Val d'Isère
UNIQUE.

8th Advanced Course on Knee Surgery

ACL-R : special case
Young population *(children , adolescent)*

Auteurs : **Dr Nicolas GRAVELEAU & Dr Nicolas BOUGUENNEC**
Bordeaux-Mérignac

And ***SFA***

CHIRURGIE DU SPORT
BORDEAUX-MÉRIGNAC

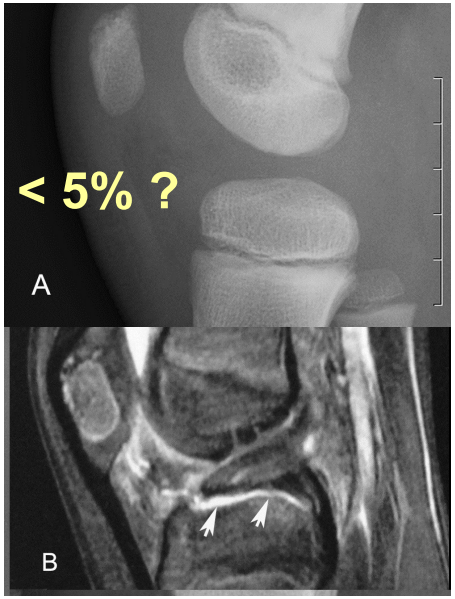
Société Francophone d'Arthroscopie
SFA

CLINIQUE DU SPORT
BORDEAUX - MERIGNAC

Epidemyology of ACL tears in Childrens

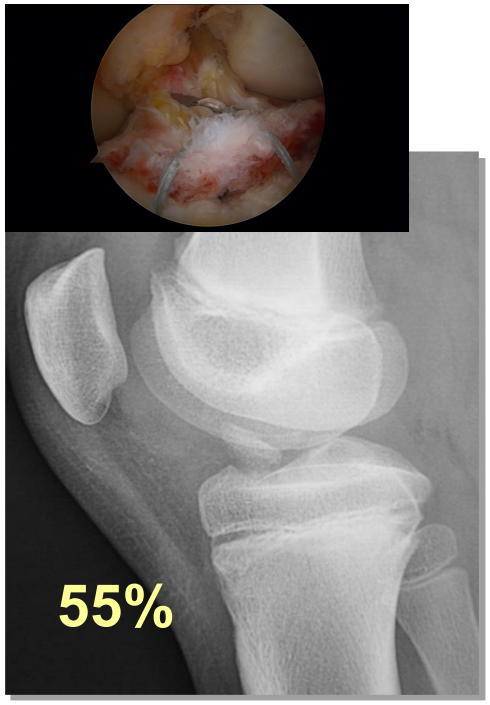
Meniscal risk

< 8 yo



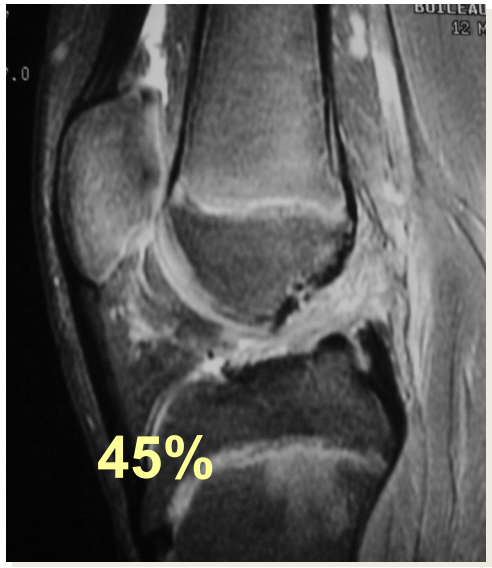
Tibial spine Fracture
Cartilage avulsion

