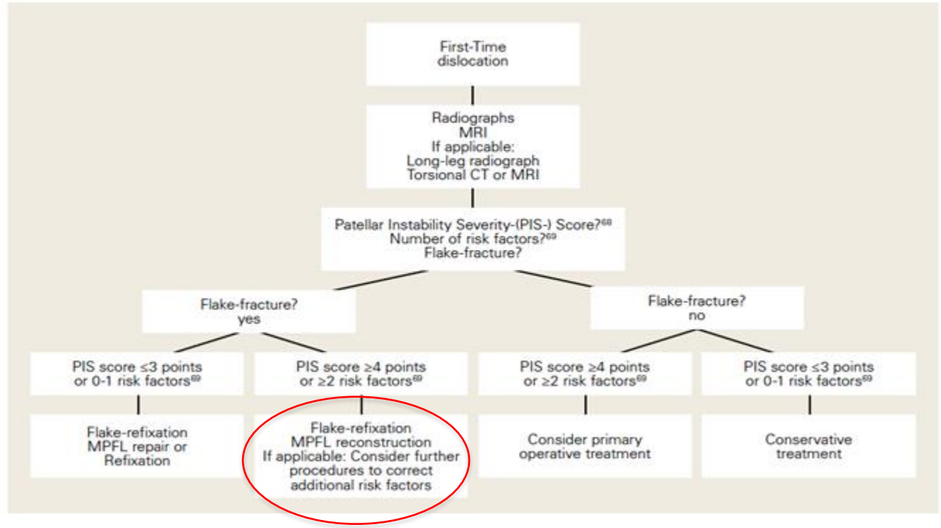
Flake fracture

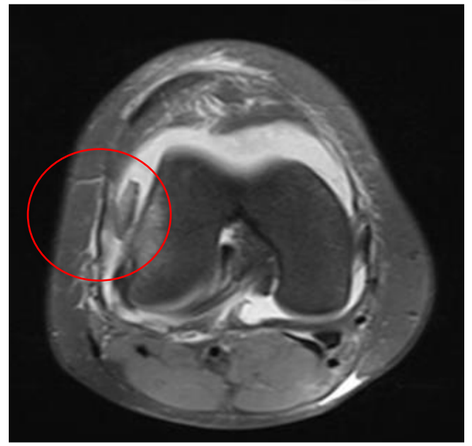
Trochlear dysplasia B/C

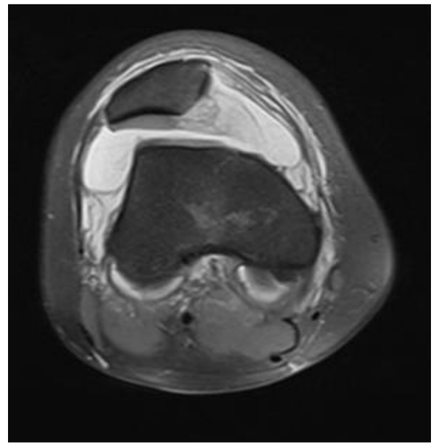
CD-Index 1.2

TT-TG/TT-PCL slightly elevated

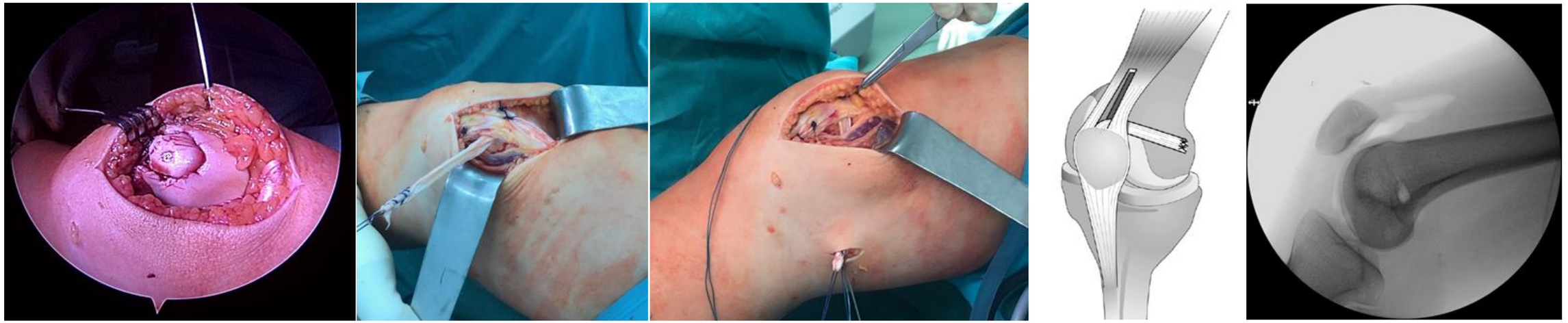
No frontal-plane malalignment







Our decision....Flake refixation + MPFL-R



„Performing concomitant MPFL reconstruction in adolescents with first-time patellar dislocation and an intra-articular loose body results in a 5-fold reduction in recurrent instability, reduces the need for subsequent surgery, and improves patients' ability to return to sports compared with repairing or not treating the MPFL.“

Gurusamy, Pradyuma et al. 2021 Am J Sports Med

Case 2

18-year old girl
First-time dislocation going down the stairs
Before recurrent subluxations

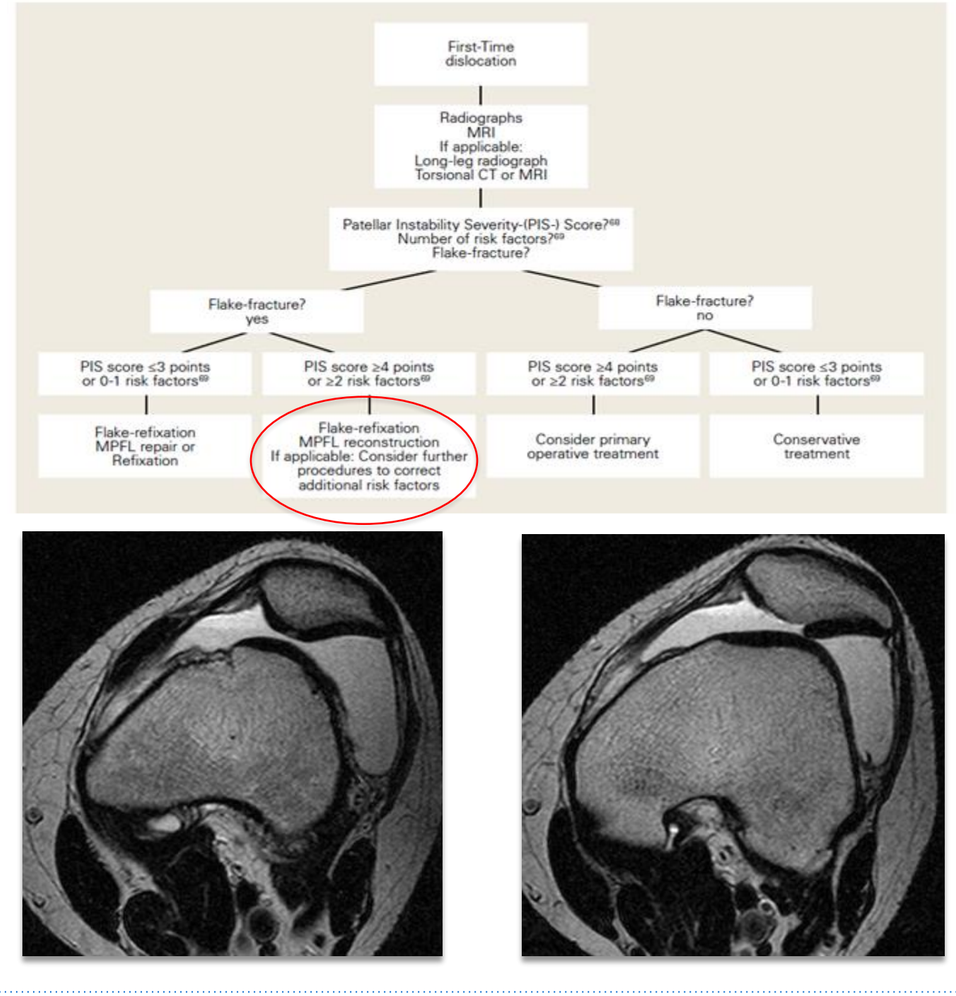
Significant cartilage deg. + loose bodies

Trochlear dysplasia D

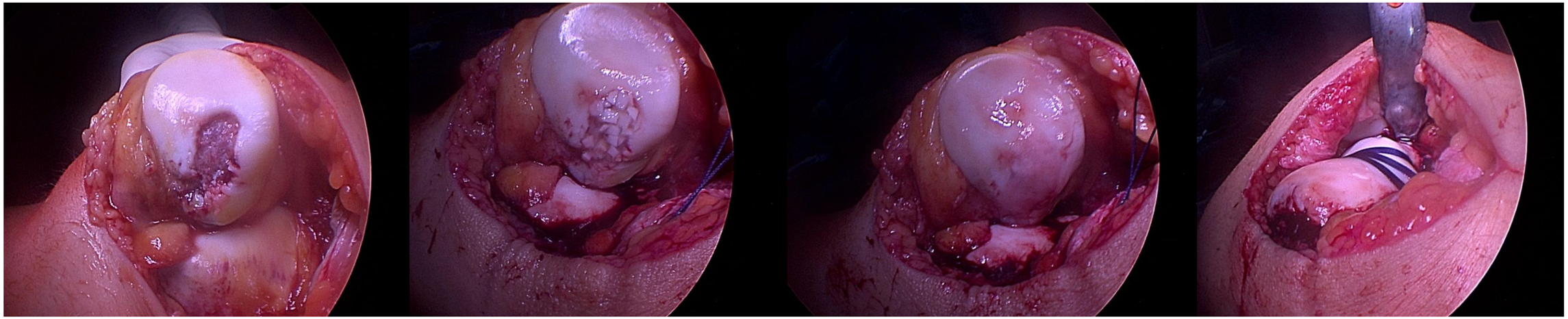
CD-Index 1.1

TT-TG/TT-PCL within normal range

No coronal/rotational malalignment



Our decision.... Minced-cartilage/Hyalofast + thin-flap Trochleaplasty + MPFL-R



Outcomes

- When comparing results of **individualized revision surgery (SG)** and comparable **primary patellar-stabilizing procedures (CG):**
  ''no between group differences….both the SG and the CG, 92% (23/25) and 84% (42/50), respectively, achieved the MCID for the BPII 2.0, without any significant difference between the groups"

  (Zimmermann F., Milinkovic DD, Balcarek P et al AJSM 2020)

- When comparing **isolated QT-MPFL-R** and **QT-MPFL + Combined** procedures:
  ''no between-group difference…the MCID for the BPII 2.0 was met by 84%(32/38) of the isolated MPFL-R and 90%(76/84) of the combined treatment group"

  (Zimmermann F, Milinkovic DD, Balcarek P et al. OJSM 2023)

Outcomes

- 32 QT vs 32 Gracilis (GT) MPFL-Rs

  - Kujala: 88.9 (QT) vs 84.8 (GT)
  - Tegner: 5.5 (QT) vs 4.6 (GT) (p = 0.027)
  - VAS: 1.3 (QT) vs 2.3 (HT) (p = 0.041)

- Donor site morbidity: 3.1% (QT) vs 59.4% (Gracilis)

Medial Patellofemoral Ligament Reconstruction Using Pedicled Quadriceps Tendon Autograft Yields Similar Clinical and Patient-Reported Outcomes but Less Donor-Site Morbidity Compared With Gracilis Tendon Autograft

Armin Runer, M.D., Stefan Klotz, M.D., Friedemann Schneider, M.D., Tim Egelseer, M.D., Robert Csapo, Ph.D., Christin Hoser, M.D., Elisabeth Abermann, M.D., Raul Mayr, M.D., Christoph Raas, M.D., Rene Attal, M.D., Rohit Arora, M.D., Christian Fink, M.D., and Michael Liebensteiner, M.D.

Outcomes

- 401 QT vs 646 Hamstrings (HT) MPFL-Rs

- Kujala: 90.0 (QT) vs 87.8 (HT) (p = 0.01)
- Lysholm: 91.5 (QT) vs 89.4 (HT) (p = 0.03)

- Redislocation: 1.3% (QT) vs 3.4% (HT)
- Complication: 4.7% (QT) vs 10.4% (HT)

Medium to long-term outcomes of medial patellofemoral ligament reconstruction using the superficial quadriceps versus a hamstring autograft in patellar instability patients

Prakasit Sanguanjit [1], Possawat Rujiraphum [1], Adinun Apivatgaroon [1,✉], Bancha Chernchujit [1]

Pearls

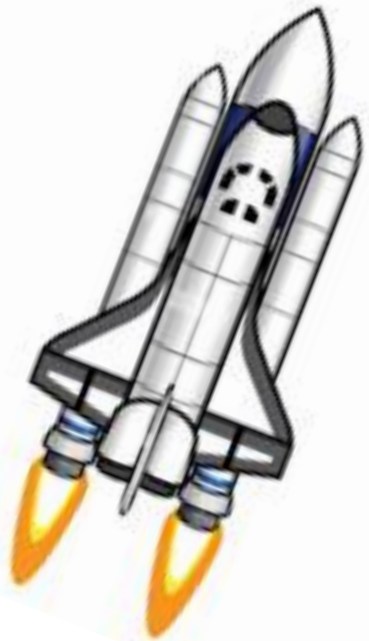
- Preserves native patellar insertion
- No drill holes in the patella
- Morphologic match to native MPFL
- Low donor-site morbidity
- Possibility of concomitant procedures with single incision (vertical)

Pitfalls

- Risk of insufficient length
- Complete release from the patellar insertion
- Extensor lag/weakness
- Steep learning curve
- Unappealing scaring (vertical vs horizontal)

Take home ..... QT-Autograft for MPFL-R is:

- A viable reproducible and safe graft option
- Biomechanically superior to other graft options
- No tunnels or implants in the patella
- Suitable for both adult- and young-patient population
- Good outcomes, with low re-luxation rates and high patient satisfaction



Special thanks to Prof. C. Fink, Prof. M. Herbort and Dr. P. Balcarek

IQTI INTERNATIONAL QT INTEREST GROUP

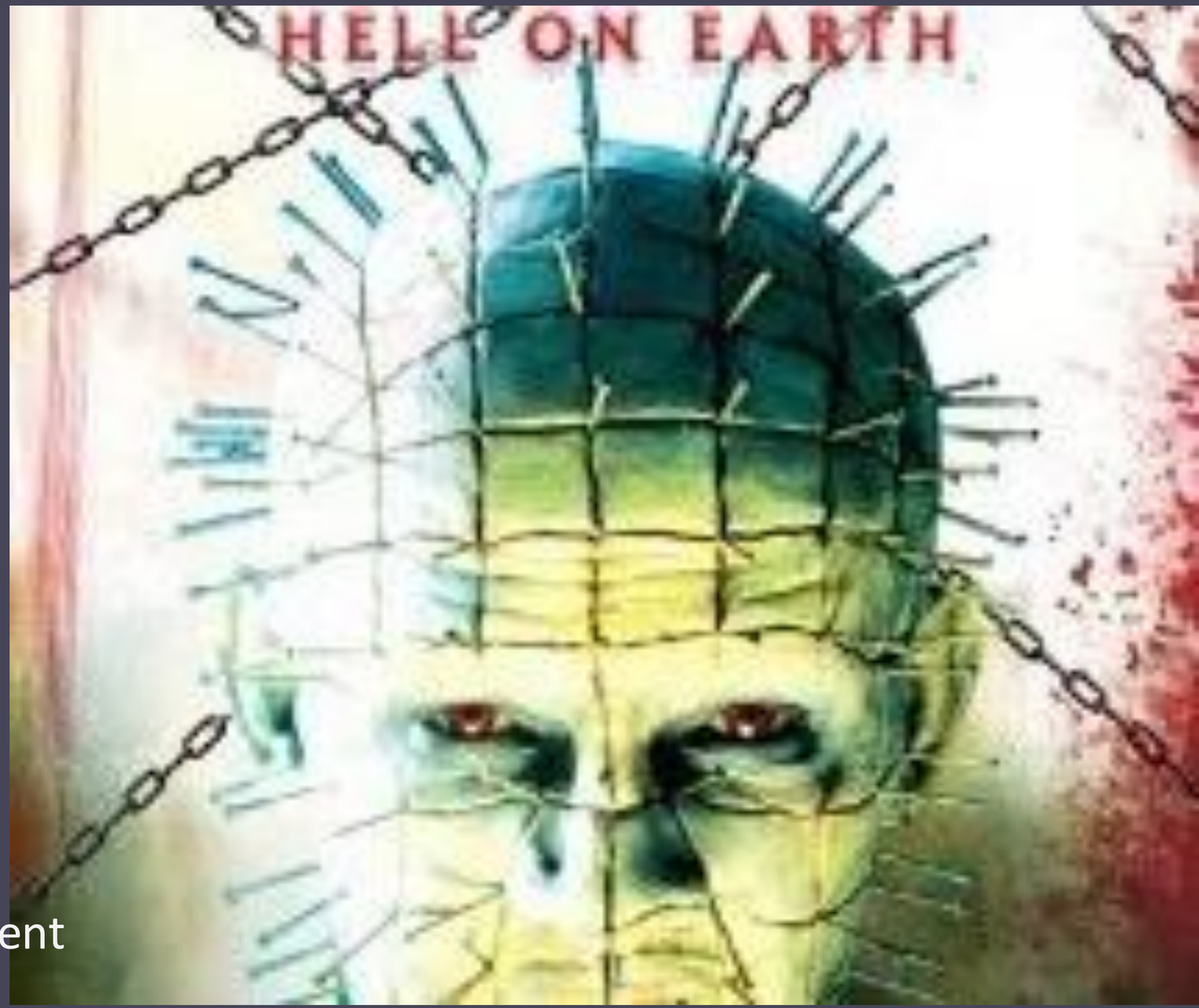
For more Info:

https://iqti.org

Grazie per la vostra attenzione!!!

NIGHTMARES IN ACL

- LOSS OF EXTENSION
- ARTHROFIBROSIS
- CYCLOPS



Prof Dr D Slullitel

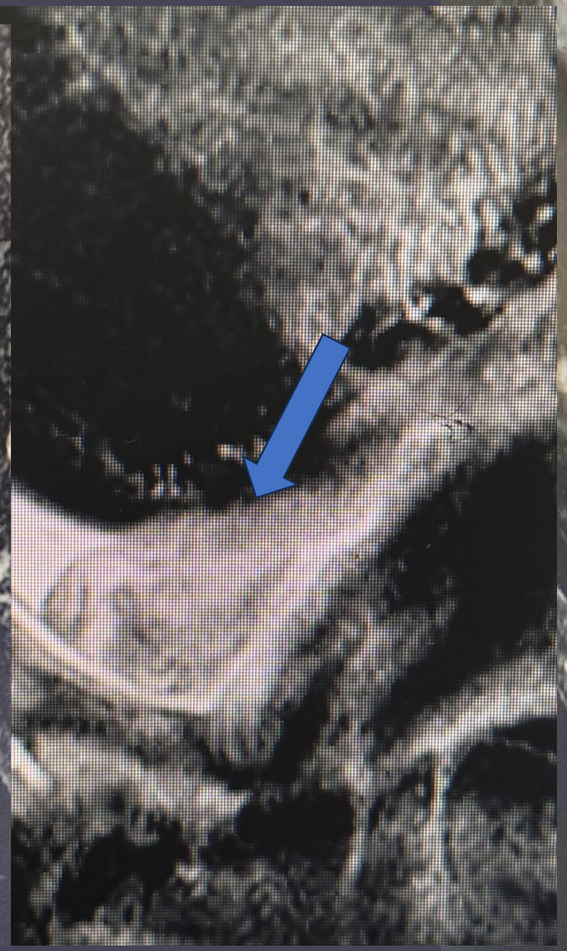
Chairman Orthopaedic Department
HOSPITAL ITALIANO

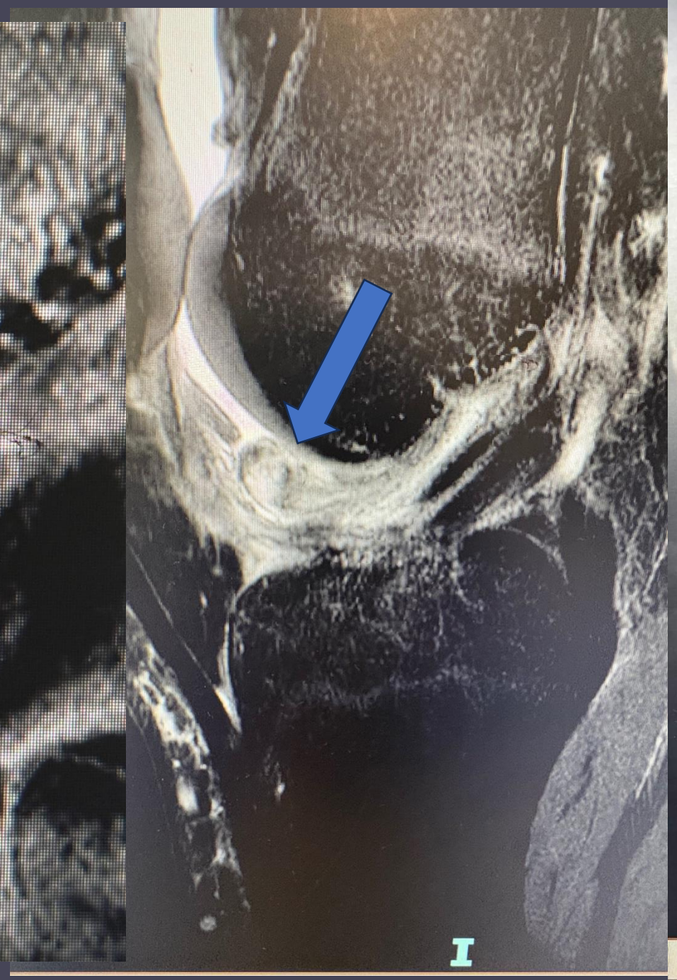
Rosario, Argentina


VISA

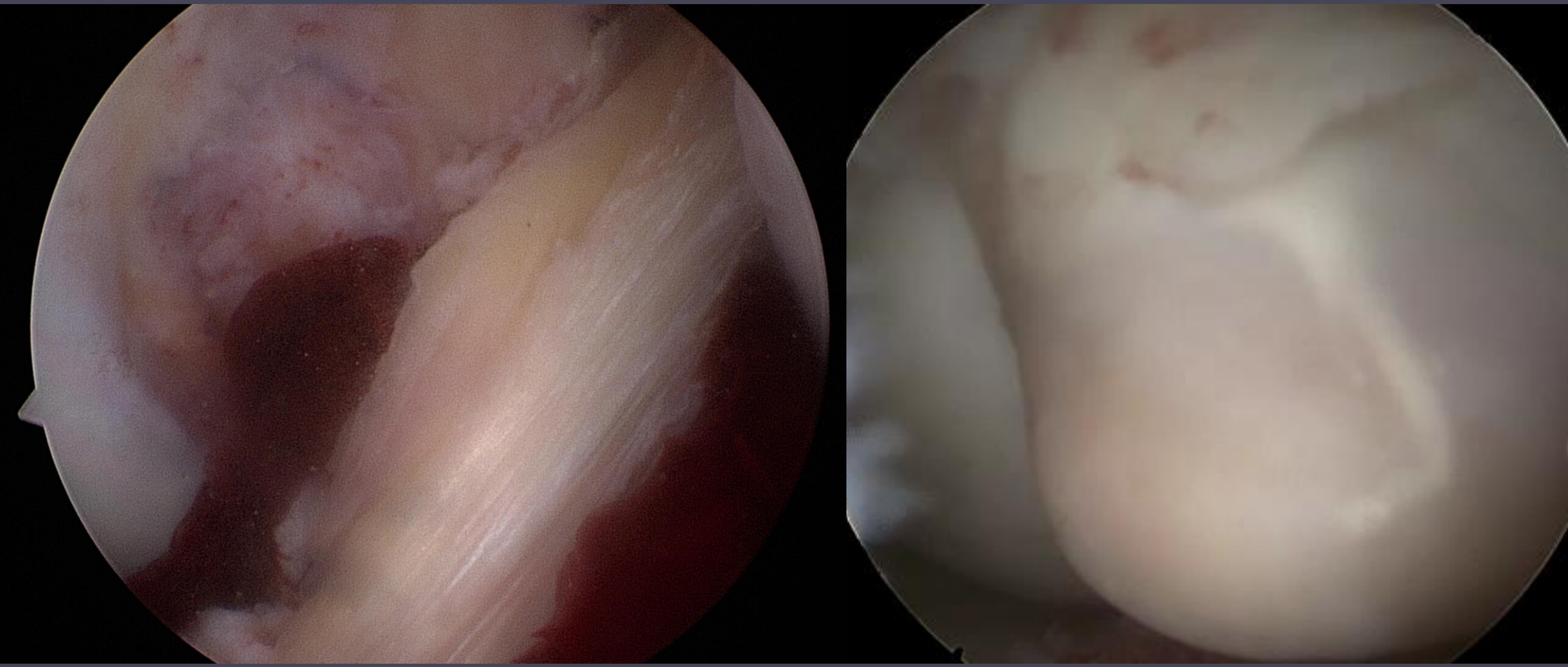
ARTHROFIBROSIS

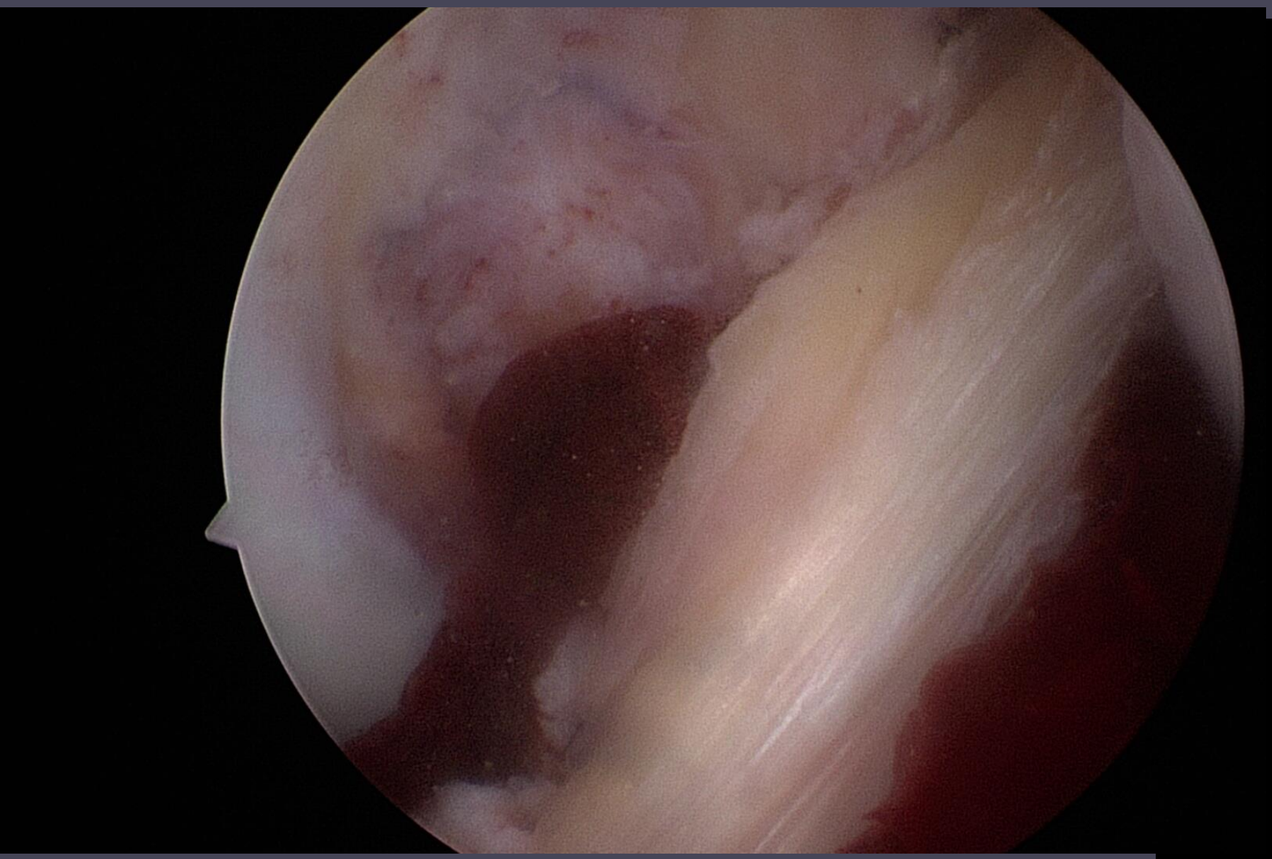
CYCLOPS

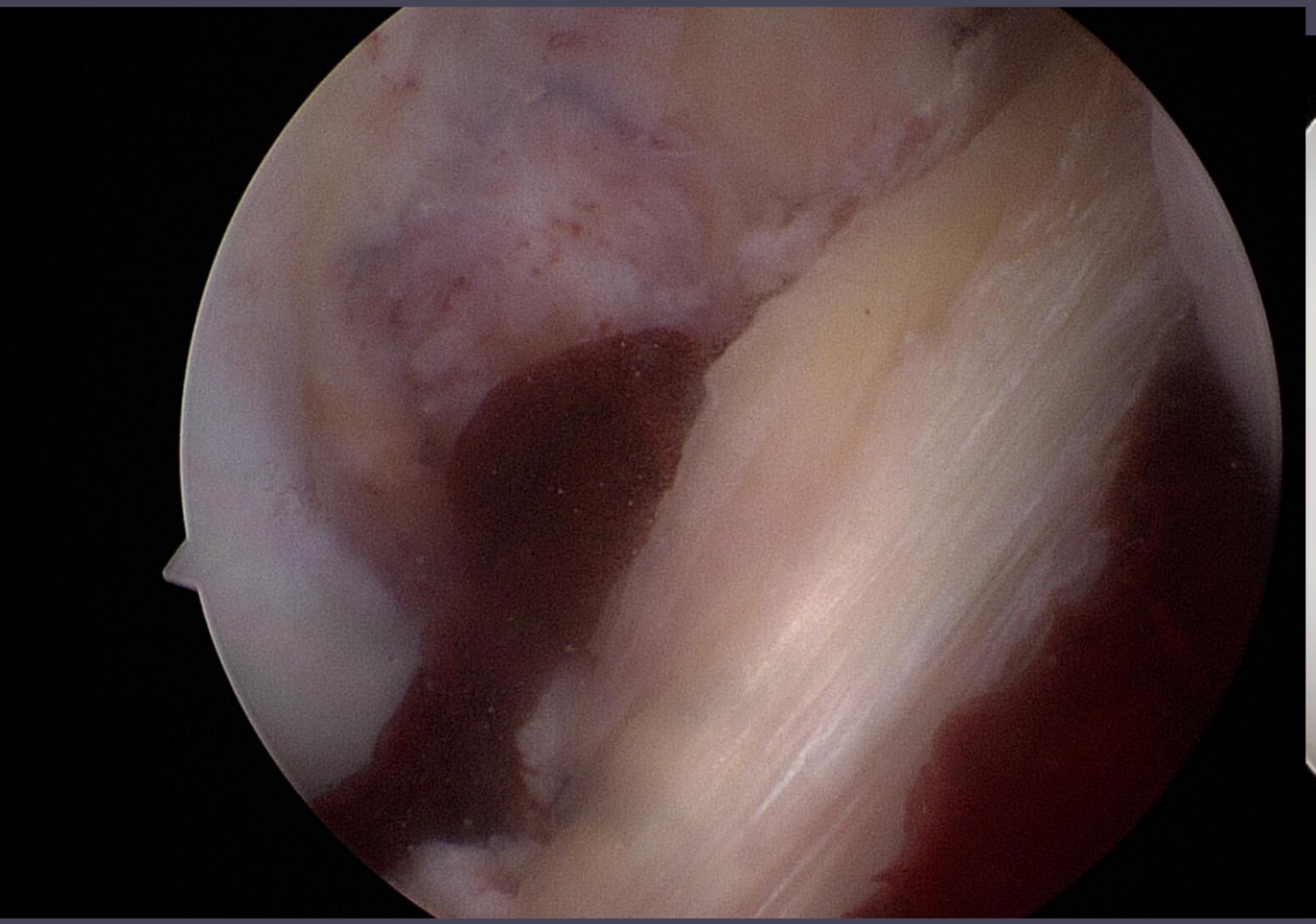


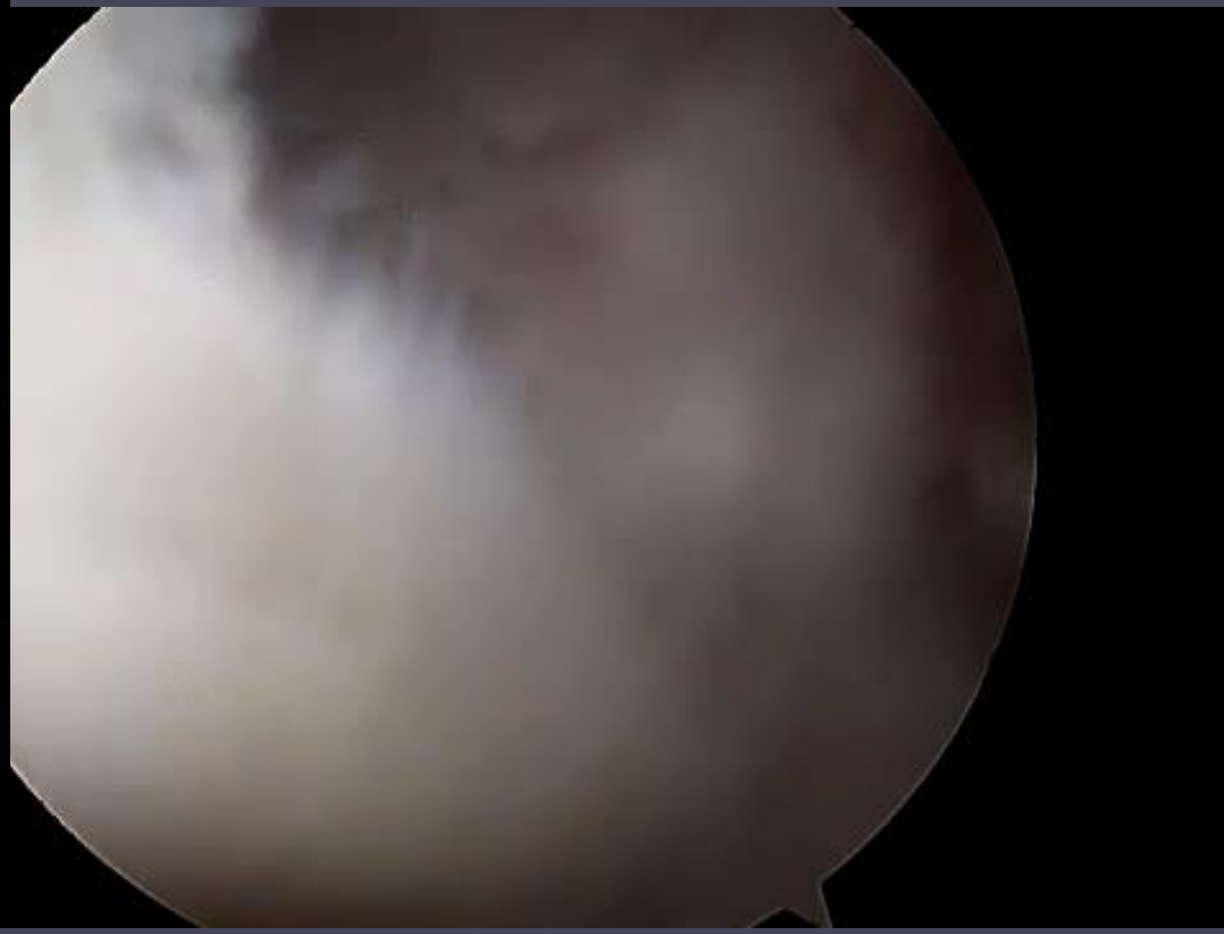


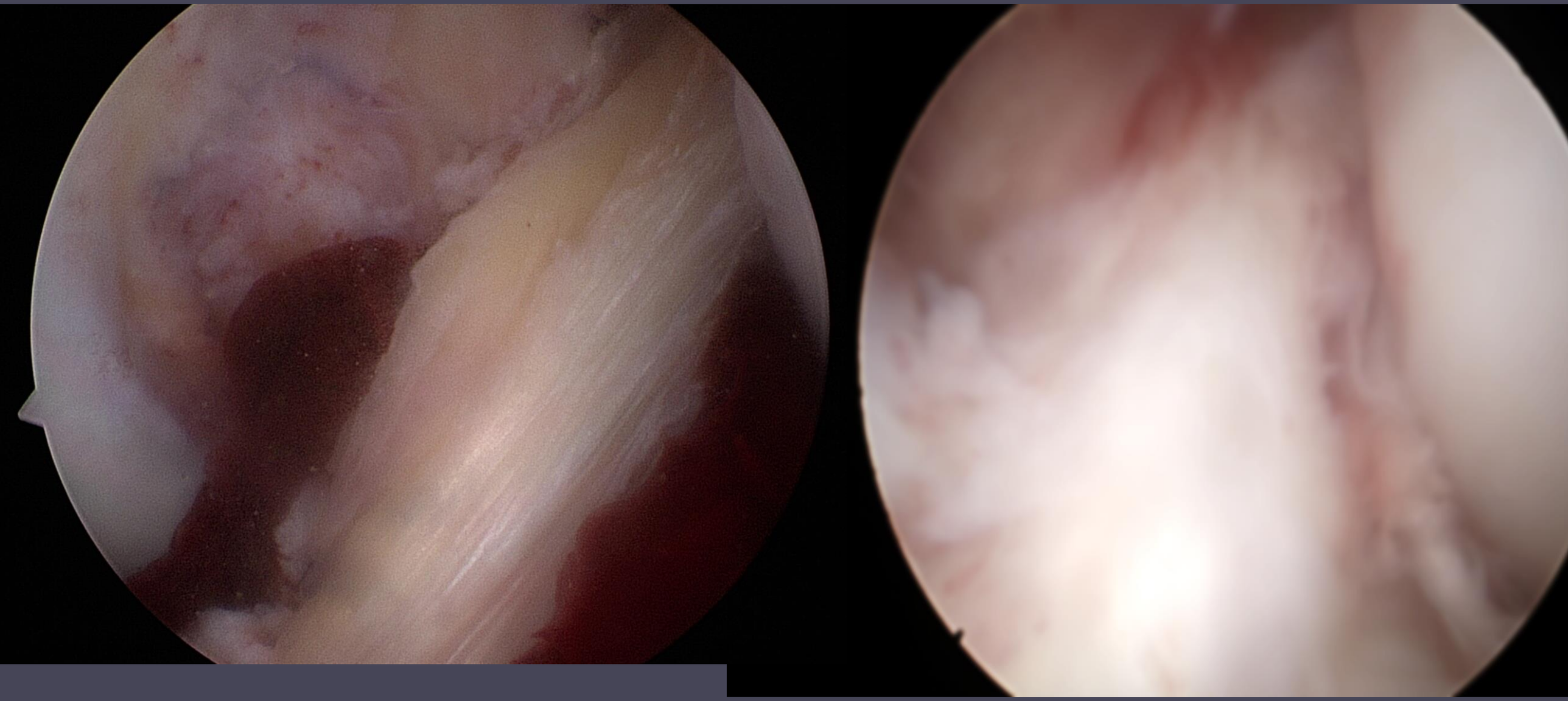

•WHY ?