8-14 yo



Tibial spine fracture
Bony lesion

12-18 yo



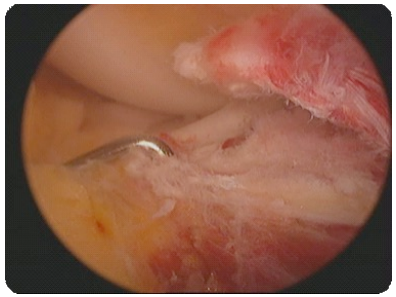
Ligament tears

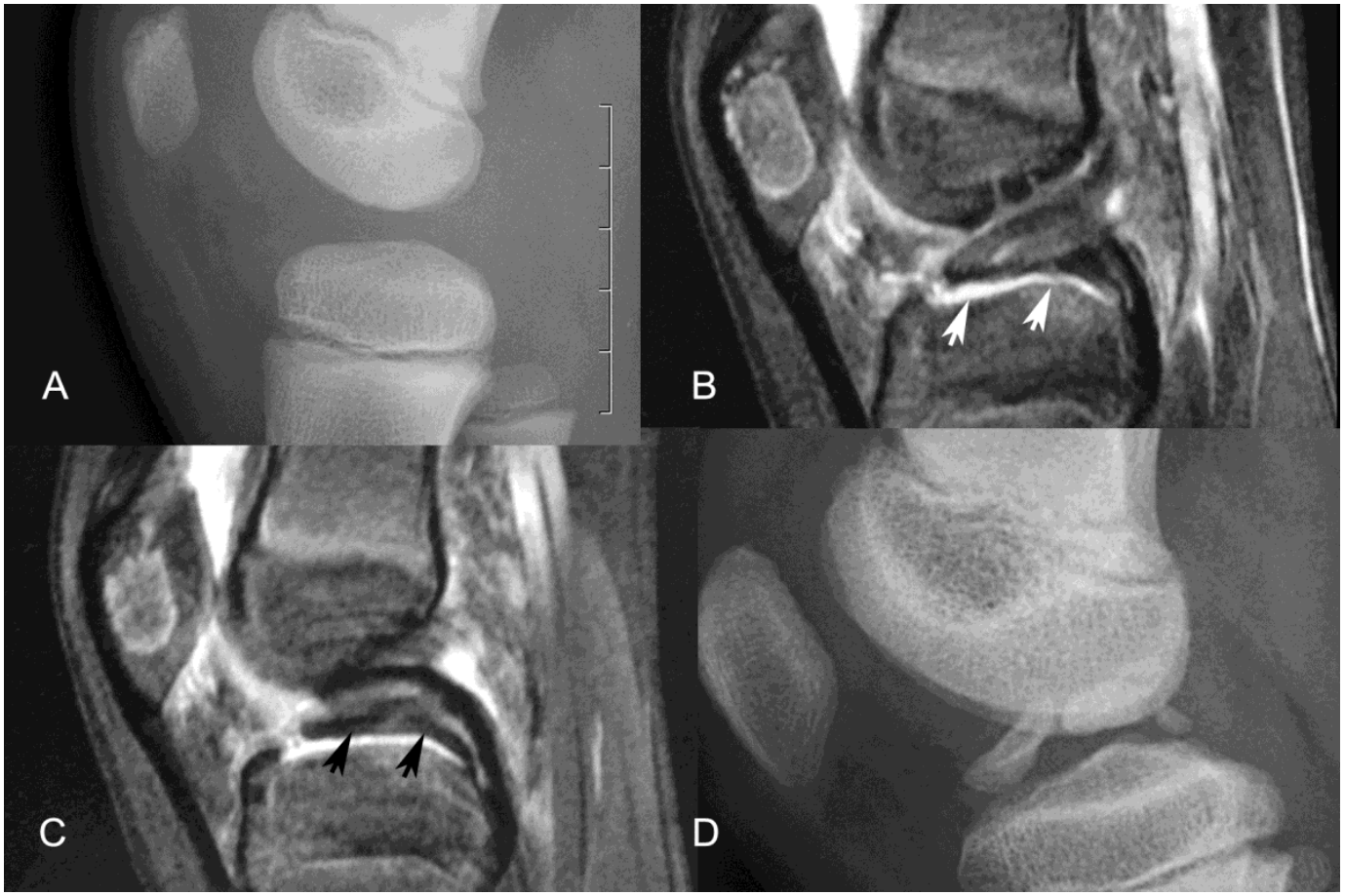
Tibial cartilage avulsion ACL

- Ski injury
- MRI :

  Epiphyseal HYPERsignal

  Double PCL

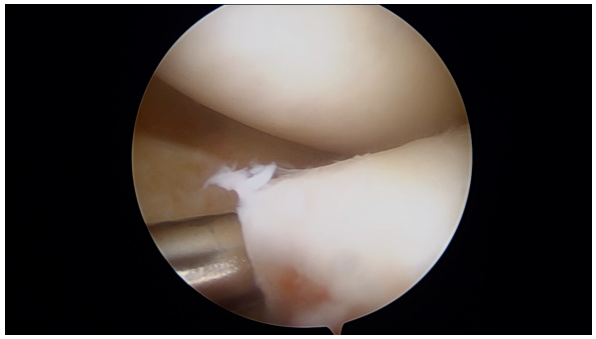


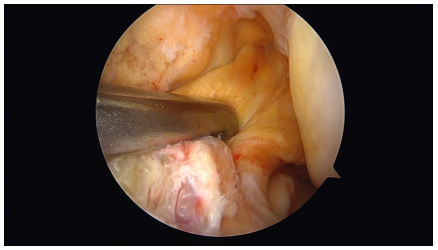


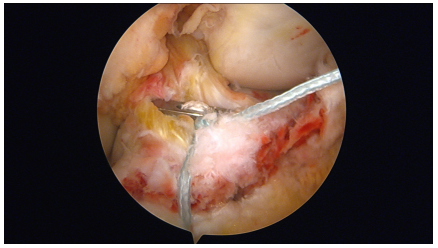
***Chotel** KSSTA 2013 & 2015*

Not a meniscal LESION

Tibial Spine fractures







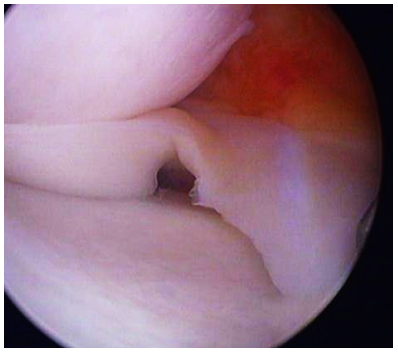
3 à 6 % ?

NO associated meniscal tears

BUT under evaluated at the time of surgery +++

Linked with age and amount of energy in the trauma mechanism

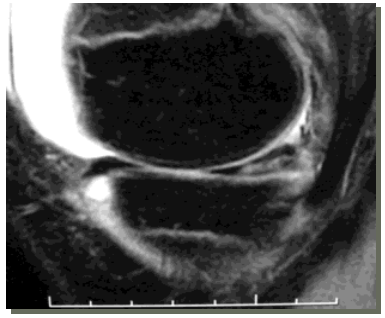
MRI : 40 % ?
Medial AND lateral
Adolescents

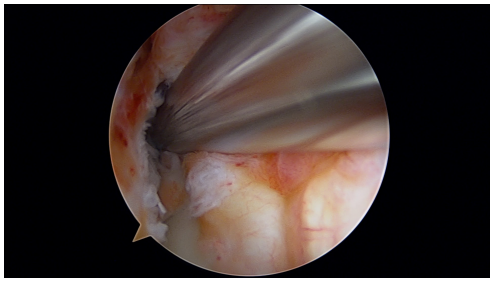


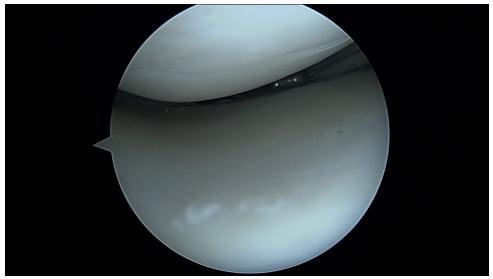
Shea *JPO 2011*
Kocher *Am J Sport Med 2003*
Ishibashi *Clin Orthop Res 2007*

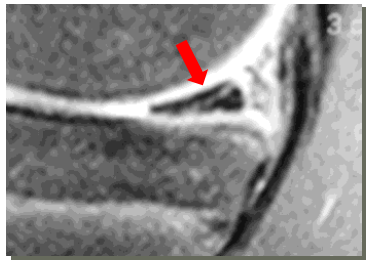
Acute ACL tears in the ligament

Acute phase
MRI : associated lesions ?







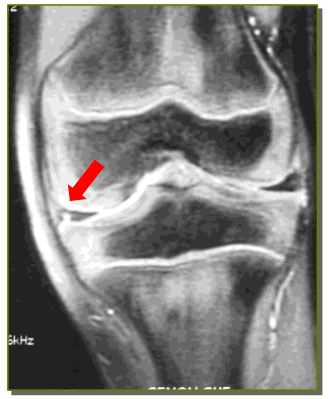


Morphologique abnomalie or linear hypersignal to the surface of the meniscus ?

False positive of Medial meniscal lesion

Intra meniscal

Vascular hypersignal



50% OF ACL tears in children / adolescent have an associated meniscal lesion!