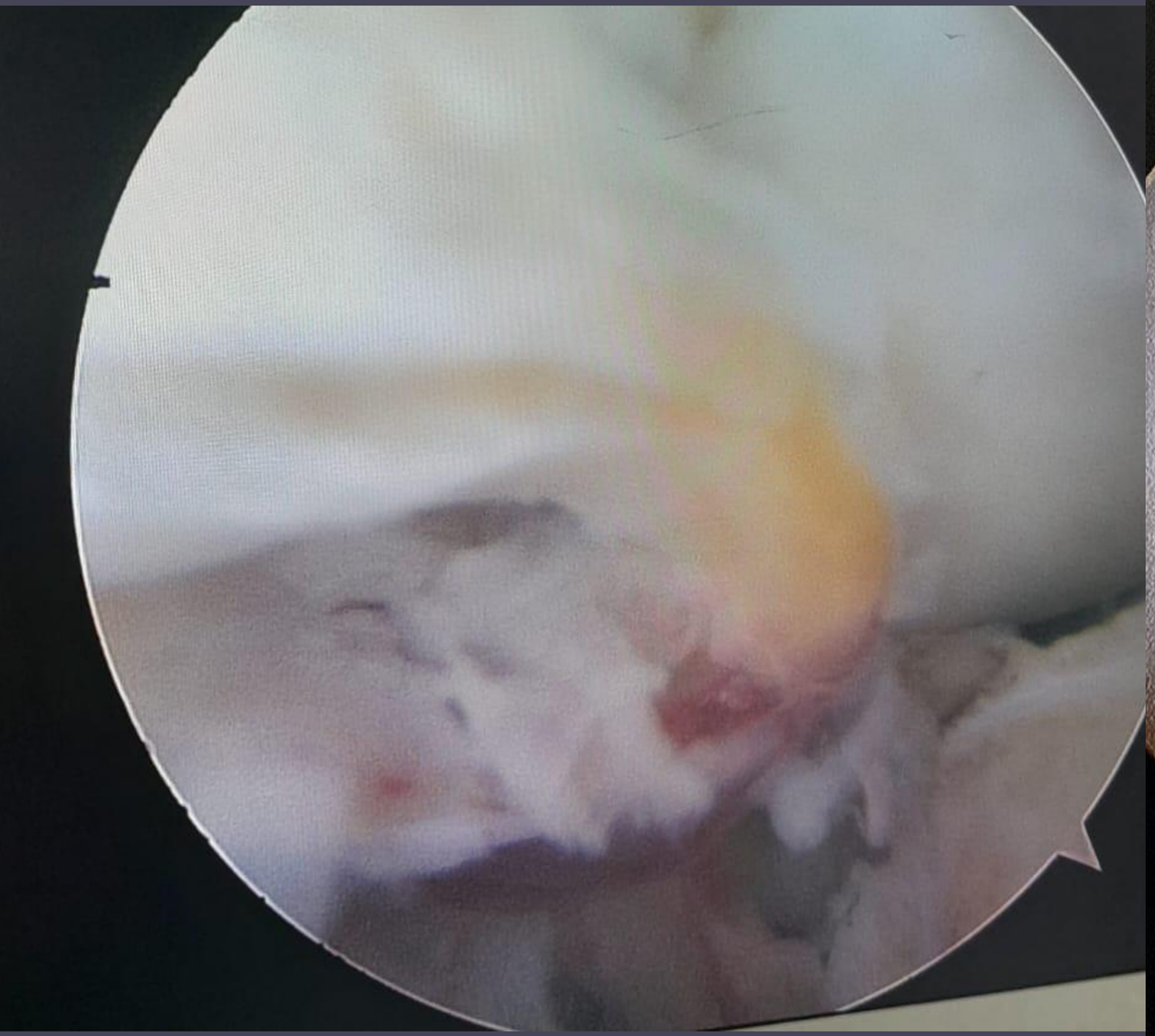


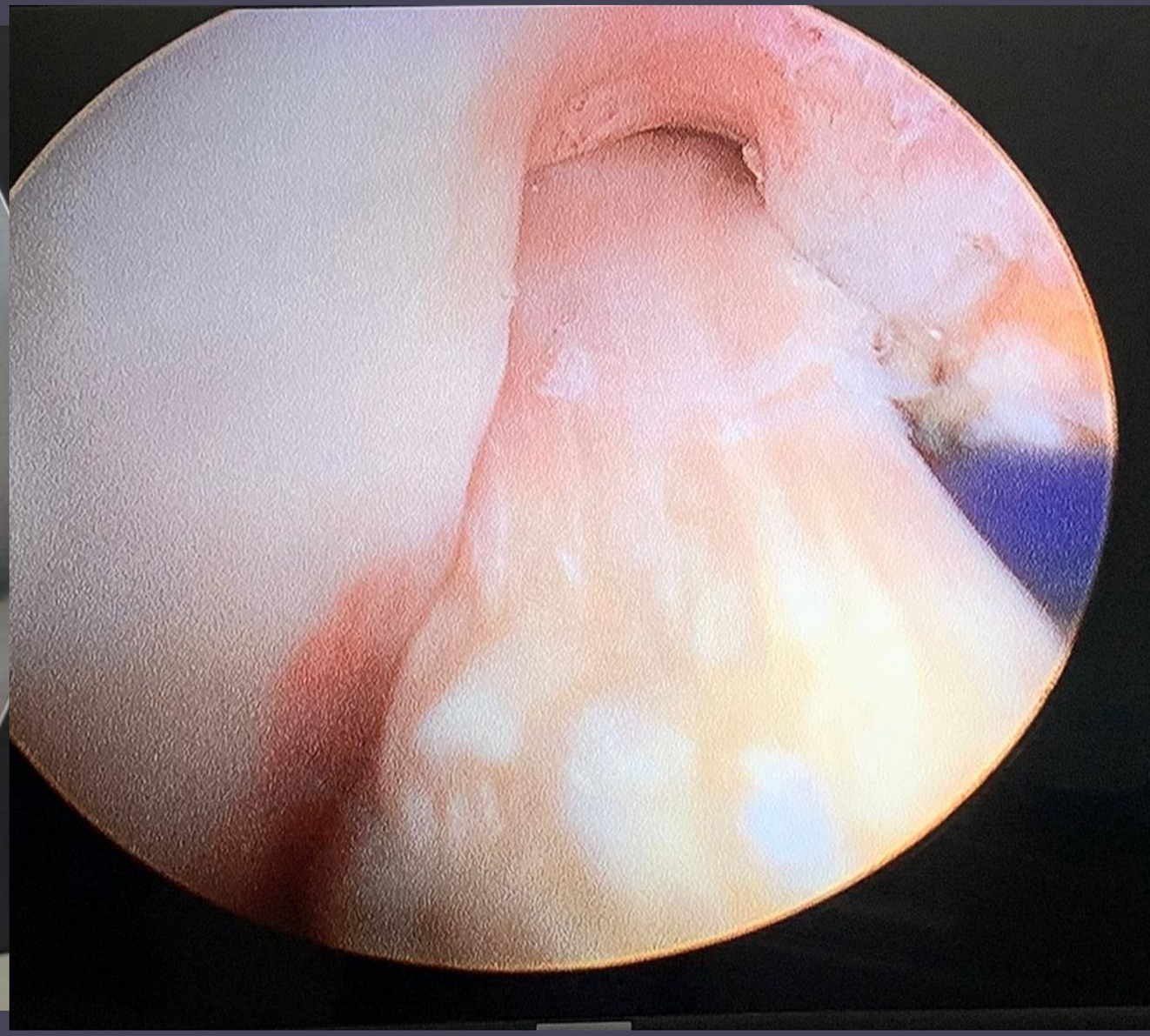












Knee Extension Deficit in the Early Postoperative Period Predisposes to Cyclops Syndrome After Anterior Cruciate Ligament Reconstruction

A Risk Factor Analysis in 3633 Patients From the SANTI Study Group Database

- AMI

Jean-Romain Delaloye,* MD, Jozef Murar,† MD, Thais D. Vieira,‡ MD, Florent Franck,‡ MD, Charles Pioger,‡ MD, Lionel Helfer,‡ MD, Adnan Saithna,§|| MD, FRCS (T&O), and Bertrand Sonnery-Cottet,‡¶ MD
Investigation performed at the Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Hôpital Privé Jean Mermoz, Groupe Ramsay-Générale de Santé, Lyon, France

Results: A total of 3633 patients were included in the study, among whom 65 (1.8%) underwent reoperation for cyclops syndrome. Multivariate analysis demonstrated that preservation of large remnants did not predispose to cyclops lesions (odds ratio [OR], 1.11; 95% CI, 0.63-1.93). The most important risk factor was extension deficit in the early postoperative period. If present at 3 weeks postoperatively, it was associated with a >2-fold increased risk of cyclops syndrome (OR, 2.302; 95% CI, 1.268-4.239; $P < .01$), which was increased to 8-fold if present 6 weeks after ACLR (OR, 7.959; 95% CI, 4.442-14.405; $P < .0001$). None of the other potential risk factors evaluated were found to be significantly associated with an increased frequency of cyclops syndrome.

Conclusion: Failure to regain full extension in the early postoperative period was the only significant risk factor for cyclops syndrome after ACLR in a large cohort of patients. Other previously hypothesized risk factors, such as preservation of a large anterior cruciate ligament remnant, did not predispose to the development of this debilitating postoperative complication.

Keywords: ACL reconstruction; cyclops; cyclops syndrome; extension deficit; arthrogenic muscle inhibition

Localized Anterior Arthrofibrosis After Soft-Tissue Quadriceps Tendon Anterior Cruciate Ligament Reconstruction Is More Common in Patients Who Are Female, Undergo Meniscal Repair, and Have Grafts of Larger Diameter

Rebecca M. Haley, M.D., Joseph D. Lamplot, M.D., Gregory D. Myer, Ph.D., Jed A. Diekfuss, Ph.D., Joan Reed, M.A.T., A.T.C., C.S.C.S., Regina Hash, M.S., A.T.C., O.T.C., Janet E. Simon, Ph.D., A.T., and John W. Xerogeanes, M.D.

- FEMALE
- DIAMETER
- GRAFT

weight, femoral and tibial tunnel sizes, meniscal repair, and meniscectomy by a binary logistic regression. **Results:** This study included 721 patients (46% female patients). There were 52 cases of localized anterior arthrofibrosis (7.2%). Female patients had a greater incidence of arthrofibrosis than male patients. Male patients with a femoral tunnel diameter of 9.25 mm or greater had an increased incidence of arthrofibrosis compared with those with a diameter of less than 9.25 mm,

Delay of Timing of Anterior Cruciate Ligament Reconstruction Is Associated With Lower Risk of Arthrofibrosis Requiring Intervention

Amil R. Agarwal, B.A., Andrew B. Harris, M.D., Omar Tarawneh, B.S., Alisa Malyavko, M.S., R. Timothy Kreulen, M.D., Savyasachi C. Thakkar, M.D., Teresa Doerre, M.D., and Matthew J. Best, M.D.

- TIMING?
- -10
- +45 ?

anesthesia and arthroscopic lysis of adhesions, respectively. **Conclusions:** Our analysis showed a delay in ACLR of at least 6 weeks in patients younger than 40 years to be associated with a 65% reduction in the risk of surgical intervention for arthrofibrosis and a delay of at least 10 weeks in patients 40 years and older to be associated with only a 35% reduction in the risk of surgical intervention for arthrofibrosis. The authors propose this difference in reduction to be multifactorial and potentially associated with mechanism of injury, activity level, and preoperative factors such as amount of physical therapy, rather than solely timing. **Level of Evidence:** Level III, retrospective comparative prognostic study.

Clinical Sports Medicine Update

Acute Anterior Cruciate Ligament Reconstruction Performed Within 10 Days of Injury Does Not Increase Risk of Postoperative Arthrofibrosis

A Systematic Review and Meta-analysis

Zachary S. Aman,* MD, Olivia K. Blaber,* MD, Emily R. McDermott,† MD, Mikalyn T. DeFoor,† MD, Nicholas N. DePhillipo,‡ PhD, LTC Jonathan F. Dickens,§ MD, and MAJ Travis J. Dekker,||¶ MD

Investigation performed at Sidney Kimmel Medical College at Thomas Jefferson University,

A Simple Method to Reduce the Incidence of Cyclops Lesion after Anterior Cruciate Ligament Reconstruction

Keita Nagira, MD, PhD[1] Makoto Enokida, MD, PhD[1] Ikuta Hayashi, MD, PhD[1] Koji Ishida, MD[1]
Haruhisa Kanaya, MD[1] Hideki Nagashima, MD, PhD[1]

remnants?

[1] Department of Orthopedic Surgery, Tottori University, Yonago, Tottori, Japan

Address for correspondence Keita Nagira, MD, PhD, Department of Orthopedic Surgery, Tottori University, 36-1 Nishi-cho, Yonago, Tottori 683-8504, Japan (e-mail: nagira@tottori-u.ac.jp; keitanagira@gmail.com).

J Knee Surg 2021;34:546–551.

posterior bowing of the ACL graft; and (3) the positional relationship between the frontmost fiber of ACL graft and Blumensaat's line. If CL caused loss of extension or pain or discomfort during knee extension, it was defined as symptomatic CL (SCL). CL was detected in 8 cases (21.1%) in Group A and 26 cases (46.4%) in Group B. The prevalence of CL was significantly lower in Group A than in Group B ($p = 0.010$), and the risk ratio of CL was 0.31 (95% confidence interval: 0.12–0.79). Furthermore, 10 patients in Group B had SCL, compared with none in Group A ($p = 0.004$). In Group A, the intercondylar site of CL was grade 1 in all cases, while in Group B, the CL grades were 1 ($n = 17$), 2 ($n = 7$), 3 ($n = 2$) ($p = 0.008$). There were no cases of posterior bowing of the ACL in Group A, but six cases in Group B ($p = 0.023$). Debridement in and around the bone tunnel is a simple and effective method of preventing CL and SCL after ACLR. The level of evidence for the study is 3.

Female Sex, Older Age, Earlier Surgery, Anticoagulant Use, and Meniscal Repair Are Associated With Increased Risk of Manipulation Under Anesthesia or Lysis of Adhesions for Arthrofibrosis After Anterior Cruciate Ligament Reconstruction: A Systematic Review

Haleigh Hopper, B.S., Matthew Adsit, M.D., Charles R. Reiter, B.S., James R. Satalich, M.D., R. Cole Schmidt, M.D., Maria I. Peri, B.S., John W. Cyrus, M.S., and Alexander R. Vap, M.D.

AGE

FEMALE

ANTICOAGULANTS

TIMING

MENISCAL REPAIR

than aspirin, and concomitant meniscal repair were associated with increased risk of MUA/LOA. The modifia
including use of anticoagulants and time between injury and surgery, can be considered when making t
decisions. **Level of Evidence:** Level IV, systematic review of Level III-IV studies.

Risk Factors for Symptomatic Cyclops Lesion Formation after Anterior Cruciate Ligament Reconstruction

Fatores de risco para formação de lesão cyclops sintomática após a reconstrução do ligamento cruzado anterior

Camilo Partezani Helito[1,2,3] Andre Giardino Moreira da Silva[2] Pedro Nogueira Giglio[2]
Vitor Barion Castro de Pádua[4] José Ricardo Pécora[1,2] Riccardo Gomes Gobbi[1,2]

[1] Department of Orthopedics and Traumatology, Faculty of Medicine, University of São Paulo, São Paulo, SP, Brazil
[2] Knee Group, Institute of Orthopedics and Traumatology, Clinical Hospital HCFMUSP, Faculty of Medicine, University of São Paulo, São Paulo, SP, Brazil
[3] Sírio Libanês Hospital, São Paulo, SP, Brazil
[4] Department of Orthopedics, Faculty of Medicine, University of Marilia, Marilia, SP, Brazil

Address for correspondence Andre Giardino Moreira da Silva, MD, Departamento de Ortopedia e Traumatologia, Instituto de Ortopedia e Traumatologia do Hospital das Clínicas – IOT HCFMUSP, Rua Dr. Ovídio Pires de Campos, 333, Cerqueira Cesar, 05403-010, São Paulo, SP, Brasil (e-mail: andre.giardino1@gmail.com).

Rev Bras Ortop 2023;58(5):e760–e765.

Conclusion In our series, 6.7% of the patients required arthroscopic removal of cyclops lesions. Female gender, associated extra-articular reconstruction and sports practice were factors related to this lesion. Remnant preservation had no relationship with cyclops lesion formation.

• EXTRA ARTICULAR ?

RESEARCH ARTICLE Open Access

Analysis of intercondylar notch size and shape in patients with cyclops syndrome after anterior cruciate ligament reconstruction

Krzysztof Ficek[1,2*], Jolanta Rajca[2], Jerzy Cholewiński[2,3,4], Agnieszka Racut[2], Paweł Gwiazdoń[1,2,5], Krzysztc

DOI: 10.1002/ksa.12073

- NOTCH ?
- TRANSTIBIAL ?

KNEE

Knee Surgery, Sports Traumatology, Arthroscopy WILEY

Risk factors for reoperation for arthrofibrosis following primary anterior cruciate ligament reconstruction

Richard Rahardja[1] | Hamish Love[2] | Mark G. Clatworthy[3] | Simon W. Young[1,4]

aHR = 0.78, not significant).

Conclusion: Female sex, previous knee surgery and a transtibial drilling technique increased the risk of reoperation for arthrofibrosis. Early surgery within 6 weeks of injury was not associated with an increased risk when compared with surgery between 6 weeks and 6 months after injury.

Technical Note

Full-Thickness Quadriceps Tendon: An Easy Cruciate Reconstruction Graft

Daniel Slullitel, M.D., Adrián Blasco, M.D., and Gabriel Periotti, M.D.

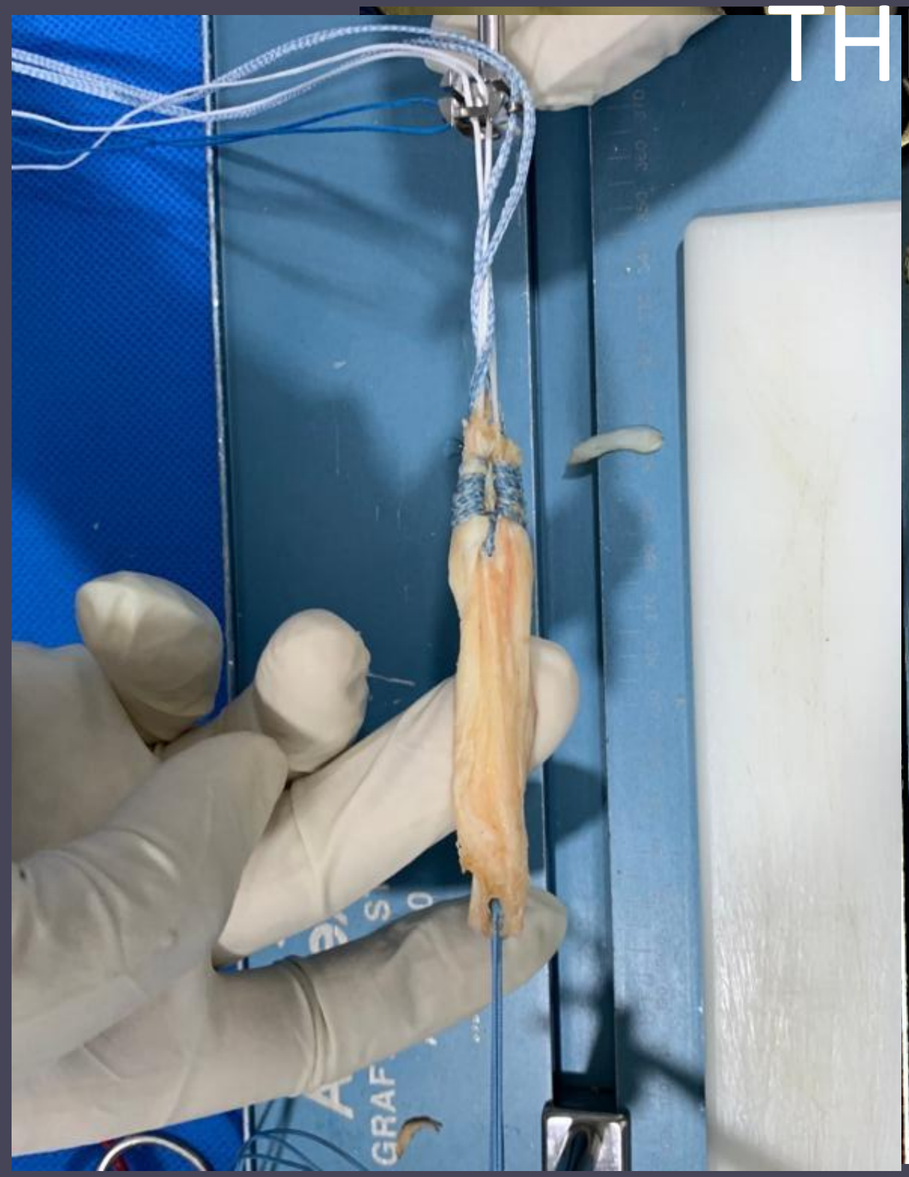
Arthroscopy: The Journal of Arthroscopic and Related Surgery, Vol 17, No 7 (September), 2001: pp 781–783

- Causes ?
- AMI
- SIZE
- NOTCH
- PLUS MENISCAL REPAIR
- PLUS EXTRAARTICULAR
- SEX
- TIMING
- REMNANTS
- DEBRIS

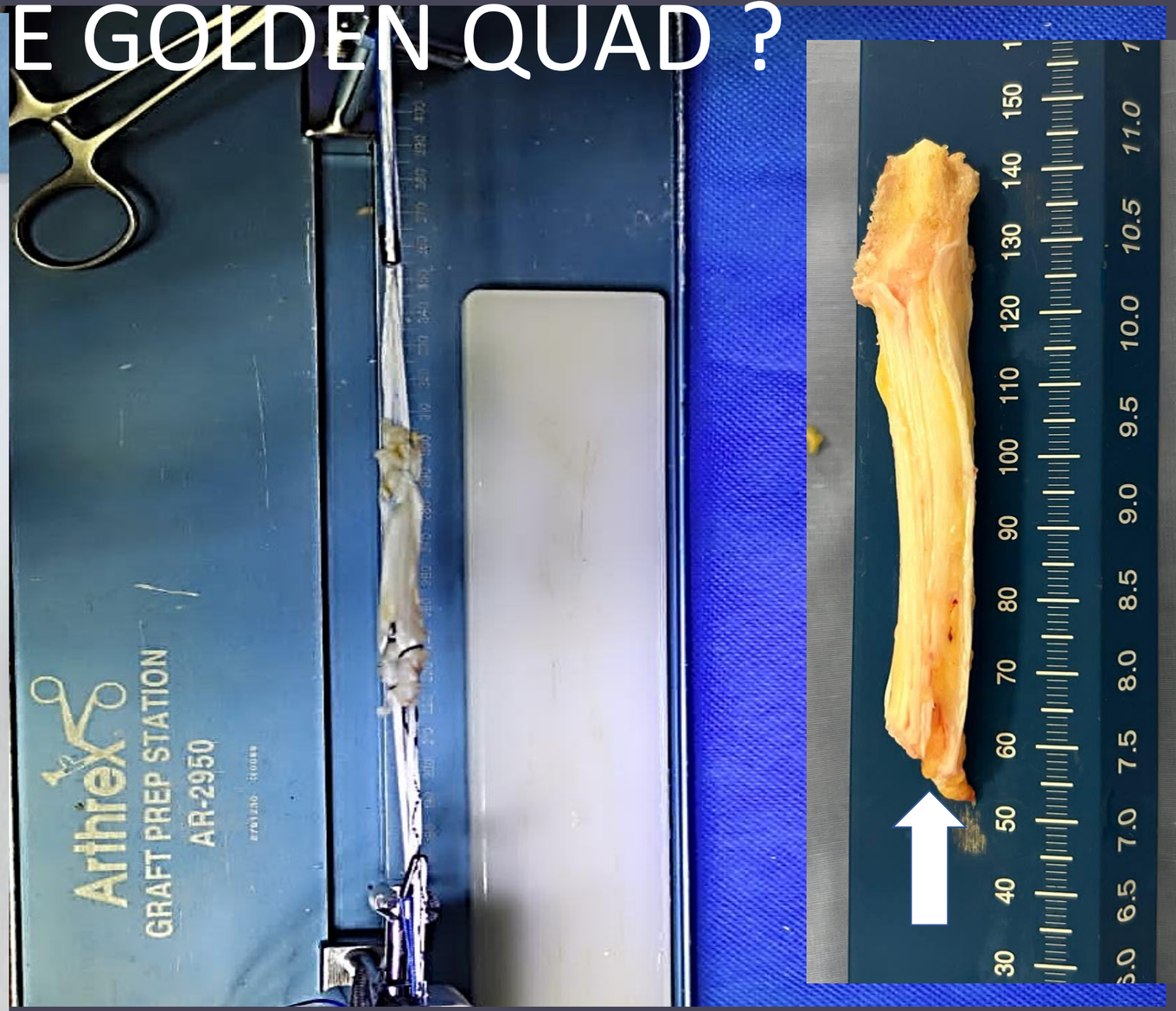
Editorial Commentary: Risk Factors of Cyclops Syndrome in Quadriceps Autograft Anterior Cruciate Ligament Reconstruction: More Helpful Data in Weighing Graft Choice

Justin W. Arner, M.D., Editorial Board

THE GOLDEN QUAD ?



TENDON BONE ?



TENDON -TENDON
PRETENSIONING AND FIXATION ?

PARTIAL THICKNESS ?

Editorial Commentary: Personalized Anterior Cruciate Ligament Reconstruction and Rehabilitation Mitigate Postoperative Arthrofibrosis: Prevention Is the Best Approach

Nikolaos K. Paschos, M.D., Ph.D., Editorial Board

Abstract: Arthrofibrosis after anterior cruciate ligament reconstruction can become a major complication requiring surgical intervention. The reported incidence approximates 8% but varies widely (2%-35%) and, as not all patients require surgery, may be underreported. Several risk factors are involved. Female sex, older age, surgery within the first month after injury, and meniscus repair are consistently associated with increased risk. Other factors include graft size and type, concomitant procedures, use of anticoagulants, and genetic factors. By identifying risk factors, we can modify our surgical technique and rehabilitation to meet each patient's needs with fewer complications.

such as arthrofibrosis.

The key for management of arthrofibrosis is prevention. Identification of patients at risk is the first step. In addition, it is important to understand that this is a multifactorial and not solely dependent on one or two risk factors. The future is promising, as big data studies and large meta-analysis—when done properly—can identify risk factors that can be hard to recognize in clinical studies.[24-26] Another promising future revolu-

REHAB: AVOID EXT DEFICIT AND STRENGHT

- Even in Meniscal Repair ?

REHAB: AVOID EXT DEFICIT AND STRENGHT

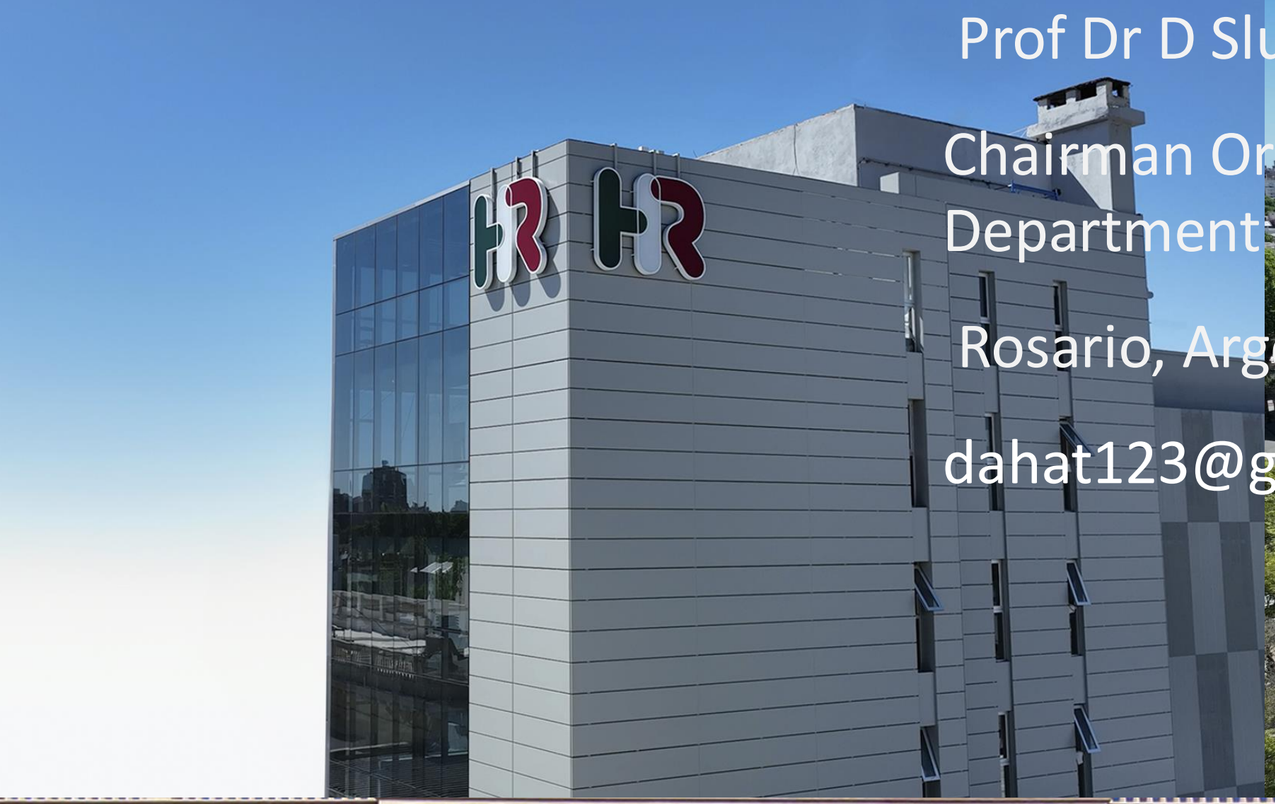
- Even in Meniscal Repair ?

Prof Dr D Slullitel

Chairman Orthopaedic Department

Rosario, Argentina

dahat123@gmail.com



Hospital ITALIANO Rosario

I J S

CURSO CIRUGÍAS EN VIVO

DE RODILLA

4 DE JULIO DE 2025

ROCKS
Rosario Complex Knee & Shoulder


Dr. Daniel Slullitel


Dr. Lisandro Nardín


Dr. Hernán Galán


Dr. Gustavo Benitez Gil


Dr. Sebastián Malier

BS
Knee Research


Dr. Camilo Helito


Dr. Pedro Baches


Dr. Sergio Canuto


Dr. Vitor Barion

Invitados Nacionales

Dr. Iván Bitar, Presidente de la Asociación Argentina de Artroscopía
Dr. Rodrigo Maestu
Dr. Cristian Collazo Blanchod
Dr. Rafael Martinez Gallino


E-posters
17th ESSKA Congress


Plasma Rico en Pla
¿Qué, donde, como

Systematic Review of Publications Regarding Quadriceps Tendon Autograft Use in Anterior Cruciate Ligament Reconstruction

Walker M. Heffron, B.S., Jennifer L. Hunnicutt, Ph.D., A.T.C., John W. Xerogeanes, M.D., Shane K. Woolf, M.D., and Harris S. Slone, M.D.

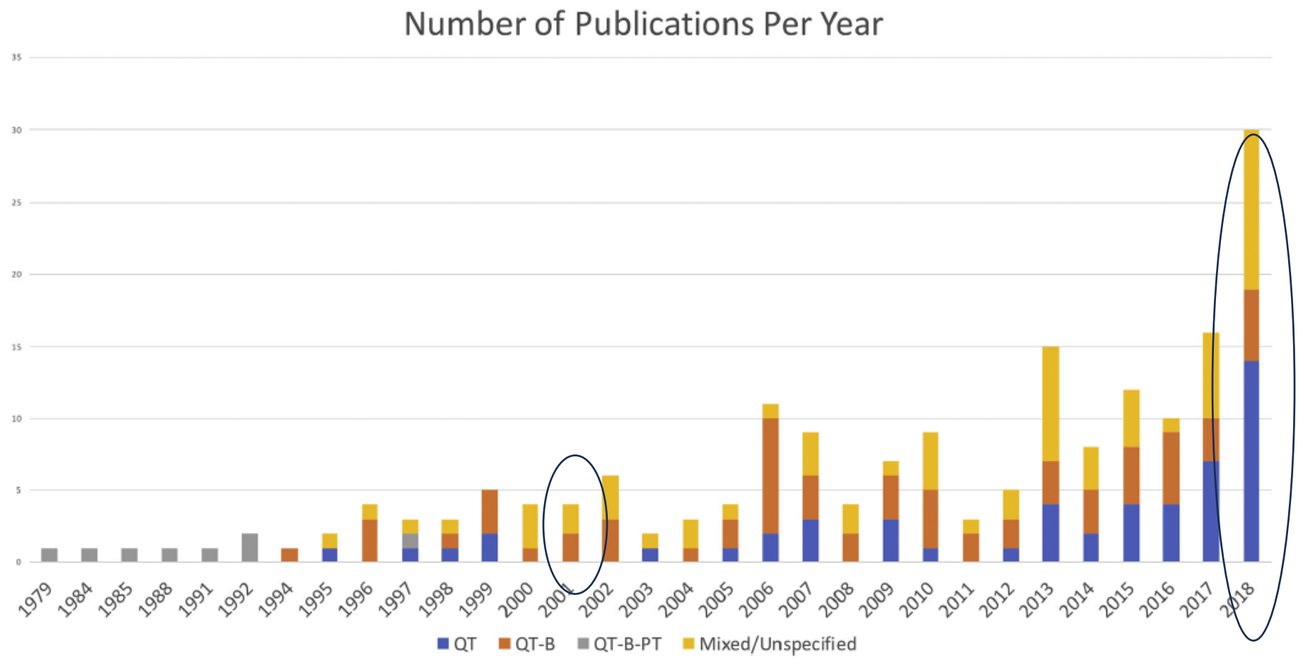


Fig 2. Number of publications involving the evaluation or use of quadriceps tendon autografts for reconstruction of the anterior cruciate ligament per year. The color bars represent the type of quadriceps tendon graft discussed in the publication: quadriceps tendon or central quadriceps tendon (QT), quadriceps tendon–bone (QT-B) (or a combination of QT and QT-B), or quadriceps tendon–bone–patellar tendon (QT-B-PT). The data represent the publication count through December 31, 2018.

Quadriceps Tendon-Bone or Patellar Tendon-Bone Autografts When Reconstructing the Anterior Cruciate Ligament: A Meta-analysis

Osman Riaz, MRCS,* Adeel Aqil, MRCS,† Ashim Mannan, MRCS,† Fahad Hossain, FRCS,*
Mubusher Ali, MBChB,† Gautam Chakrabarty, FRCS,* and Graham Radcliffe, FRCS†

However, significantly less patients had graft site pain 1 year after surgery in the QTB group (OR = 0.10; CI = 0.02-0.43; Z = 3.12, P = 0.002). Similarly, fewer patients reported moderate to severe pain while kneeling, in the QTB group (OR = 0.16; CI = 0.07-0.37; Z = 4.26, $P < 0.001$). **Conclusions:** This study demonstrates comparable survival rates and joint stability when BPTB and QTB grafts are used. However, fewer adverse donor site symptoms are evident with QTB grafts. **Level of Evidence:** III.

Key Words: anterior cruciate ligament, ACL, reconstruction, bone-patellar tendon bone, quadriceps tendon-bone

(*Clin J Sport Med* 2018;28:316–324)

Systematic Review

Quadriceps Tendon Autograft in Anterior Cruciate Ligament Reconstruction: A Systematic Review

Eoghan T. Hurley, Manuel Calvo-Gurry, Dan Withers, F.F.S.E.M., F.R.C.S. (Tr & Orth), Shane K. Farrington, B.Sc., Ray Moran, M.Ch., F.F.S.E.M., F.R.C.S.I. (Tr & Orth), and Cathal J. Moran, M.D., F.R.C.S.I. (Tr & Orth)

than BPTB, and another study found increased stability compared with HT. One study found that QT resulted in improved functional outcomes compared with BPTB, and another found improved outcomes compared with HT, but one study found worse outcomes compared with BPTB. **Conclusions:** Current literature suggests QT is a viable option in anterior cruciate ligament reconstruction, with published literature showing comparable knee stability, functional outcomes, donor-site morbidity, and rerupture rates compared with BPTB and HT. **Level of Evidence:** Level III, systematic review of Level I, II, and III studies.

Arthroscopy: The Journal of Arthroscopic and Related Surgery, Vol 34, No 5 (May), 2018: pp 1690-1698

Galan *et al. Journal of Experimental Orthopaedics* (2020) 7:13
https://doi.org/10.1186/s40634-020-00226-w

Journal of
Experimental Orthopaedics

RESEARCH Open Access

All inside full thickness quadriceps tendon ACL reconstruction: Long term follow up results

Hernan Galan, Mateo Escalante, Franco Della Vedova and Daniel Slullitel*

ment as high as 5 mm. Range of motion of the knee was normal in 87% of patients.