Two different situations

Isolated ACL tear

(stable knee)

WAIT

Is it reliable in term on healing ?

Which lesion has the potential to heal ?

Lateral meniscus ≠medial M.

Unstable meniscal tear(s) + ACL insufficiency

(unstable knee)

STABILIZE the KNEE

Long term result on unstable knee is well known

ACL reconstruction should be efficient

Lateral meniscus ≠ medial M. ?

CONTROVERSY in pediatric

Initial management : NON operative versus operative

Operative management

- Technique
  - Nontransphyseal
  - Partial transphyseal
  - Transphyseal
- Graft choice / fixation
- Age / skeletal maturity

COMPLICATIONS

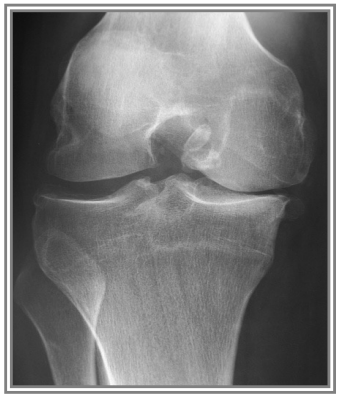
- ***Growth disturbance***

Chronic ACL tear

Conservative treatment can lead to early arthritis

Patients followed by … surgeons

- No ability to resume sport
- Pain
- **Instability**
- **Meniscal lesions**
- **Early arthritis**



Aichroth JBJS 2002; Graf Arthroscopy 1992; Janarv JPO 1996; Mizuta JBJS-B 1985 McCarroll AJSM 1988, AJSM 1994

Delayed surgery at the end of growth

↗↗ rate of MENISCAL lesion and subsequent MENISECTOMY
(compare to early reconnstruction)

Henry, Chotel *KSSTA 2009*

Knee Surg Sports Traumatol Arthrosc (2009) 17:748–755
DOI 10.1007/s00167-009-0741-0

KNEE

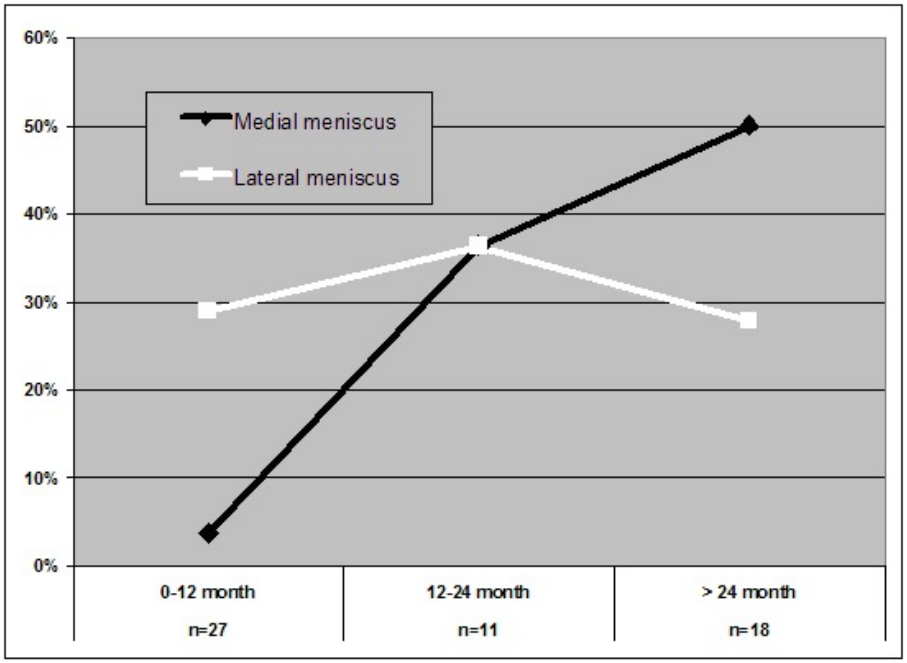
Rupture of the anterior cruciate ligament in children: early reconstruction with open physes or delayed reconstruction to skeletal maturity?

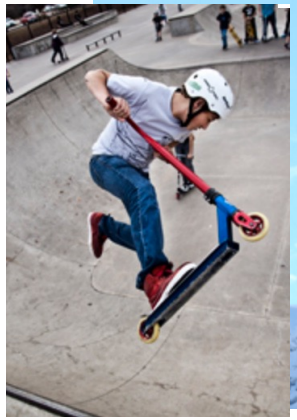
Julien Henry · Franck Chotel · Julien Chouteau · Michel Henri Fessy · Jérôme Bérard · Bernard Moyen

Received: 9 October 2008 / Accepted: 28 January 2009 / Published online: 28 February 2009

Abstract The purpose of this study was to compare two different strategies of management for ACL rupture in skeletally immature patient. In group 1, patients were

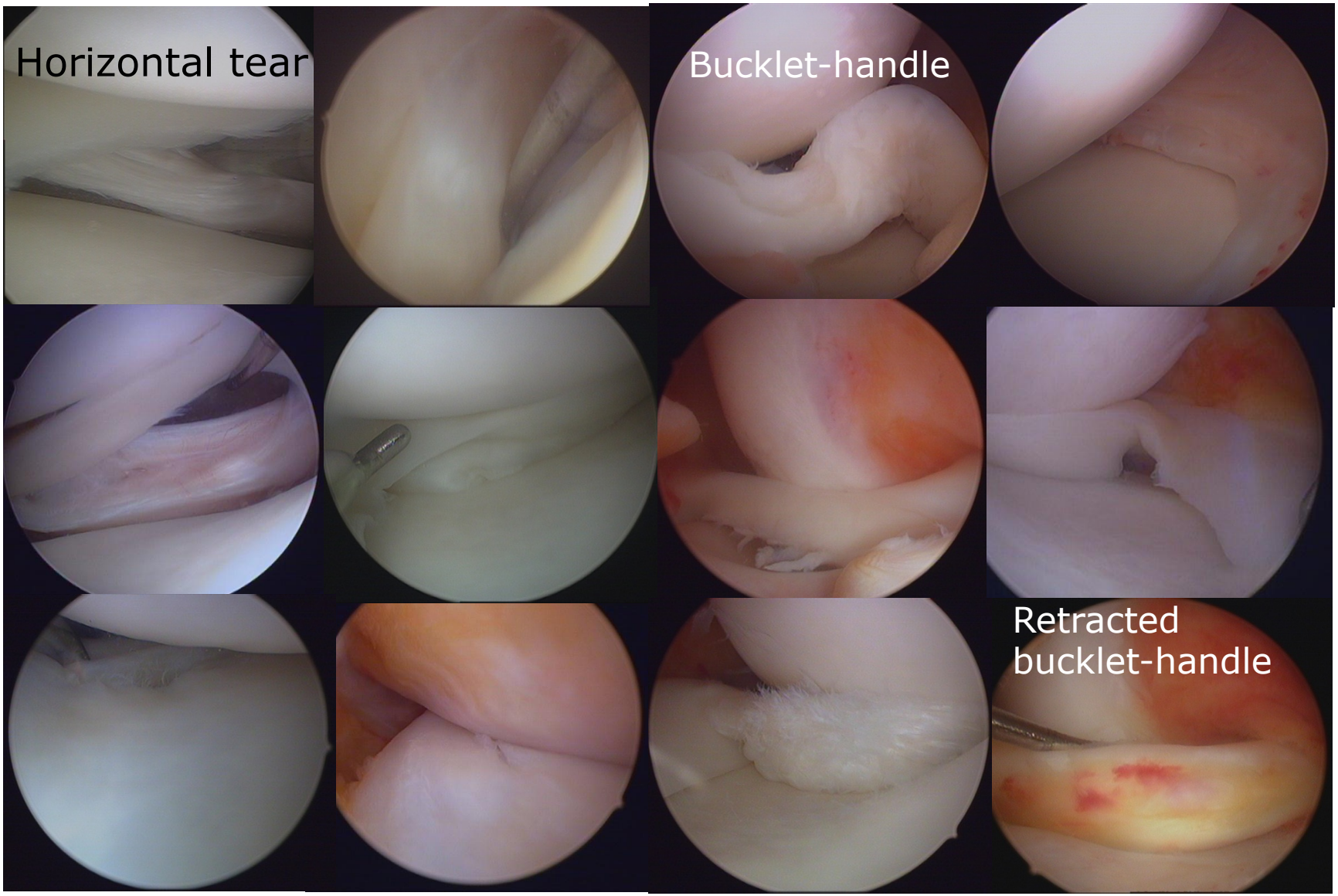
Keywords Anterior cruciate ligament · Meniscus · Children · Adolescent · Surgery · Skeletally immature · Delayed · Reconstruction





At « RISK » for the menisci

Potentialy at risk for the meniscus



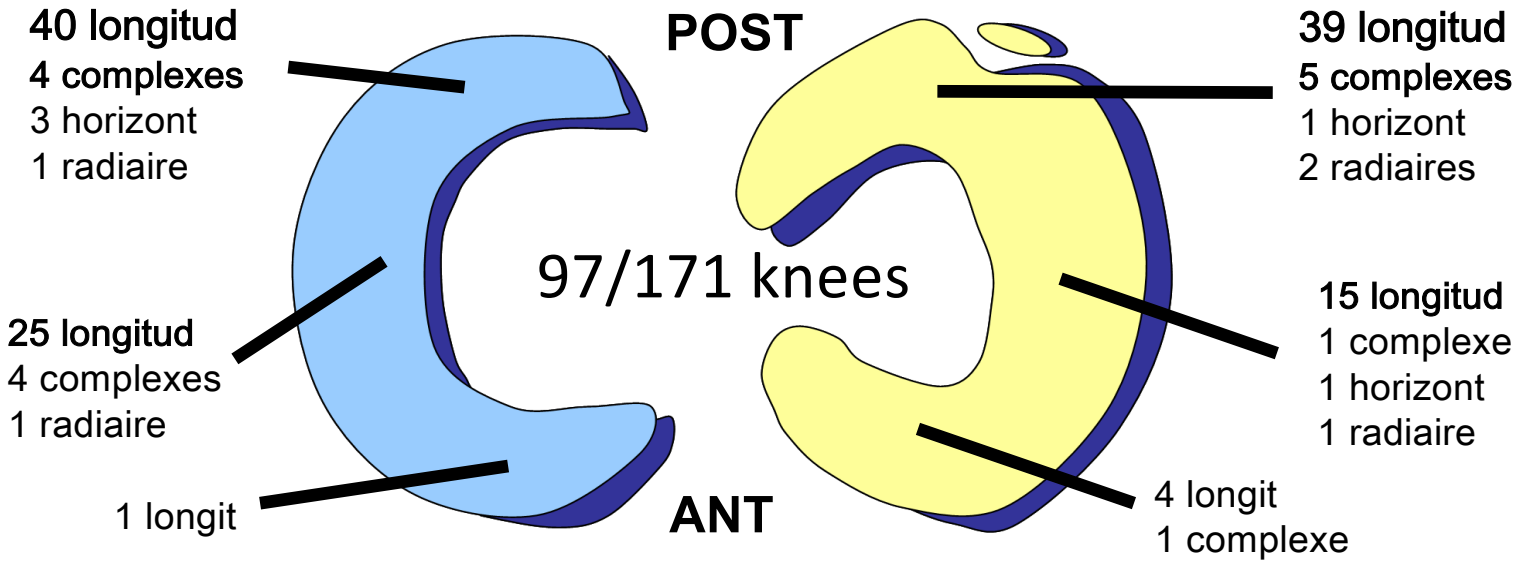
menisco-capsular lesions

Meniscal lesions in ACL deficient knees

- Open physis : 46 % of meniscal tears
- Closed physis : 66 % of meniscal tars

Significative différence

ADOLESCENTS are more likely to have associated meniscal lesion compare to CHILDREN (bony immaturity)



Ménisque médial = 52 **Ménisque latéral= 56**

Chotel KSSTA 2015

Meniscal lesions in ACL deficient knees

Do conservative treatment increase the risk of subsequent meniscal lesion ?

Prevalence and incidence of new meniscus and cartilage injuries after nonoperative treatment algorithm for ACL tears in skeletally immature children.