Loss of extension
Quad Strenght

Contents lists available at ScienceDirect

Journal of ISAKOS

journal homepage: www.elsevier.com/locate/jisakos

State of the Art Review

Quadriceps tendon autograft for anterior cruciate ligament reconstruction: state of the art

Bryce Clinger, MD [a], John Xerogeanes, MD [b], Julian Feller, MD [c], Christian Fink, MD [d], Armin Runer, MD [e], Dustin Richter, MD [a], Daniel Wascher, MD [a,*]

[a] Department of Orthopaedics and Rehabilitation, University of New Mexico, Albuquerque, NM, 87131, USA
[b] Department of Orthopaedics, Emory University, Atlanta, GA, 30322, USA
[c] OrthoSport Victoria, Melbourne, 3121, Australia
[d] Gelenkpunkt, Innsbruck, 6020, Austria
[e] Department of Orthopaedics and Traumatology, Medical University of Innsbruck, Innsbruck, 6020, Austria

properties that are equal or possibly better than other autografts. The QT can be harvested as a full thickness or partial thickness graft and with or without a bone plug. These differences in harvest technique don't appear to greatly affect the outcomes. QT harvest can also be done with a minimally invasive technique. Short-term studies suggest that the QT autograft has equal failure rates and patient reported outcomes when compared to BPTB or HT with less donor site morbidity.

Impact of Quadriceps Tendon Graft Thickness on Electromechanical Delay and Neuromuscular Performance After ACL Reconstruction

Rosalia L. Parrino,* MS, PhD, Will Adams,* DC, Michael I. Letter,*† PhD, PA-C, Zachary Ripic,* PhD, Michael G. Baraga,† MD, Lee D. Kaplan,† MD, Tanner Harrah,‡ DO, Julien Tremblay,§ BS, Dylan Luxenburg,§ BS, Joseph Conti,* BS, Thomas M. Best,† MD, PhD, and Joseph F. Signorile,*‖ PhD

Investigation performed at the Laboratory of Neuromuscular Research, Department of Kinesiology and Sports Sciences, University of Miami, Coral Gables, Florida, USA

CONCLUSION

The full-thickness QT graft showed a shorter VM EMD at higher loading, slower RTD, and lower PT across all testing speeds when compared with the partial-thickness graft. The invasive nature and the results for EMD, PT, and RTD of full-thickness QT harvest versus partial thickness should be considered when employing QT graft for ACLR.

Let s go Partial !!

Let s go Partial ?

Original Research

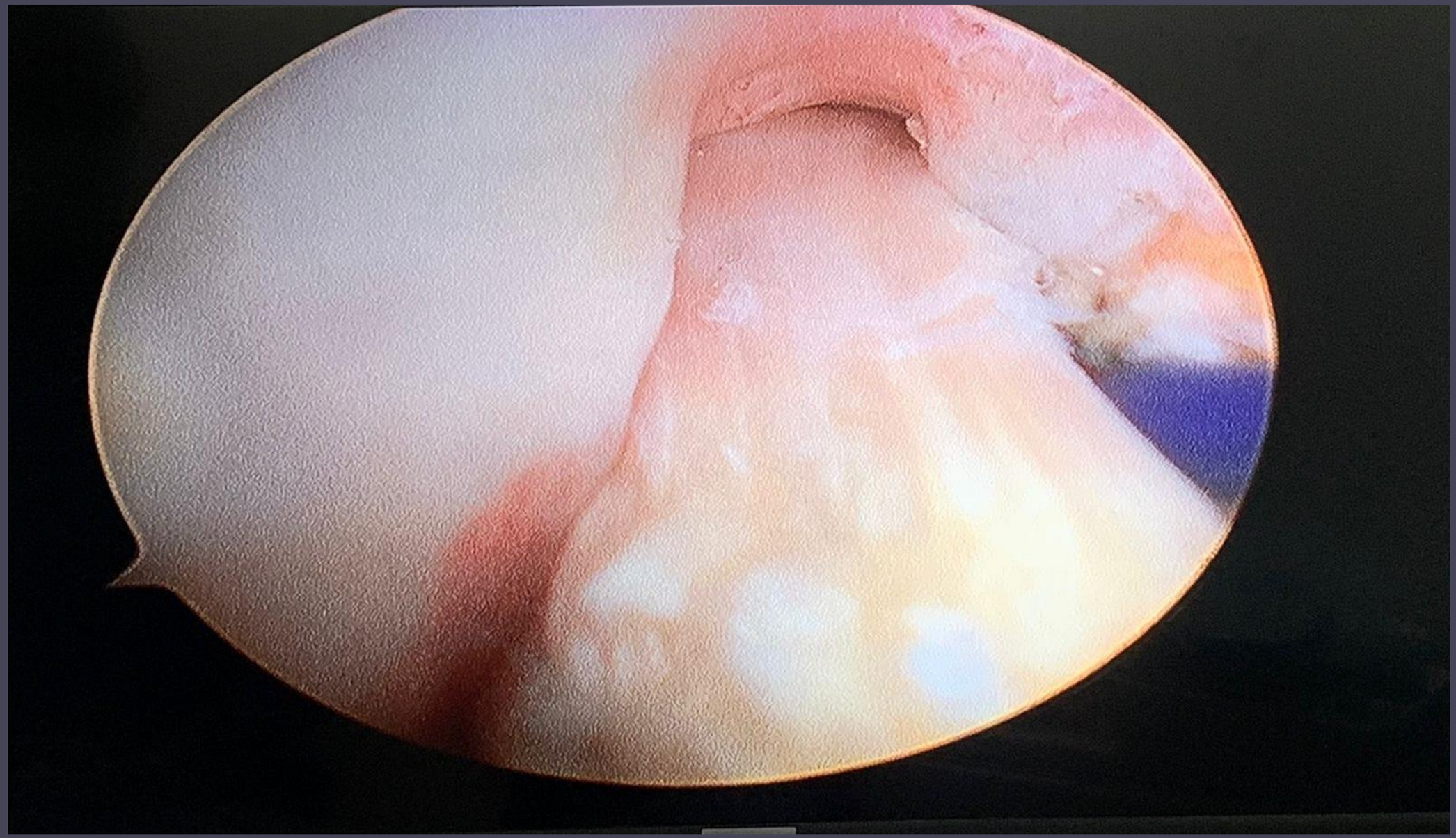
Risk Factors for Manipulation Under Anesthesia and/or Lysis of Adhesions After Anterior Cruciate Ligament Reconstruction

Joel Huleatt,* MD, Michael Gottschalk,* MD, Kelsey Fraser,* ATC, OTC, Allison Boden,* MD, Poonam Dalwadi,* BS, John Xerogeanes,* MD, and Kyle Hammond,*† MD

Investigation performed at the Department of Orthopaedic Surgery, Emory University School of Medicine, Atlanta, Georgia, USA

compared with a hamstring autograft,[4] this graft has also shown to be stiffer, with increased collagen quantity compared with an equivalently sized patellar tendon graft.[9,19] We surmise that this may increase the risk for arthrofibrosis.

The Orthopaedic Journal of Sports Medicine, 6(9), 2325967118794490
DOI: 10.1177/2325967118794490



Let s not go Partial !!

KNEE

Full thickness quadriceps tendon grafts with bone had similar material properties to bone-patellar tendon-bone and a four-strand semitendinosus grafts: a biomechanical study

Marc J. Strauss[1,2,3] · Jon W. Miles[1] · Mitchell L. Kennedy[1] · Grant J. Dornan[1] · Gilbert Moatshe[2,3] · Martin Lind[5] · Lars Engebretsen[2,3] · Robert F. LaPrade[4]

Received: 10 March 2021 / Accep

Therefore, a FT QT graft with bone, BTB, or a 4-SST graft should be considered for ACLR over FT QT without bone as well as PT QT in order to best restore native ACL material properties. Additionally, harvesting of grafts with a bone plug should be considered when trying to maximize

loads to BTB grafts ($p < 0.005$) a

Conclusions Full thickness QT grafts with bone had similar material properties to BTB and a 4-SST grafts, while Partial thickness QT graft without bone had significantly lower material properties than BTB and 4-SST, in a biomechanical setting.

Let s go with bone !!

Review

Adverse Events and Complications After Primary ACL Reconstruction With Quadriceps Tendon Autograft

A Systematic Review

Garrett R. Jackson,* MD, Enzo S. Mameri,*†‡ MD, Trevor Tuthill,* BS, Morgan Wessels,* BS, Shaan Asif,* BS, Joan Sugrañes,*§ MD, Anjay K. Batra,* BS, Johnathon R. McCormick,* MD, Obianuju A. Obioha,* MD, Daniel J. Kaplan,* MD, Derrick M. Knapik,‖ MD, Nikhil N. Verma,* MD, and Jorge Chahla,*¶ MD, PhD
Investigation performed at Rush University Medical Center, Chicago, Illinois, USA

Background: Anterior cruciate ligament reconstruction (ACLR) surgery with quadriceps tendon (QT) grafts, both with and without a patellar bone plug, have gained popularity in recent years in the primary and revision settings. Postoperative complications occur with the use of QT autografts.

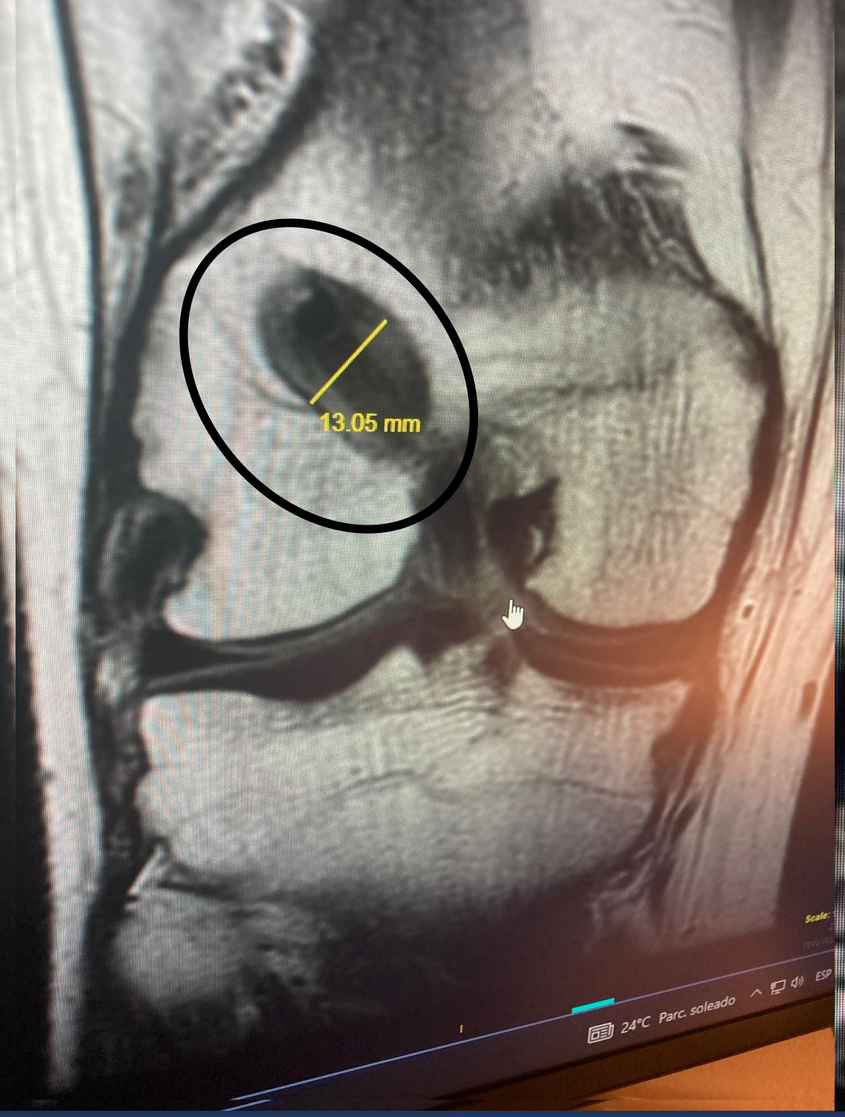
Purpose: To systematically review the incidence of postoperative complications after primary ACLR QT autograft and compare complication rates in patients undergoing all-soft tissue QT grafts versus QT grafts with a patellar bone plug (QTPB).

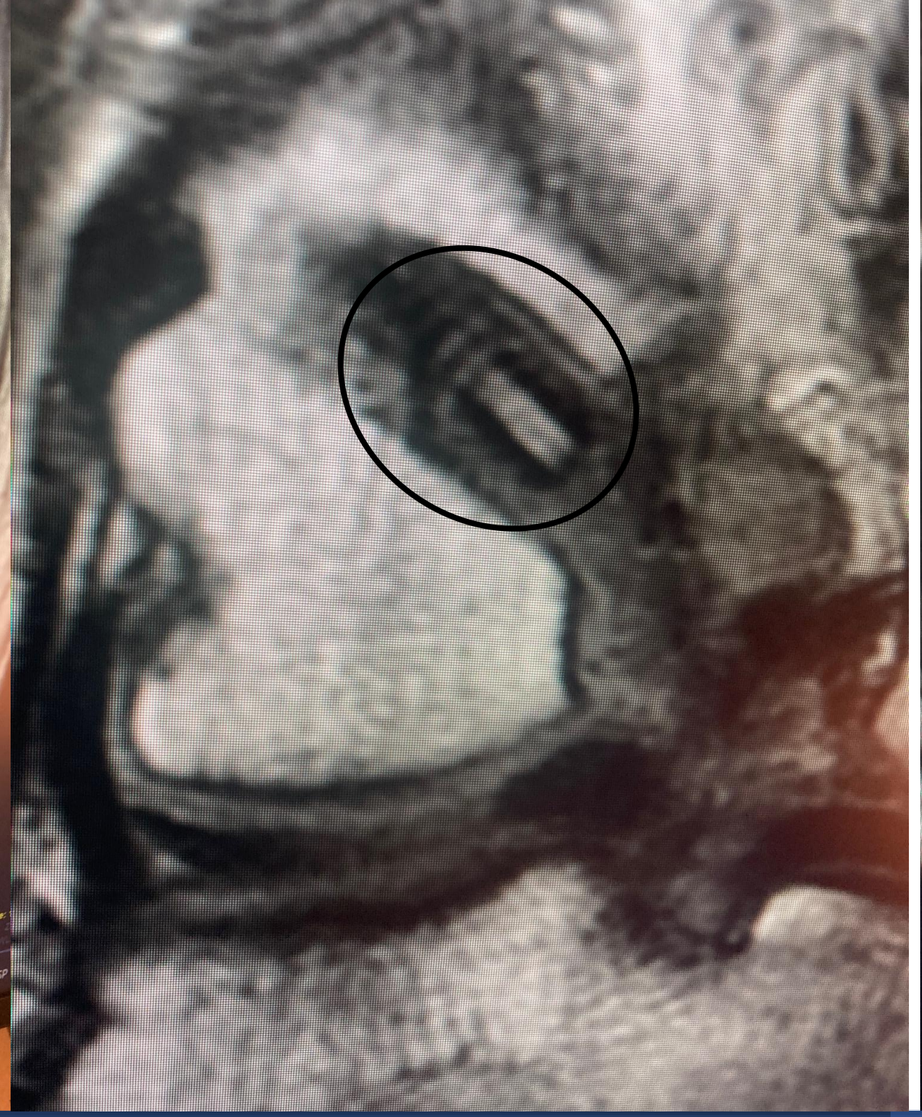
deficit, particularly in female patients. A possible explanation behind the increased anterior pain rate found in all-soft tissue QT versus QTPB is the potential for more aggressive and more proximal dissection of the quadriceps in all-soft tissue graft harvest, in an effort to maximize graft length, which may lead to decreased extensor mecha-