- 41 patients
- Average age 11 +/-1,4
- 65% ♂, 88% pivot-contact
- Delai between trauma & FU **3,8 years** +/-1,4.
- **28 CONSERVATIVE treatment** : 28,5% initial meniscal lesions **3,6% « new » tears**
- 13 SURGICAL treatment at 13,2 y.o., intervalle / trauma de 1,6 years

prévalence of meniscal tears : 46,2%

incidence « new » tears : **19,5%**

Moksnes, *AmJSportsMed 2013*

Type of surgical treatment

Reconstruction of the Anterior Cruciate Ligament in the Skeletally Immature Athlete: A Review of Current Concepts

AAOS Exhibit Selection

Peter D. Fabricant, MD, Kristofer J. Jones, MD, Demetris Delos, MD, Frank A. Cordasco, MD, MS, Robert G. Marx, MD, MSc, Andrew D. Pearle, MD, Russell F. Warren, MD, and Daniel W. Green, MD, MS

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

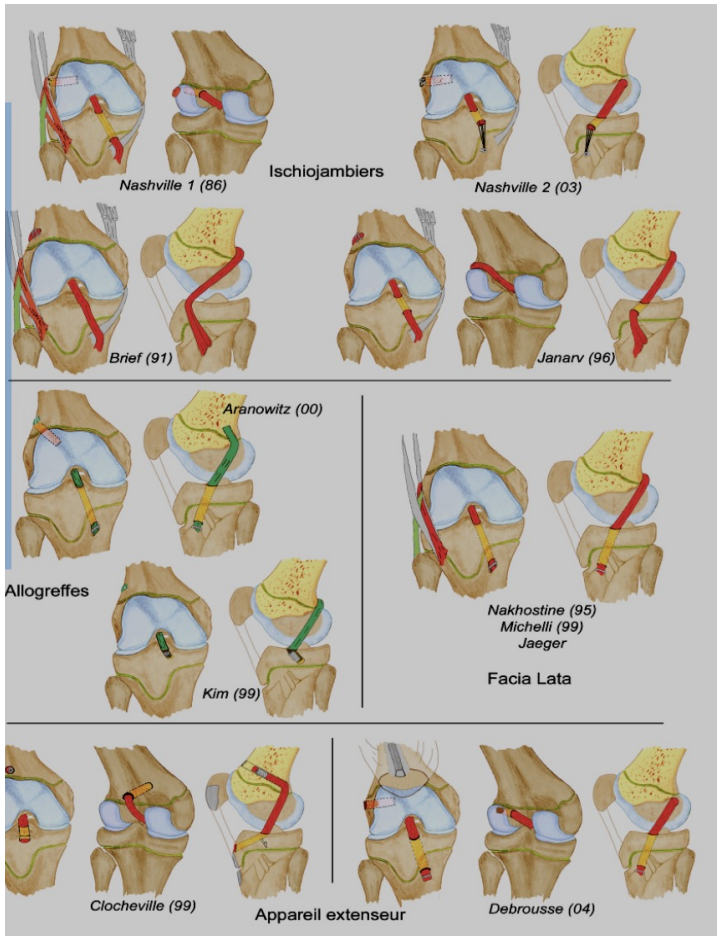
	First Author	No. of Patients	Mean Age *(yr)*	Mean Follow-up *(mo)*	Graft	Recurrent Instability	Reinjury
All-epiphyseal (physeal-sparing)	Anderson[44], 2003	12	13.3	49.2	Hamstring	NR	NR
	Guzzanti[49], 2003	8	11.2	69.2	Hamstring	NR	NR
	Hui[36], 2012	16	12	24.0	Hamstring auto./allo.	NR	NR
Extraphyseal (physeal-sparing)	Parker[55], 1994	6	13.3	33.2	Hamstring	NR	NR
	Nakhostine[54], 1995	5	14.0	52.8	Fascia lata	NR	None
	Kocher[33], 2005	44	10.3	63.6	ITB	NR	NR
	Bonnard[47], 2011	56	12.2	66.0	BTB	NR	5.4%
Partial transphyseal	Andrews[45], 1994	8	13.5	58.0	FL/Achilles allo.	None	NR
	Lo[52], 1997	5	12.9	88.8	Hamstring/quad.	None	NR
Transphyseal	Lipscomb[51], 1986	24	15.0	35.0	Hamstring	None	NR
	Aronowitz[46], 2000	15	14.0	25.0	Achilles allo.	NR	NR
	McIntosh[53], 2006	16	13.5	41.1	Hamstring	NR	12.5%
	Kocher[56], 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.

$N_{max} = 56$

Fabricant *JBJS(Am) 2013*

What is the best surgical treatment ?



EXTRA ARTICULAR

Dahlstedt 1988
McCarroll 1988
Lazzarone 1990
Graf 1992
Nakhostine 1995

PHYSEAL SPARING

DeLee 1983
Brief 1991
Janarv 1996
Micheli 1999
Anderson 2004
Guzzanti 2004

PARTIAL TRANSPHYSEAL

Liscomb 1986
Andrews 1994
Lo 1997
Bisson 1998

FULL TRANSPHYSEAL

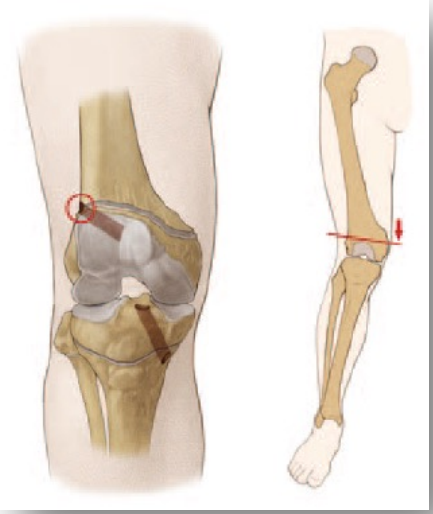
Liscomb 1986
McCarroll 1988
Matavan 1997
Aronowitz 2000

Potential growth disturbances in pediatric ACL reconstructions

4 types of gross complications

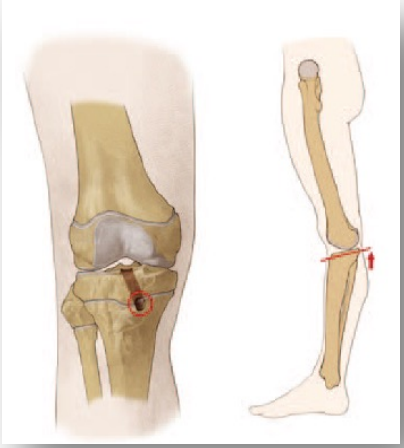
N = 354 in the literature

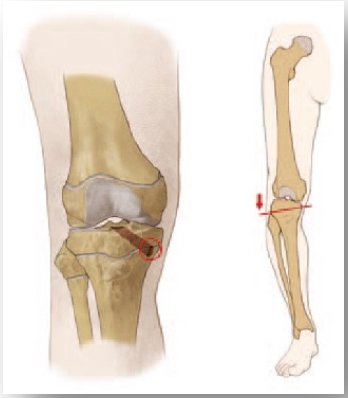
Moksnes, Engebretsen, Seil, KSSTA 2015



Arrest distal lateral femur physis: valgus knee

Arrest tibial tuberosity: recurvatum





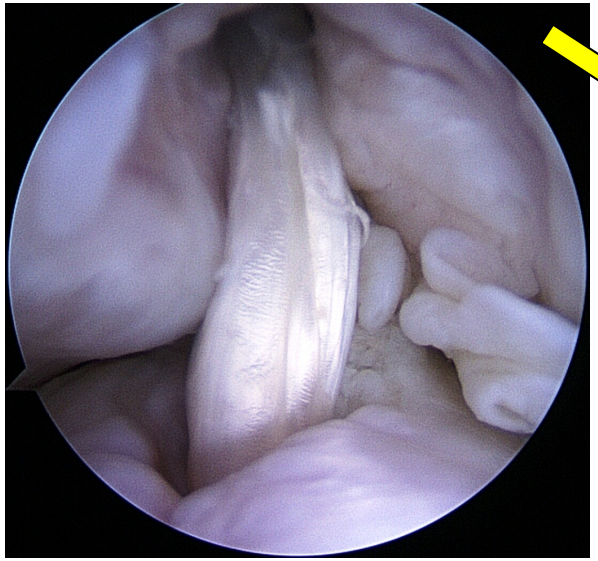
Arrest medial proximal tibial physis: Varus knee

Chotel F, KSSTA 2010

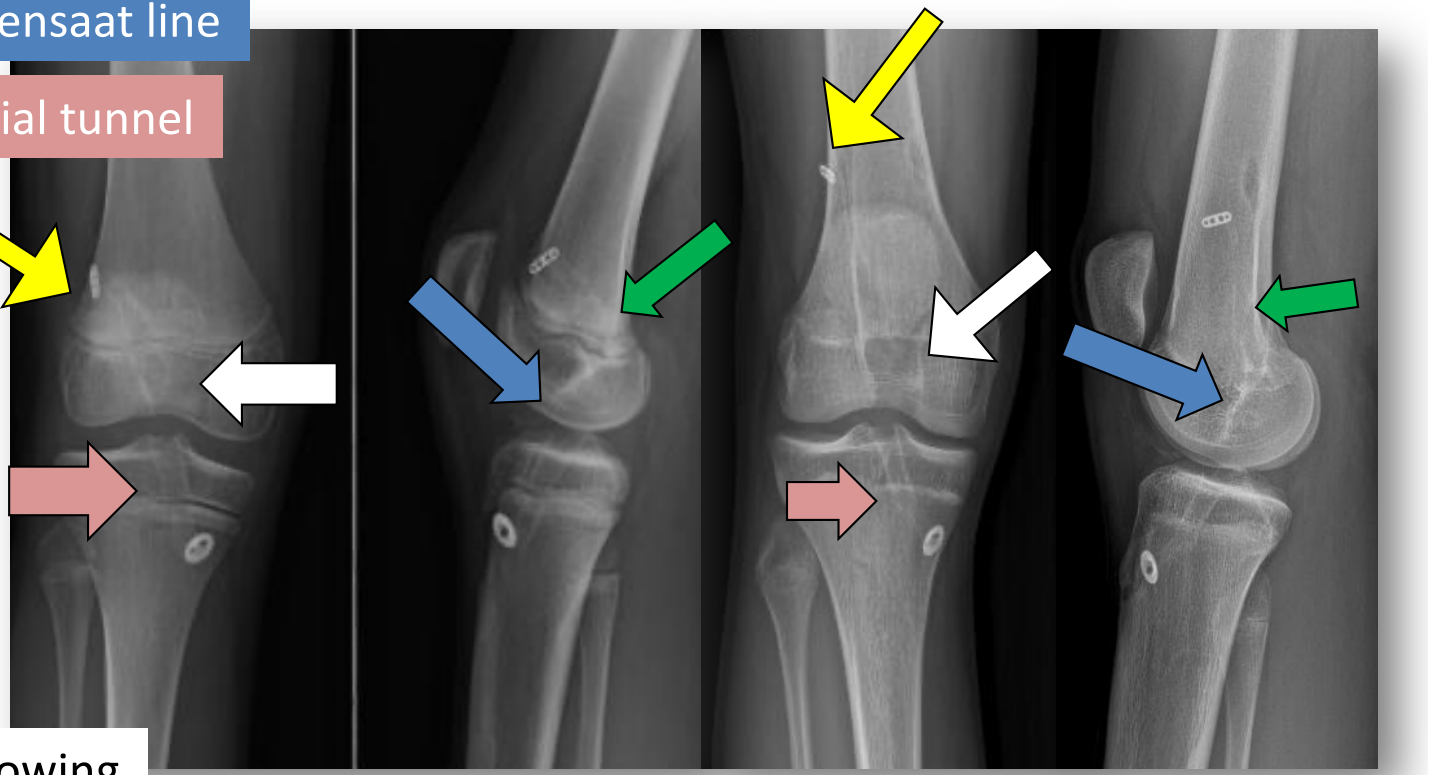
NO transphyseal hardware or synthetic graft

Graft mofications with knee growth after ACL reconstructions

1. Upward migration of femoral fixation
2. Verticalization of femoral tunnel
3. Verticalization of Blumensaat line
4. Relative thinning of tibial tunnel



5. Intercondylar notch narrowing



Changes in the four-strand hamstring graft in anterior cruciate ligament reconstruction in the skeletally-immature knee