2.7 times


E-posters


Plasma Rico en Pla
¿Qué, donde, como

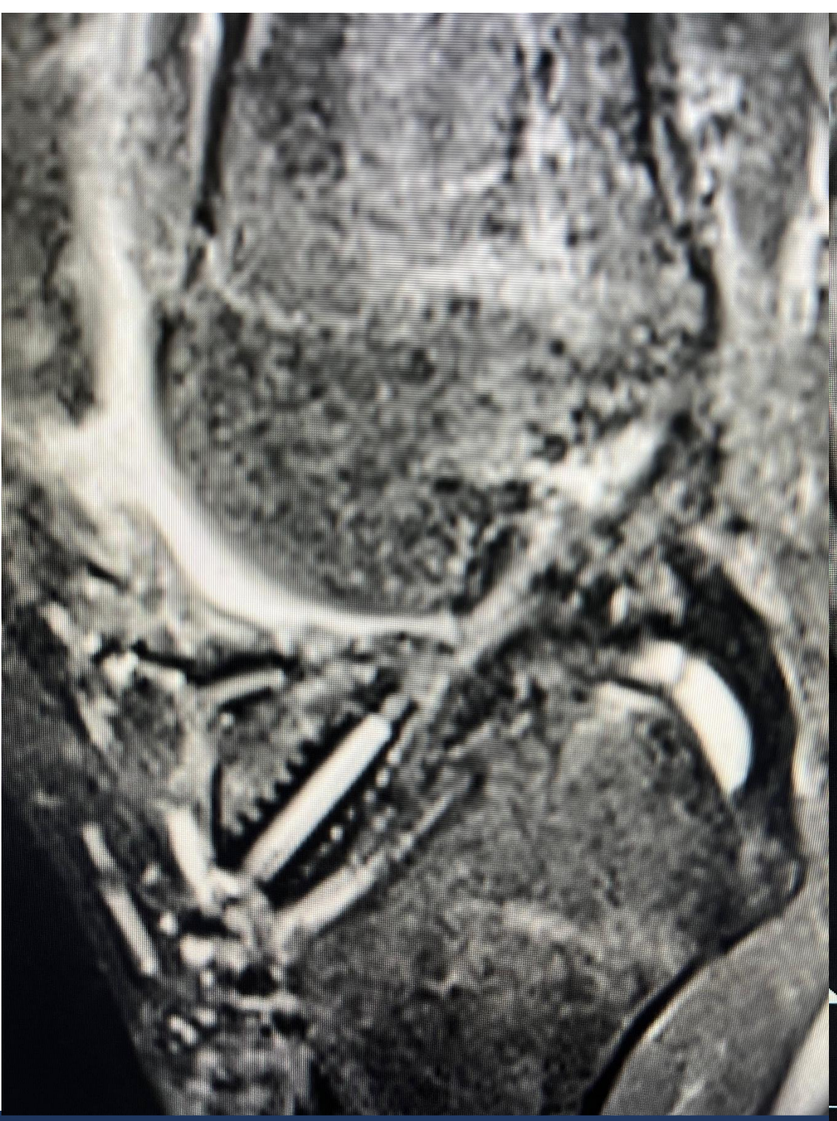




Cortical Fix T

Screw T

BONE T



Screw Anterog

Screw Ret Bone

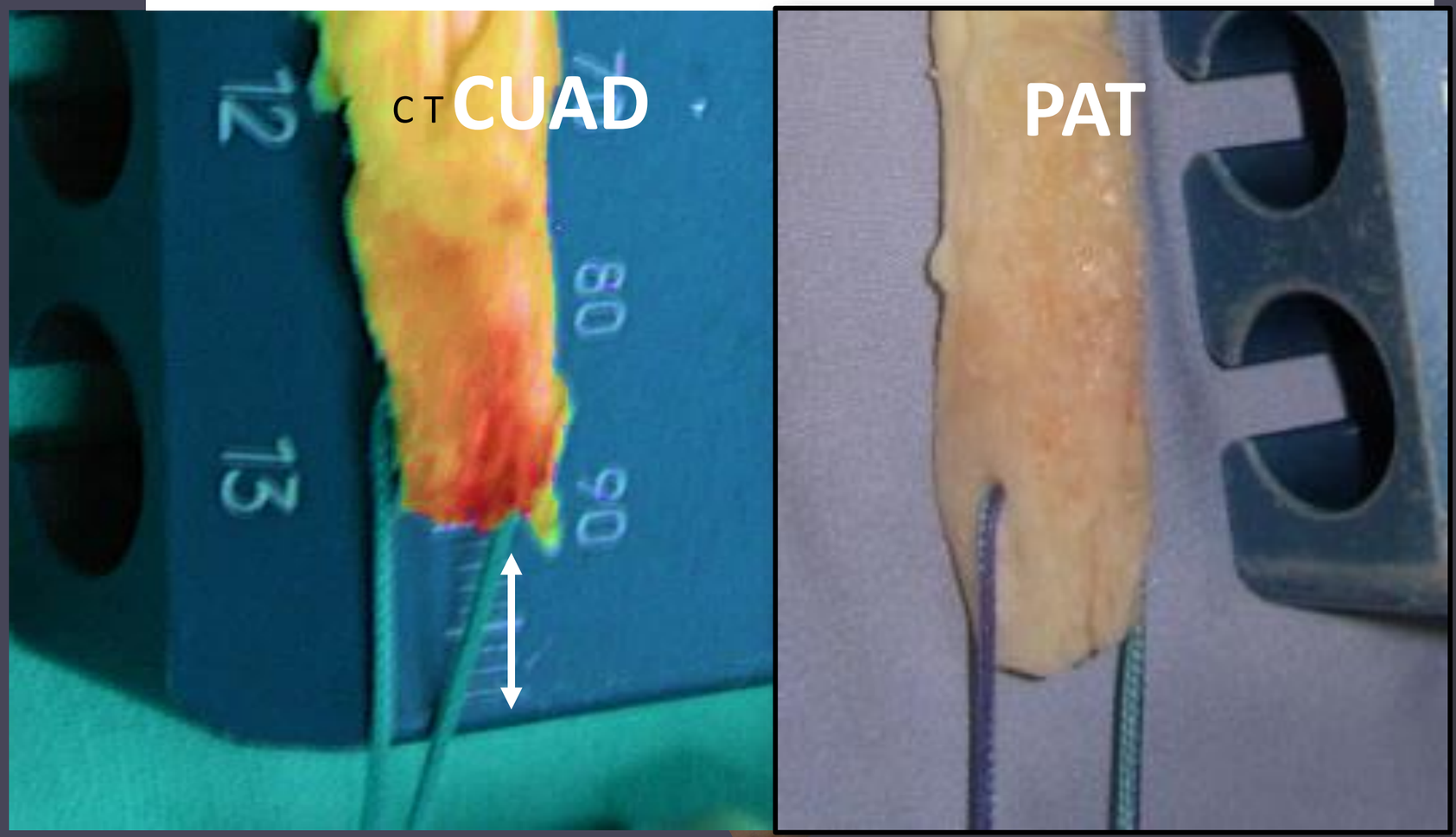
Cortical Fix T

Simply the best !
But the golden one will give more difference

Son todos los 10 mm = ?

Son todos los 10 mm = ?

• *TENDON-HUESO*



FIJACIONES !!!!

Preten

Original Research

Association of Lateral Extra-Articular Tenodesis With Improved Graft Maturity on MRI 2 Years After ACL Reconstruction With Quadriceps Tendon Autograft in Skeletally Immature Athletes

Julia S. Retzky,* MD, Danielle E. Chipman,* BS, Douglas N. Mintz,* MD, Frank A. Cordasco,* MD, MS, and Daniel W. Green,*† MD, MS
Investigation performed at the Hospital for Special Surgery, New York, New York, USA

Results: Overall, 29 patients were included in the study: 16 patients in the ACLR+LET group and 13 patients in the ACLR-only group. There were no significant differences in SIR values between groups at the 6-month or 1-year postoperative timepoints. At 2 years postoperatively, the median SIR of the ACLR+LET group was significantly lower than that of the ACLR-only group on both univariate (1.33 vs 1.86, respectively, $P = .0012$) and multivariate regression analyses adjusting for both sex and surgical technique ($\beta = -0.49$ [95% CI, -0.91 to -0.05]; $P = .029$). There were no cases of reoperation for physeal disturbance in patients who underwent ACLR+LET.

Conclusion: The addition of LET to an ACLR with QTA was associated with lower average SIR values and thus improved graft maturity at 2 years postoperatively compared with ACLR alone in skeletally immature patients. The addition of LET to an ACLR was found to be safe in skeletally immature patients.

The Orthopaedic Journal of Sports Medicine, 12(1), 23259671231211885
DOI: 10.1177/23259671231211885

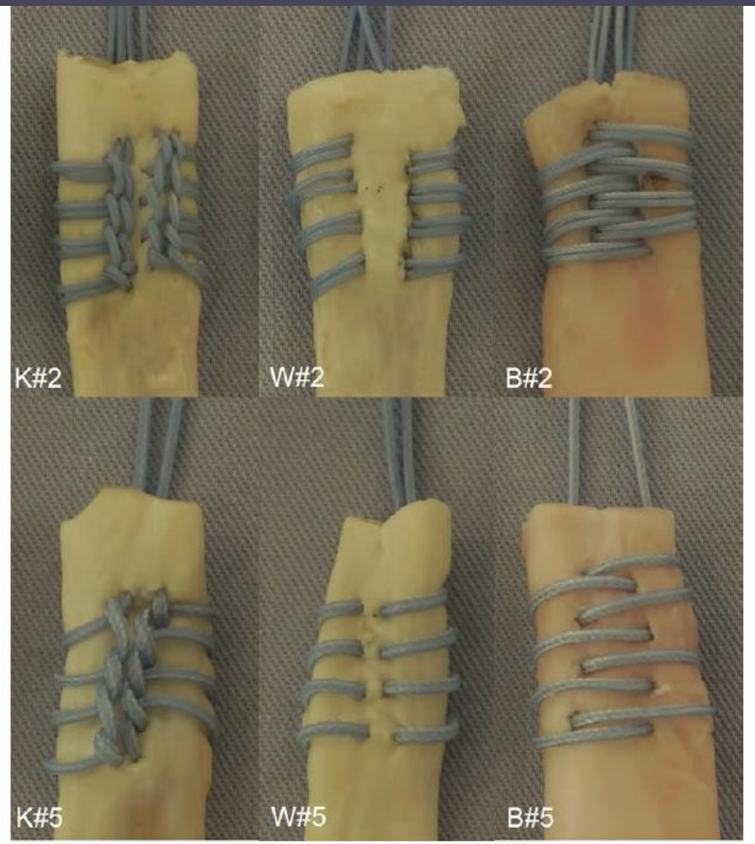


Fig 1. Demonstration of the different fixation techniques using porcine Achilles tendons. (#2, 2× no. 2; #5, 1× no. 5 braided composite suture; B, baseball stitch; K, Krackow locking stitch; W, whipstitch.)

applied preload. It is not surprising that a preload of 5 N for 1 minute[15] results in higher values for elongation compared with 3 pretensioning cycles with 100 N.[26] At present, there is no uniform recommendation of how much preload best reflects the pretensioning of the graft by the surgeon. The excellent clinical results with

Soft Tissue Fixation Strategies of Human Quadriceps Tendon Grafts: A Biomechanical Study

Philipp A. Michel, M.D., M.Sc., Christoph Domnick, M.D., Michael J. Raschke, M.D., Christoph Kittl, M.D., Johannes Glasbrenner, M.D., Lucas Deitermann, M.D., Christian Fink, M.D., and Mirco Herbort, M.D.

Purpose: To evaluate the effects of different stitching methods and suture diameters on the graft fixation of soft tissue human quadriceps tendon grafts for anterior cruciate ligament (ACL) reconstruction. **Methods:** The Krackow locking stitch (K), whipstitch (W), and baseball stitch (B) were combined with either a 2× no. 2 (#2) or a 1× no. 5 (#5) braided composite suture for graft fixation of 36 human quadriceps tendons in 6 groups. Biomechanical testing was performed using a cyclic protocol with loads between 0 and 100 N. The maximum load until failure, cyclic elongation, and failure mode were recorded. **Results:** The highest mean maximum load to failure was observed in the 2 Krackow stitch groups. The K#2 group had significantly higher load to failure values compared with those of the W#2 and B#2 groups (K#2, 553 ± 82 N vs W#2, 392 ± 107 N, $P = .0349$; K#2 vs B#2 366 ± 118 N, $P = .0129$). The mean cyclic elongation was lowest in the Krackow groups (K#2, 10.59 ± 2.63 mm; K#5, 13.66 ± 2.3 mm). The regular failure mode was the rupture of the suture for the Krackow stitch (8 of 12) and suture pullout for the whipstitch (11 of 12) and baseball stitch groups (12 of 12). **Conclusions:** The double Krackow stitch with no. 2 braided composite suture exhibits a high maximum load to failure combined with a low amount of elongation in a biomechanical study for human quadriceps tendon soft tissue graft fixation. Unlike the whipstitch and the baseball stitch, it can solidly prevent suture pullout. **Clinical Relevance:** A safe soft tissue graft fixation technique is especially important for quadriceps tendon grafts with their laminar anatomical structure and physiologically varying diameter. Unlike other grafts for ACL replacement, it fully relies on the soft tissue suture fixation to resist the pullout force.

See commentary on page 3077

Conclusions

The double Krackow stitch with no. 2 braided composite suture exhibits a high maximum load to failure combined with a low amount of elongation in a biomechanical study for human QT soft tissue graft fixation. Unlike the whipstitch and the baseball stitch, it can solidly prevent suture pullout.

DEBILIDAD DEL CUADRICEPS

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

Results In total, 18 studies met the inclusion criteria. Knee strength outcomes of 952 QT ACL reconstructions were included and compared to either the contralateral limb or 1 of 4 alternative ACL graft types; 245 hamstring tendon autograft (HT), 143 patellar tendon autograft (PT), 45 quadriceps tendon allograft, and 21 tibialis anterior allograft. Knee extensor strength LSI following QT ACL reconstruction did not reach 90% even at 24 months post-operatively. Conversely, knee flexor strength LSI following QT ACL reconstruction exceeded 90% at the 9–15 months post-operative period. Knee extensor strength at 5–8 months following QT ACL reconstruction appears similar to PT but weaker than HT ACL reconstruction. In addition, peak knee flexor LSI was significantly greater at 5–8 months in QT ACL reconstruction patients compared to HT patients.
Conclusion The decision to utilize a QT graft for ACL reconstruction should include consideration of strength outcomes. Knee extensor strength recovery following QT ACL reconstruction appears not to be restored before 24 months.
Level of evidence Level IV

Arthrogenic Muscle Inhibition Following Knee Injury or Surgery: Pathophysiology, Classification, and Treatment

Bertrand Sonnery-Cottet,*† MD, Graeme P. Hopper,*† MD, FRCS (Tr & Orth), Lampros Gousopoulos,*† MD, Thais Dutra Vieira,*†‡ MD, Mathieu Thaunat,*† MD, Jean-Marie Fayard,*† MD, Benjamin Freychet,*† MD, Hervé Ouanezar,§ MD, Etienne Cavaignac,‖ MD, and Adnan Saithna,¶ MD

Investigation performed at Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Groupe Ramsay-Générale de Santé, Hopital Privé Jean Mermoz, Lyon, France

- **Grade 0** — Normal VMO contraction
- **Grade 1** – VMO contraction inhibited with no knee extension deficit
  - **1a** - Activation failure reversible within a few minutes of commencing simple active-assisted extension exercises
  - **1b** - Refractory to simple active-assisted extension exercises, requiring longer and specific rehabilitation programs
- **Grade 2** – VMO contraction inhibited with associated knee extension deficit due to hamstring contracture
  - **2a** - Activation failure and loss of motion reversible within a few minutes of fatiguing the hamstrings and commencing simple active-assisted extension exercises
  - **2b** - Refractory to fatiguing of the hamstrings and/or simple active-assisted extension exercises therefore longer and specific rehabilitation programs required
- **Grade 3** – Passive chronic extension deficit due to posterior capsular retraction
  - Extensive posterior arthrolysis mandatory with specific preoperative and postoperative rehabilitation programs

GRADO 1 VMO inhibido sin Perdida de extension

GRADO 2 VMO inhibido con Perdida de extension por contractura de isquiosurales

GRADO 3 Rigidez plano posterior

Biomechanical Comparison of Quadriceps and Patellar Tendon Grafts in Anterior Cruciate Ligament Reconstruction

Raj H. Shani, M.D., Erica Umpierez, M.D., Michael Nasert, B.A., Elise A. Hiza, M.D., and John Xerogeanes, M.D.

Results

Failure Mode

In the QT group, 5 of the 12 specimens failed at the midsubstance whereas 7 failed at the distal patellar insertion site. In the BPTB group, 7 of the 11 specimens failed at the midsubstance, 3 tore at the distal insertion site, and 1 tore at the proximal insertion site.

58 %

64%

Arthroscopy: The Journal of Arthroscopic and Related Surgery, Vol 32, No 1 (January), 2016: pp 71-75

Knee Surgery, Sports Traumatology, Arthrosc
https://doi.org/10.1007/s00167-020-05902-z

ESTABILIDAD VS DOLOR POTENCIA

KNEE

Check for updates

Quadriceps tendon anterior cruciate ligament reconstruction

Theresa Diermeier[1,2] · Rob Tisherman[1,2] · Jonathan Hughes[1] · Michael Tulman[3] · Erica Baum Coffey[4] · Christian Fink[5,6] · Andrew Lynch[3,4] · Freddie H. Fu[1] · Volker Musahl[1]

Received: 24 October 2019 / Accepted: 3 February 2020

[26]. Therefore, with regard to rehabilitation and return to sport a partial thickness graft may be more beneficial. With focus on soccer a partial thickness QT ACL reconstruction is recommended, followed by a staged progressive rehabilitation including training with a ball as early in the rehabilitation process as possible to optimize outcomes in top-level athletes.

Primary ACLR with QT Graft in Females shows Equivalent Graft Failure, but Lower Activity Scores and Slower Quadriceps Strength Recovery as compared to Males: A Systematic Review and Meta-Analysis.

Shahbaz Malik

BSc (Hons), MB BCh, MSc (Orth Engin), LLM, FRCS (Tr&Orth)

Consultant Orthopaedic Surgeon

Clinical Service Lead Countywide Trauma

Worcestershire Acute Hospitals NHS Trust, UK

Education Training Programme Director, Health Education West Midlands, UK

Co-authors & Disclosure

Anirudh Sharma, UK
Muaaz Tahir, UK
Osama Aweid, UK
Tarek Boutefnouchet, UK
Tamer Swee, UK
Amit Meena, India
Darren De SA, Canada
Rachel M. Frank, USA
Peter D. Alessandro, Australia

The authors have no disclosures relevant to this study.

Introduction

- Sex-specific differences following ACLR are recognized.
- Higher risk of poorer outcomes in females *(MOON cohort AJSM 2018)* –
  - emphasis on improving outcomes in female patients
- Current evidence on outcomes in females is based mainly on data from hamstring and BPTB grafts *(Tiplady et al NZ Registry Cohort, AJSM 2023)*
- QT ACLR is gaining popularity – 'graft of the future' *(Xerogeanes, Arthroscopy 2019)* but limited data reporting in females!

Purpose

To assess the outcomes of ACLR with a QT autograft

- specifically in females, and
- elucidate any sex-specific outcome differences with males.

Methods

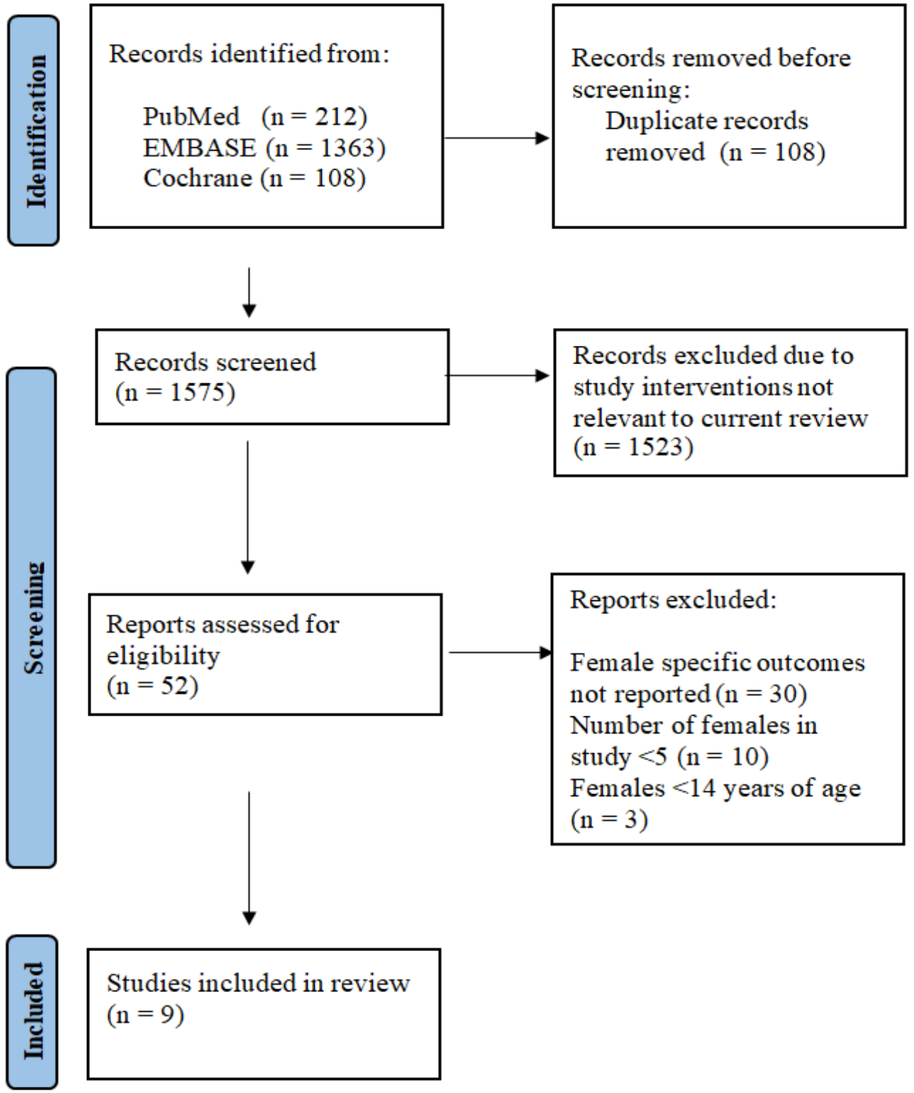
- Literature search undertaken as per PRISMA guidelines on **four** databases
  - PubMed/MEDLINE // EMBASE // Cochrane // Google Scholar

- Registered on PROSPERO database – CRD42024613583

- Studies reporting sex-specific outcomes with primary quadriceps ACL reconstruction in females (age > 14 years) included

- Exclusions
  - Revision ACL data
  - Sex-specific outcomes not reported
  - Studies prior to 2004