JBJS-B 2008

S. Bollen, F. Pease, A. Ehrenraich, S. Church, J. Skinner, A. Williams

♂ ACL-replacement @ 11 y

+ 5 years

Adapt the technique to the age

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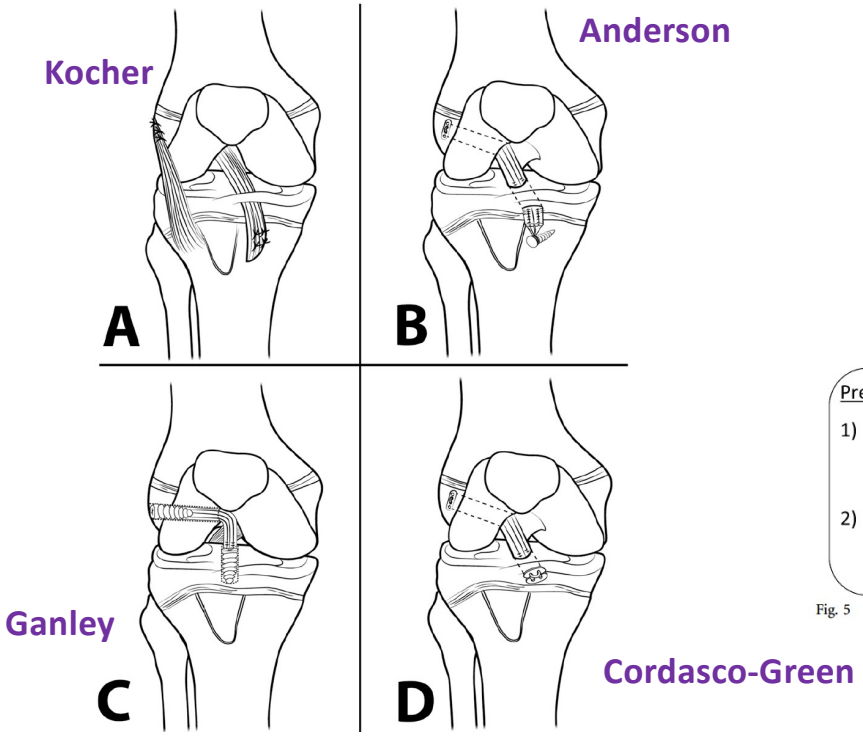


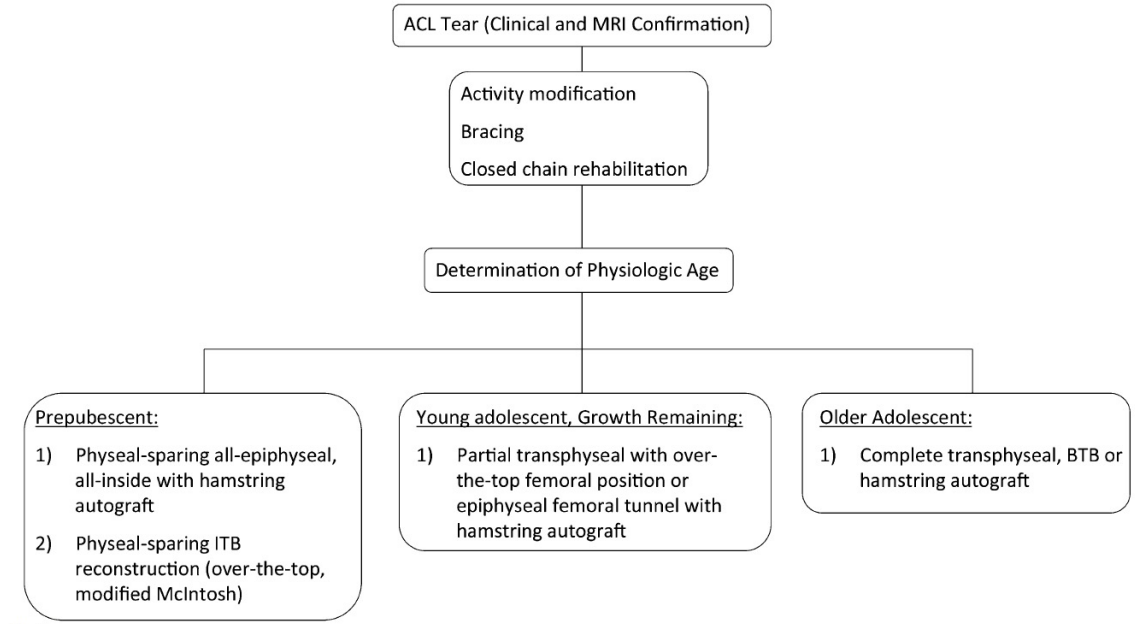


Fig. 5

***Fabricant** JBJS(Am) 2013*

ACL-r Pediatric & Adolescent

Technical Guidelines - R Seil

- Avoid hardware across Lateral Fistal Femoral Physis
- Avoid hardware across Tibial Tubercle Apophysis
- Avoid Bone Plugs across Physis
  - Hamstrings Graft
- Avoid LARGE tunnels
- Avoid Extra-Articular Tenodesis
- Minimal Over-the-Top dissection & Notchplasty
- Consider Physeal Sparing Reconstruction in prepubescent patients

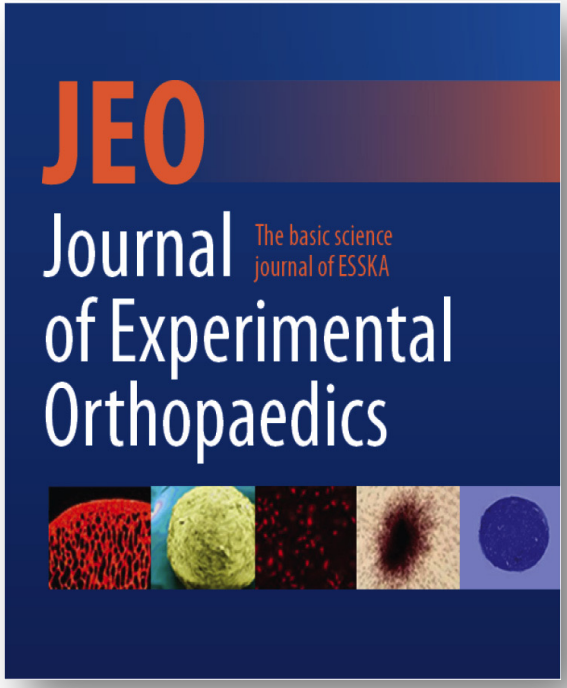
Seil *et al. Journal of Experimental Orthopaedics* _####################_
DOI 10.1186/s40634-015-0027-z

Journal of Experimental Orthopaedics
a SpringerOpen Journal

REVIEW Open Access

Surgical-experimental principles of anterior cruciate ligament (ACL) reconstruction with open growth plates

Romain Seil[1,2*], Frederick K Weitz[3] and Dietrich Pape[1,2]



RE-injury rates - *Kocher*

Transphyseal Anterior Cruciate Ligament Reconstruction in Skeletally Immature Pubescent Adolescents

By Mininder S. Kocher, MD, MPH, Jeremy T. Smith, MD, Bojan J. Zoric, MD, Ben Lee, BA, and Lyle J. Micheli, MD

Continuous cohort with transepiphyseal Hamstrings ACL reconstruction in 61 adolescents aged 14,7 yo (11.6-16.9) & (Tanner stage 3) b. 1996 et 2004. FU at 3.6 ans (2.0 à 10.2 ans)

2 iterative reconstruction of ACL (3%)
IKDC 89.5 /Lysholm knee score 91.2
Lachman 0 51 / 59 cas
Pivot-shift normal 56 / Glide 3 / franc +explosive 0