PRISMA flowchart



Methods

- Data collected under 3 main categories:

PROMS	Objective Functional Outcomes	Complications
• Lysholm Score • Tegner Activity Scale • IKDC score • ACL-RSI scale	• Instrumented laxity, • Extension loss, • Quadriceps strength LSI • Return to sport	• Graft failures/re-tears • Contralateral ACL tears

- Meta-analysis performed to compare outcomes with males where data available

Results

- A total of **714** primary QT ACLRs in females included

- Mean age 23.0 (14-58) years
- Mean follow-up 38.9 months (6-139 months)

- **Cumulative graft failure rate 7.4%** (vs 8.8% in males)
- **Contralateral ACL tear rate 9.1%**

Outcomes in females

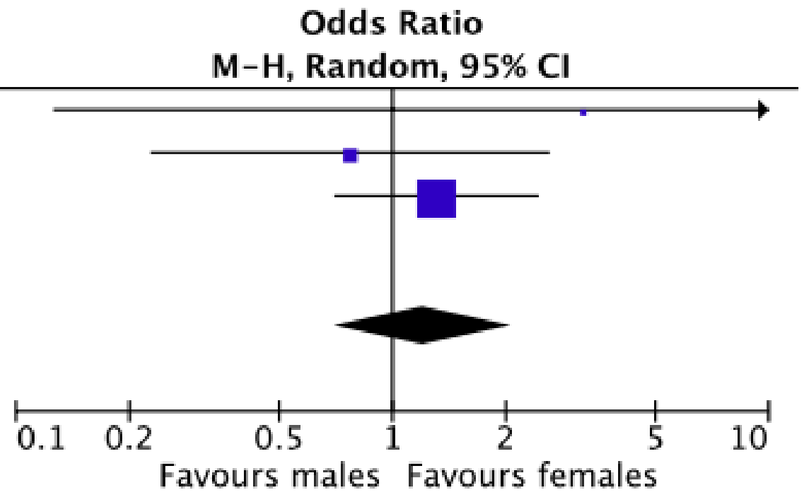
Parameter (n)	Follow-up range (months)	Pooled Mean (range)
IKDC (58)	24-53	89.5 (88.8-91.6)
Lysholm (134)	24	85.4 (82-92.9)
Tegner (129)	24-53	6.09 (5.7-8.2)
ACL-RSI (98)	9-24	67.1 (65.3-69.5)
Extension loss (193)	24-58.3	0.07 (-0.22-0.58)
Quadriceps Strength LSI (266)	6-24	6m - 63.9% 24m – 88.3%
Instrumented laxity (201)	6-24	6m – 0.96mm (0-5) 24m – 1mm (0-3.5)
Return to Sport (229)	24-139	82% (71.4-82.7%)

Re-tear Rate in Males vs Females at 24m or more

Study or Subgroup	Males Events	Males Total	Females Events	Females Total	Weight	Odds Ratio M-H, Random, 95% CI
Ebert et al	1	28	0	29	2.9%	3.22 [0.13, 82.38]
Geib et al	5	102	6	96	20.3%	0.77 [0.23, 2.62]
Petit et al	22	174	22	221	76.8%	1.31 [0.70, 2.45]
Renfree et al	0	13	0	19		Not estimable
Total (95% CI)		**317**		**365**	**100.0%**	**1.21 [0.70, 2.09]**
Total events	28		28			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.93$, $df = 2$ ($P = 0.63$); $I^2 = 0\%$

Test for overall effect: $Z = 0.67$ ($P = 0.50$)



No difference in QT re-tear rates between males and females at >24 months follow-up

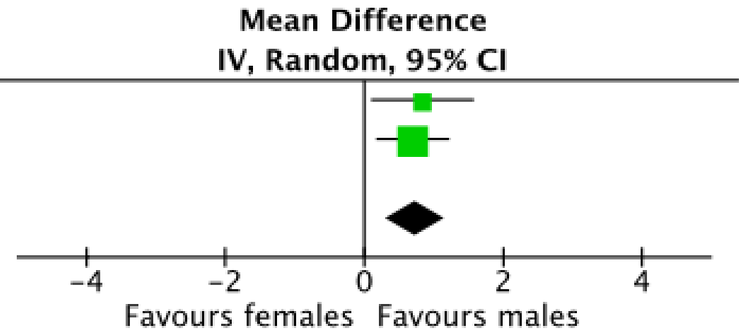
Worcestershire Acute Hospitals NHS Trust

Tegner Activity Score in Males vs Females at 24 months

Study or Subgroup	Males Mean	Males SD	Males Total	Females Mean	Females SD	Females Total	Weight	Mean Difference IV, Random, 95% CI
Ebert et al	7.14	1.4	23	6.3	1.3	29	33.7%	0.84 [0.10, 1.58]
Runer et al	6.4	1.9	127	5.7	2	90	66.3%	0.70 [0.17, 1.23]
Total (95% CI)			**150**			**119**	**100.0%**	**0.75 [0.32, 1.18]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.09$, df = 1 (P = 0.76); $I^2 = 0\%$

Test for overall effect: Z = 3.40 (P = 0.0007)



- Males showed higher Tegner Activity Scores (p = 0.0007) at 24 months follow-up
  - *Difference in Tegner Score in both studies was less than 1 point (less than MCID for Tegner Score)*

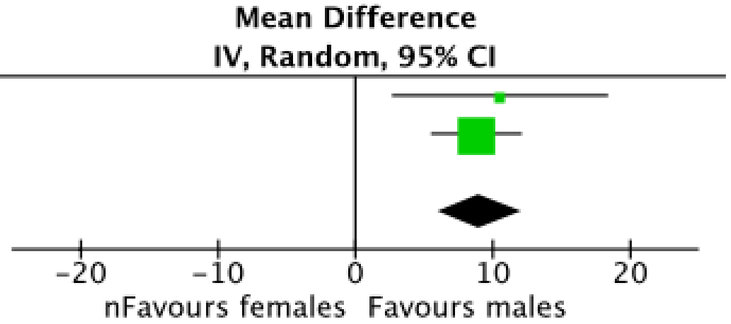
Worcestershire Acute Hospitals NHS Trust

Quadriceps Strength LSI in Males vs Females at 6 months Post-op

Study or Subgroup	Males Mean	Males SD	Males Total	Females Mean	Females SD	Females Total	Weight	Mean Difference IV, Random, 95% CI
Ebert et al	67.1	15.9	23	56.6	12.2	29	15.1%	10.50 [2.63, 18.37]
Hunnicutt et al	72.1	14.8	156	63.3	15.5	164	84.9%	8.80 [5.48, 12.12]
Total (95% CI)			**179**			**193**	**100.0%**	**9.06 [6.00, 12.12]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.15$, df = 1 (P = 0.70); $I^2 = 0\%$

Test for overall effect: Z = 5.80 (P < 0.00001)



- Males showed higher quadriceps strength symmetry ($p < 0.001$) at 6 months post-op
- Mean Quadriceps strength LSI in females 63.9% of opposite side at 6-9 months post-op

Worcestershire Acute Hospitals NHS Trust

Comparison of Outcomes in Males v Females - Summary

No difference in:

- failure rates
- return to sport
- instrumented laxity testing
- IKDC and Lysholm scores

Females:

- Slower to gain quadriceps strength symmetry
- Lower Tegner Activity Scale scores at 2 years

NHS
Worcestershire Acute Hospitals NHS Trust

Discussion

- QT grafts overall show equivalent graft survival rates to BPTB in meta-analyses *(Dai et al AJSM 2022, Mourabes et al AJSM 2019)* but female specific data lacking

- Quads LSI lower in females even with BTB and HS grafts *(Schwery et al 2019 Int J Sports Phys Ther)*

- Tegner Activity score lower in females even with other graft types *(Tan et al AJSM 2016)*

- Our review suggests same sex-specific differences seen with QT as with BTB and HS grafts

Discussion

- **Strengths**
  - Thorough review of current evidence to suggest equivalent graft failure between males and females with QT
  - Data on wide range of outcomes (PROMS, instrumented laxity, quads LSI failure rates etc)

- **Limitations**
  - Review limited by lack of sex-disaggregated data reporting with QT graft
  - Heterogeneous female population included (age, activity/sports involvement)

Conclusions

- Primary QT ACLR in females shows similar re-tear and RTS rates as males
- Lower Tegner Activity scores (MCID?) and slower quadriceps strength recovery (also seen with other grafts!)
- Recovery of knee extension and quadriceps strength symmetry require closer monitoring in female patients with QT graft
- Highlights lack of sex-disaggregated data reporting with regards to QT graft
  - future studies should report female-specific data with different graft types

References

- Ebert JR, Calvert ND, Radic R. A Prospective Randomized Controlled Trial Investigating Quadriceps Versus Hamstring Tendon Autograft in Anterior Cruciate Ligament Reconstruction. *Am J Sports Med*. 2024;52(3):660-669. doi:10.1177/03635465231222279
- Geib TM, Shelton WR, Phelps RA, Clark L. Anterior Cruciate Ligament Reconstruction Using Quadriceps Tendon Autograft: Intermediate-Term Outcome. *Arthrosc J Arthrosc Relat Surg*. 2009;25(12):1408-1414. doi:10.1016/j.arthro.2009.06.004
- Goto K, Duthon VB, Menetrey J. Anterior cruciate ligament reconstruction using quadriceps tendon autograft is a viable option for small-statured female patients. *Knee Surg Sports Traumatol Arthrosc*. 2022;30(7):2358-2363. doi:10.1007/s00167-021-06845-9
- Herman ZJ, Benvegnu NA, Dadoo S, et al. Outcomes of bone-patellar tendon-bone autograft and quadriceps tendon autograft for ACL reconstruction in an all-female soccer player cohort with mean 4.8-year follow up. *J ISAKOS*. Published online November 2023:S2059775423005928. doi:10.1016/j.jisako.2023.11.002
- Hunnicutt JL, Xerogeanes JW, Tsai LC, et al. Terminal knee extension deficit and female sex predict poorer quadriceps strength following ACL reconstruction using all-soft tissue quadriceps tendon autografts. *Knee Surg Sports Traumatol Arthrosc*. 2021;29(9):3085-3095. doi:10.1007/s00167-020-06351-4
- Petit CB, Slone HS, Diekfuss JA, et al. Sex-Specific Outcomes After Anterior Cruciate Ligament Reconstruction Using an All–Soft Tissue Quadriceps Tendon Autograft in a Young Active Population. *Am J Sports Med*. 2024;52(10):2450-2455. doi:10.1177/03635465241262018
- Rakauskas R, Šiupšinskas L, Streckis V, et al. Hamstring vs. All-Soft-Tissue Quadriceps Tendon Autograft for Anterior Cruciate Ligament Reconstruction in Adolescent Athletes: Early Follow-Up Results of a Prospective Study. *Appl Sci*. 2023;13(11):6715. doi:10.3390/app13116715
- Renfree SP, Brinkman JC, Tummala SV, Economopoulos KJ. ACL Reconstruction With Quadriceps Soft Tissue Autograft Versus Bone-Patellar Tendon-Bone Autograft in Cutting and Pivoting Athletes: Outcomes at Minimum 2-Year Follow-up. *Orthop J Sports Med*. 2023;11(9):23259671231197400. doi:10.1177/23259671231197400
- Runer A, Csapo R, Hepperger C, Herbort M, Hoser C, Fink C. Anterior Cruciate Ligament Reconstructions With Quadriceps Tendon Autograft Result in Lower Graft Rupture Rates but Similar Patient-Reported Outcomes as Compared With Hamstring Tendon Autograft: A Comparison of 875 Patients. *Am J Sports Med*. 2020;48(9):2195-2204. doi:10.1177/0363546520931829

To: Anirudh Sharma <anirudh_utd@yahoo.co.in>
From: dtilton@ajsm.org
Subject: AMJSPORTS/2024/344129 -- Manuscript Decision
Cc: Muaaz Tahir <muaaz.tahir@doctors.org.uk>, Osama Aweid <oaweid@gmail.com>, Tarek Boutefnouchet <tboutefnouchet@hotmail.com>, Tamer Sweed <tamerano@hotmail.com>, Amit Meena <dr.meenaamit1624@gmail.com>, Darren De SA <darren.desa@medportal.ca>, "Rachel M. Frank" <rachel.frank@cuanschutz.edu>, Peter D'Alessandro <peter@coastalorthopaedics.com.au>, Shahbaz S Malik <shahb.malik@gmail.com>, Anirudh Sharma <anirudh_utd@yahoo.co.in>, dtilton@ajsm.org

AMJSPORTS/2024/344129

MS Title: ACL reconstruction with Quadriceps Tendon Autograft in Females shows

Equivalent Graft Failure, but Lower Activity Scores and Slower Quadriceps Strength

Recovery as compared to Males: A Systematic Review and Meta-Analysis

Dear Dr. Sharma,

Congratulations. Your above-referenced manuscript has been accepted for publication in an upcoming issue of The American Journal of Sports Medicine.

Sex-specific differences in the laminar organization of the quadriceps tendon

Lorenz Pichler [1, 2], Felix Euler-Rolle [1], Jakob Mayerl [1], Thomas Sator [1], Marcus Hofbauer [1], Thomas Tiefenböck [1]

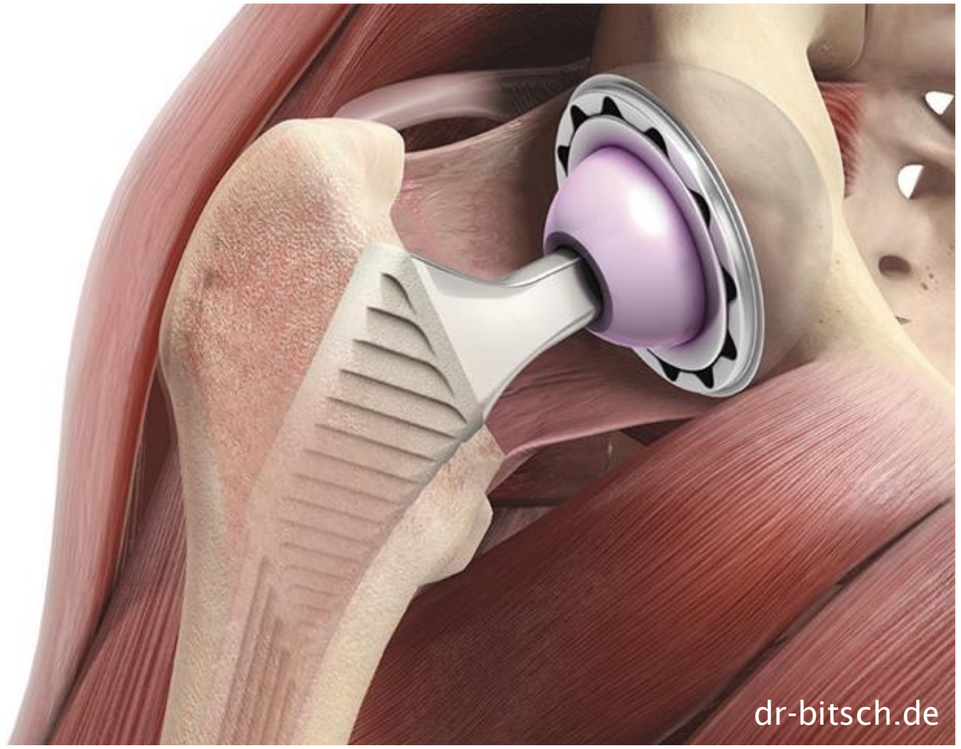
1. Department of Orthopedics and Trauma-Surgery, Medical University of Vienna
2. Center for Musculoskeletal Surgery, Charité – Universitätsmedizin Berlin

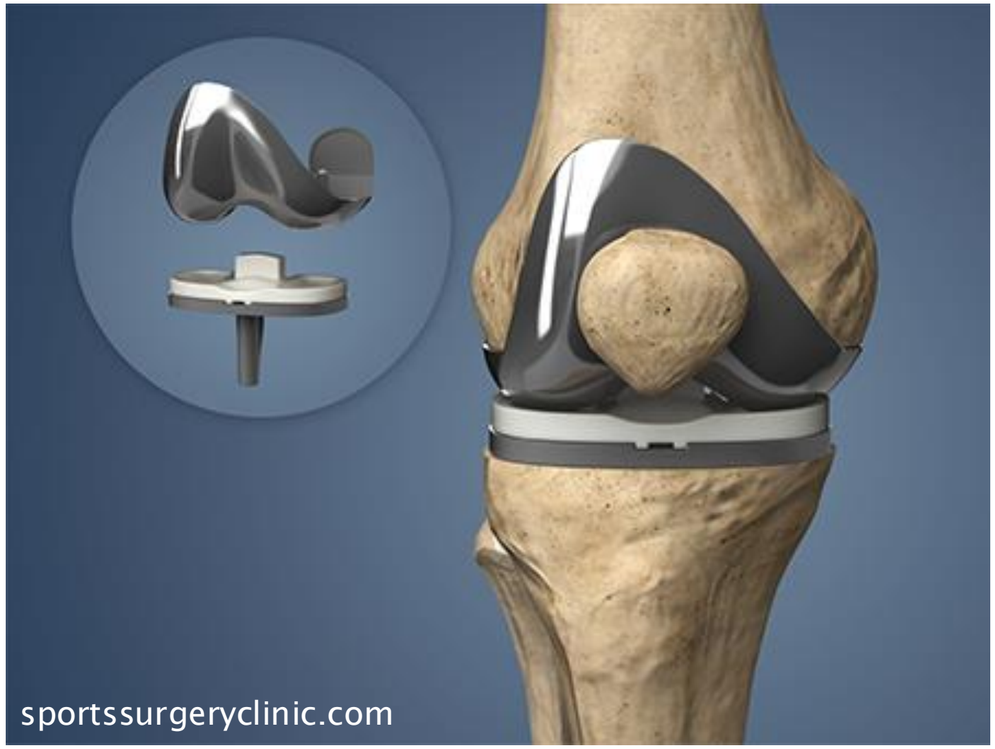
MEDIZINISCHE UNIVERSITÄT WIEN

CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN

No conflict of interest.

Patient-specific treatments in orthopedics





QT-Autograft Techniques

Longitudinal	vs.	Perpendicular incision
Bone block	vs.	All-Soft-Tissue
Full thickness	vs.	Partial thickness

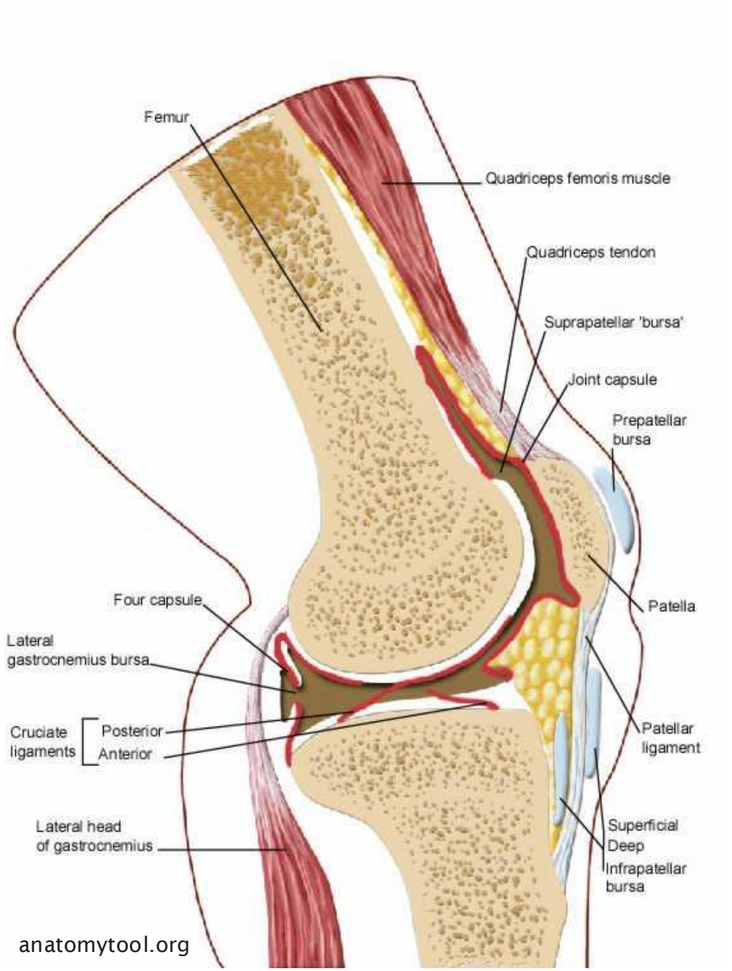
QT-Autograft Techniques

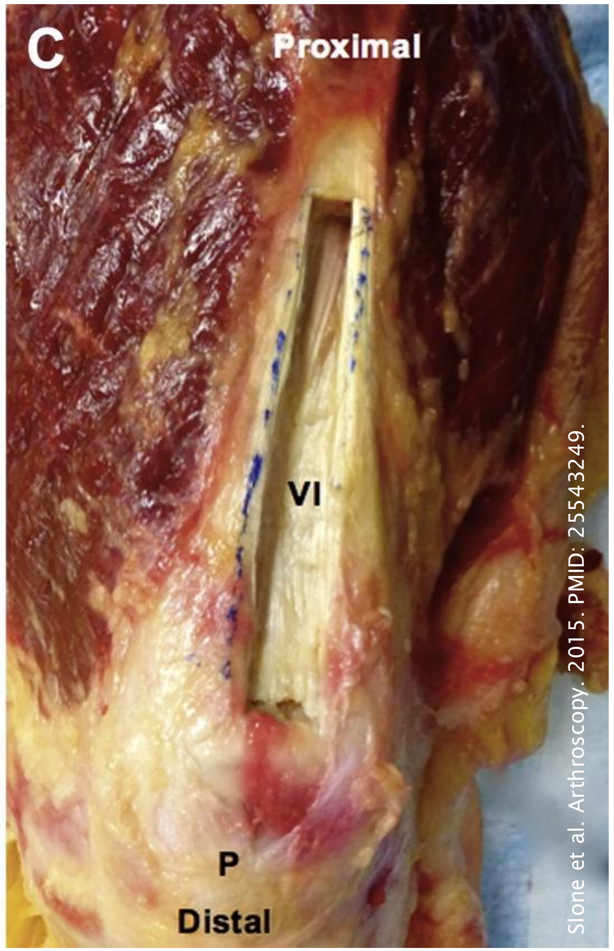
Longitudinal	vs.	Perpendicular incision
Bone block	vs.	All-Soft-Tissue
Full thickness	vs.	Partial thickness

QT-Autograft Techniques

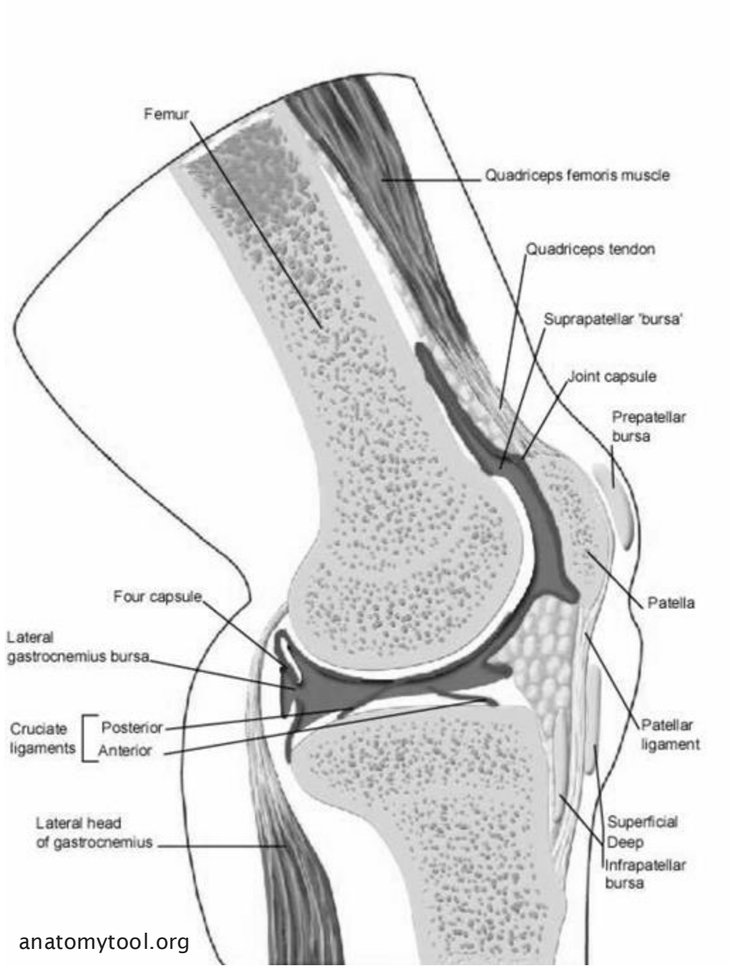
Longitudinal	vs.	Perpendicular incision
Bone block	vs.	All-Soft-Tissue
Full thickness	vs.	Partial thickness

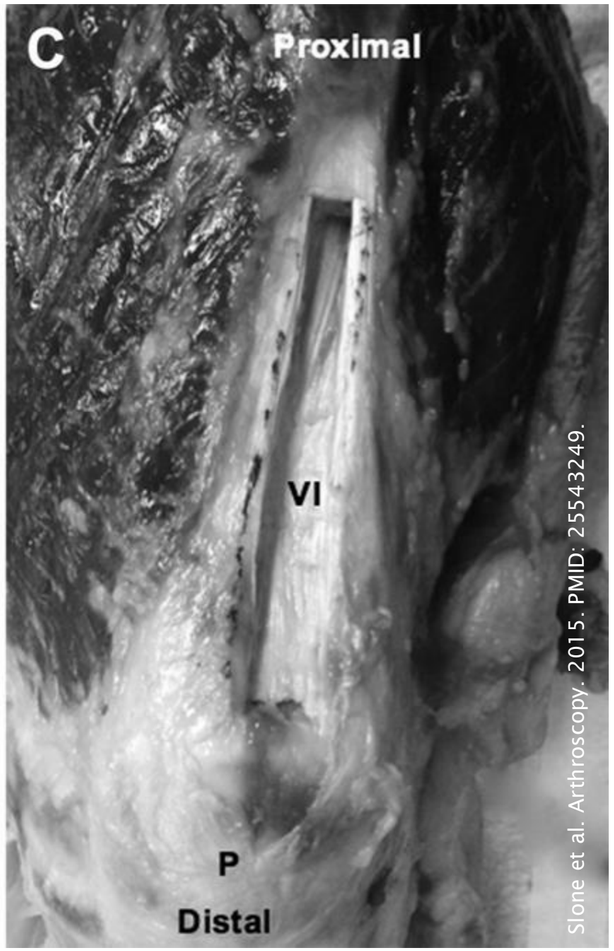
Partial thickness technique

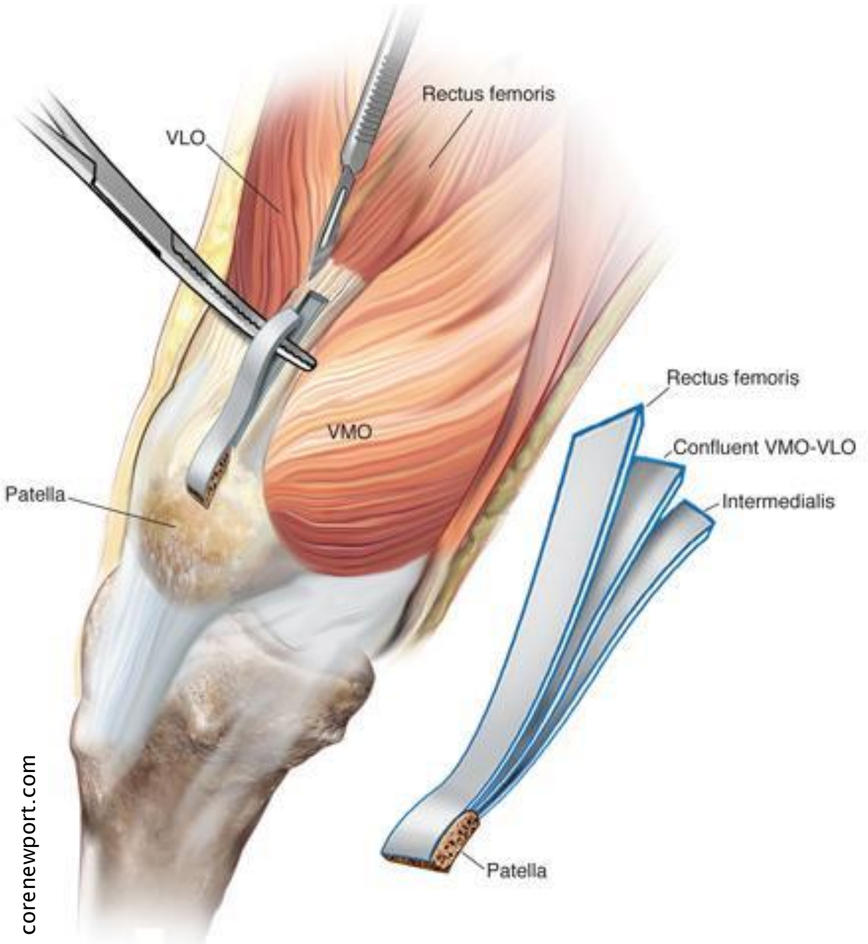




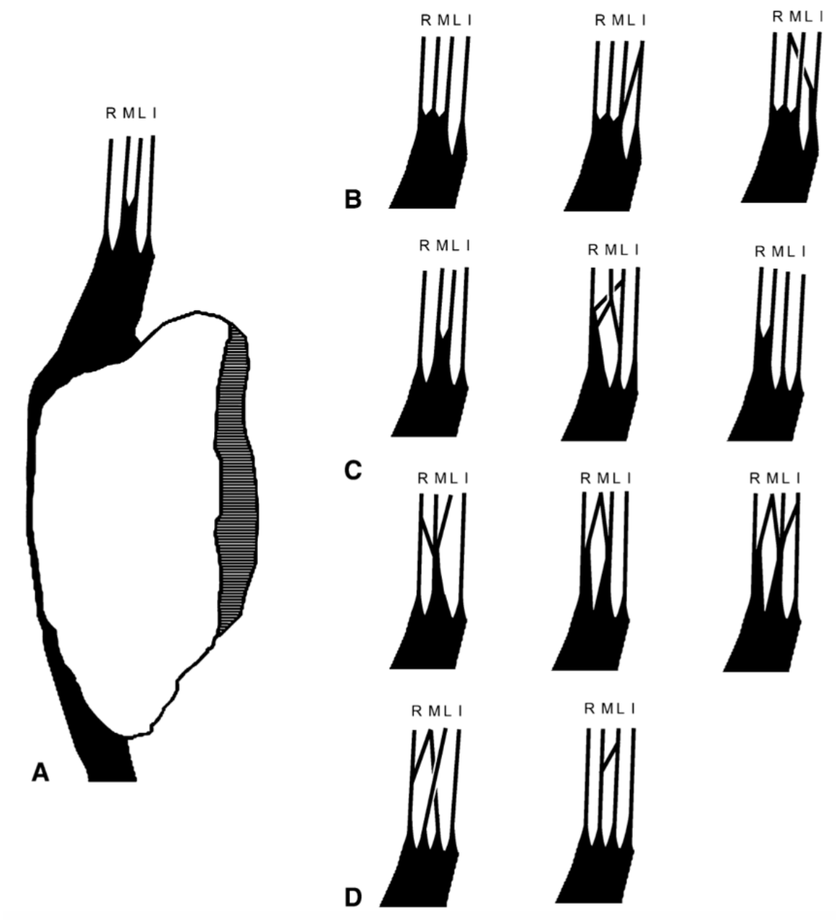
Partial thickness technique







Laminar organization (LO) of the QT



Waligora et al. Clinical anatomy of the quadriceps femoris and extensor apparatus of the knee.CORR. 2009. PMID: 19690926.

"Only three of the 20 specimens exhibited the typically described quadriceps pattern."

Research Questions

1. Can the laminar organization of the QT be measured on standard MRI imaging of the knee and if so, how reliable?

2. Are there significant sex-difference in the laminar organization of the QT?

Methods

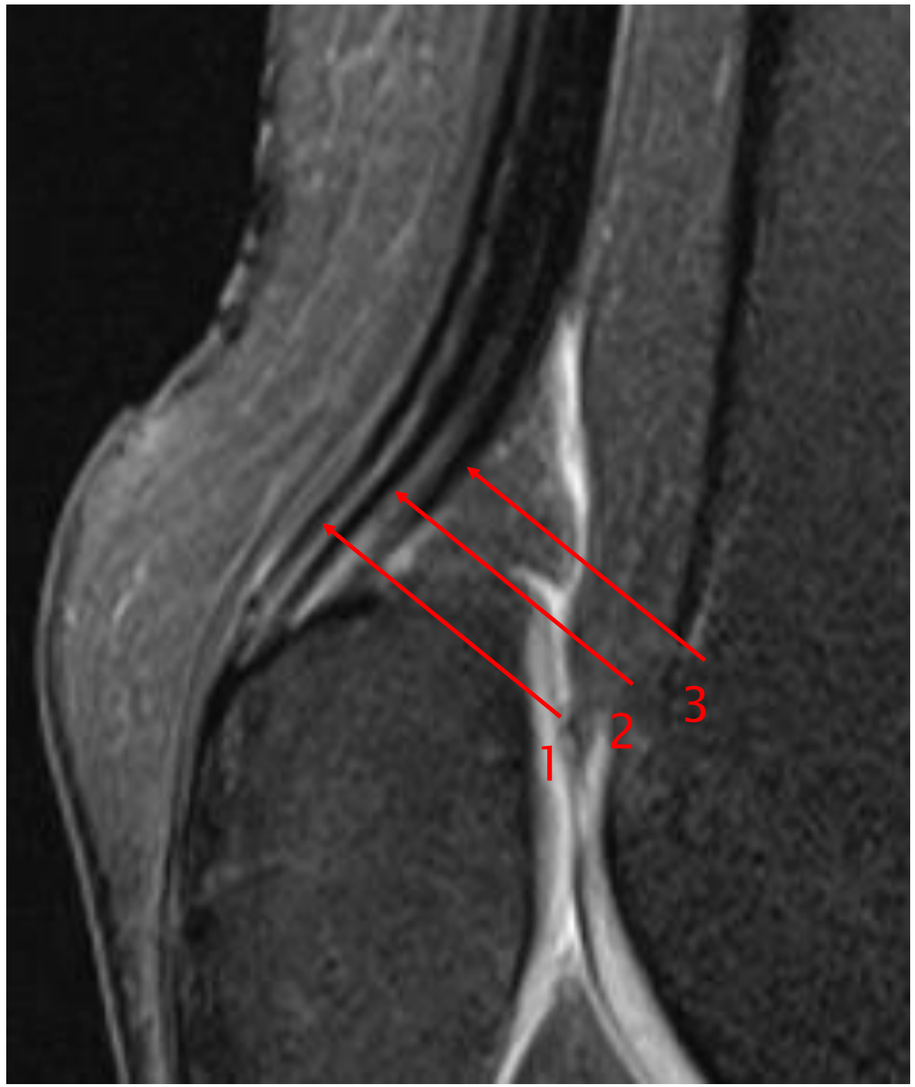
200 MRI images of knees without QT injury form 36 institutes

- 100 female (50 20-29 years, 50 30-40 years)
- 100 male (50 20-29 years, 50 30-40 years)

Measurement of the QT by two observers (F.E. & J.M.) on T2-weighted images according to standardized protocol [1]

1. Zeiss et al. MR imaging of the quadriceps tendon: normal layered configuration and its importance in cases of tendon rupture. AJR Am J Roentgenol. 1992. PMID: 1414770.

Methods



Results Question I

1. Laminar Organization measurable in 100 % of cases
2. Good Interrater Variability (ICC 0,78; p < 0,001)

Results Question II

# of Laminars	Overall		Female		Male		p-value
	N	%	N	%	N	%	
One	21	10.5 %	15	15 %	6	6 %	0.027*
Two	18	9 %	13	13 %	5	5 %	
Three	125	62.5 %	56	56 %	69	69 %	
Four	36	18 %	16	16 %	20	20 %	

* Chi-Square-Test

Results Question II

# of Laminars	Overall		Female		Male		p-value
	N	%	N	%	N	%	
One	21	10.5 %	15	15 %	6	6 %	0.027*
Two	18	9 %	13	13 %	5	5 %	
Three	125	62.5 %	56	56 %	69	69 %	
Four	36	18 %	16	16 %	20	20 %	

* Chi-Square-Test

Results Question II

# of Laminars	Overall		Female		Male		p-value
	N	%	N	%	N	%	
One	21	10.5 %	15	15 %	6	6 %	0.027*
Two	18	9 %	13	13 %	5	5 %	
Three	125	62.5 %	56	56 %	69	69 %	
Four	36	18 %	16	16 %	20	20 %	

* Chi-Square-Test

Results Question II

# of Laminars	Overall		Female		Male		p-value
	N	%	N	%	N	%	
One	21	10.5 %	15	15 %	6	6 %	0.027*
Two	18	9 %	13	13 %	5	5 %	
Three	125	62.5 %	56	56 %	69	69 %	
Four	36	18 %	16	16 %	20	20 %	

* Chi-Square-Test

Results Question II

1. Weak correlation laminar organization with body height

   (r = 0,16; p = 0,023)

2. No correlation laminar organization with body weight

   (r = 0,01; p = 0,094)

Further results

1. Full length of QT measurable in 0 % of cases
2. Length of > 6 cm of QT measurable in 15 % of cases

Limitations

1. Different echo and relaxation times of MRI imaging

2. Uniplanar measurement

Potential clinical implications

1. The laminar organization can be measured on standard MRI imaging with good interrater variability.

Potential clinical implications

1. The laminar organization can be measured on standard MRI imaging with good interrater variability.
2. When planning for partial thickness technique preoperative MRI assessment of the laminar organization might be helpful.

Potential clinical implications

1. The laminar organization can be measured on standard MRI imaging with good interrater variability.
2. When planning for partial thickness technique preoperative MRI assessment of the laminar organization might be helpful.
3. The measurement of the full length of the QT requires specific MRI protocols.

Potential clinical implications

1. The laminar organization can be measured on standard MRI imaging with good interrater variability.
2. When planning for partial thickness technique preoperative MRI assessment of the laminar organization might be helpful.
3. The measurement of the full length of the QT requires specific MRI protocols.

Thank you.