- NO radiologic axes change
- NO lenght discrepency
- 3 stiffness

Transphyseal *reconstruction of the anterior cruciate ligament with use of an* ***autogenous quadrupled hamstrings-tendon graft*** *with metaphyseal fixation in skeletally immature pubescent adolescents provides an excellent functional outcome with a low revision rate and a minimal risk of growth disturbance. There was a low revision rate (3%),*

RE-injury rates - *Shelbourne*

Incidence of Subsequent Injury to Either Knee Within 5 Years After Anterior Cruciate Ligament Reconstruction With Patellar Tendon Autograft

K. Donald Shelbourne,* MD, Tinker Gray, MA, and Marc Haro, MD
From the Shelbourne Knee Center, Indianapolis, Indiana

♀ < 18 ans = 19 %
7 % at 5 years
12 % controlateral

TABLE 3
Subsequent ACL Injuries to Either Knee Based on Age Group and Gender[a]

Age Group/Gender	n	ACL Tear to ACL-Reconstructed Knee		ACL Tear to Contralateral Knee		*P* Value (Difference in Tears Between Knees)
		n	%	n	%	
<18 years old	528	46	8.7	46	8.7	1.00
Female	310	23	7.4	36	11.6	.00998[b]
Male	218	23	10.6	10	4.6	.02845[b]
P value (difference in tears between genders)		.214		.0046[b]		
18 to 25 years old	350	9	2.6	14	4.0	.3969
Female	103	2	1.9	5	4.9	.4450
Male	247	7	2.8	9	3.6	.800
P value (difference in tears between genders)		1.00		.5631		
>25 years old	537	6	1.1	15	2.8	.0754
Female	139	1	0.7	2	1.4	1.00
Male	398	5	1.3	13	3.3	.0925
P value (difference in tears between genders)		1.00		.3746		
Totals	1415	61	4.3	75	5.3	.2185
Female	552	26	4.7	43	7.8	.0459[b]
Male	863	35	4.1	32	3.7	.8034
P value (difference in tears between genders)		.5543		.0014[b]		

[a]ACL, anterior cruciate ligament.
[b]Statistically significant difference between groups.

♀
< 18
19%

7,8%

RE-injury rates - *Webster*

Exploring the High Reinjury Rate in Younger Patients Undergoing Anterior Cruciate Ligament Reconstruction

Kate E. Webster and Julian A. Feller

Am J Sports Med published online July 7, 2016

Cohorte study 316 (FU) / 354 patients < 20 YO Hamstrings

5 years FU (3-10) : RE-rupture & CONTRO lateral rupture

- **RE-ruptures** : 57 patients (**18%**) after 1.8 y.
- Highest RE-rupture rate = **28.3% in males <18 ans** (13.8% if >18 ans)
- **Controlateral ruptures** : **17.7%** average 3.7 years post-op

110 patients **(35%) sustain ANOTHER ACL tears** (any side)

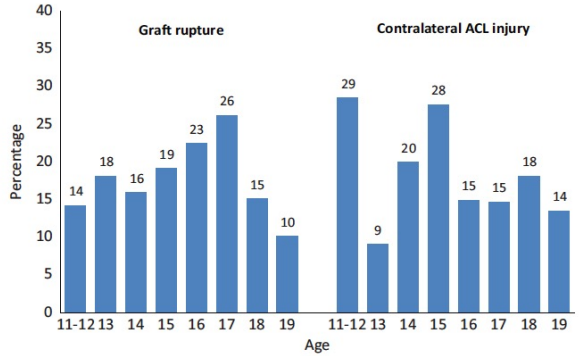


Figure 1. Percentage of patients with graft ruptures and contralateral anterior cruciate ligament injuries by each year of age.

TABLE 2
Graft Rupture Rates Categorized by Sex and Age

Age at Surgery, y	Male Patients, %	Female Patients, %
<18	28.3[a,b,c]	12.9
18 or 19	13.8	9.7

TABLE 3
Contralateral ACL Injury Rates Categorized by Sex and Age

Age at Surgery, y	Male Patients, %	Female Patients, %
<18	18.9	18.8
18 or 19	17.0	12.9

TABLE 4
All Second (Graft Rupture and Contralateral ACL Injury) ACL Injuries Categorized by Sex and Age

Age at Surgery, y	Male Patients, %	Female Patients, %
<18	44.3[a,b]	31.8
18 or 19	30.9	22.6

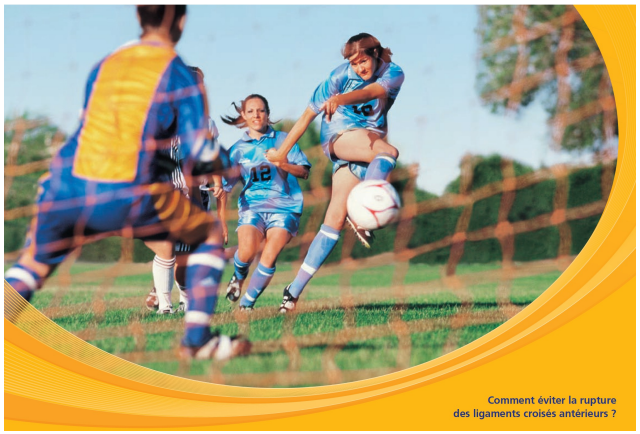
Prevention program
Decrease te RISK of (RE-)injury

2C. Etirement des ischio-jambiers (2 séries de 30 secondes)	
Temps écoulé	3,5-4,5 minutes
Objectif	Etirer les ischio-jambiers (muscles de l'arrière de la cuisse).
Instructions	Asseyez-vous au sol avec la jambe droite tendue devant vous. Pliez le genou gauche et placez le pied gauche au niveau de votre cuisse droite. Gardez le dos bien droit et penchez le buste en direction du genou droit. N'arrondissez pas le dos. Si possible, tentez d'attraper vos orteils et tirez-les en direction de votre tête. Evitez les à-coups. Maintenez la position 30 secondes et changez de jambe.

3B. Ischio-jambiers (3 séries de 10)	
Temps écoulé	7,5-8,5 minutes
Objectif	Renforcer les ischio-jambiers.
Instructions	Agenouillez-vous au sol. Un partenaire vous tient fermement les chevilles. Le dos plat, penchez-vous en avant avec le bassin bien en avant. Genoux, hanches et épaules doivent former une ligne droite lorsque vous vous penchez en avant. Ne fléchissez pas le tronc. Vous devez sentir la tension dans les muscles à l'arrière de votre cuisse. Répétez l'exercice trois fois en séries de 10 ou une fois trente.

Roald BAHR, Grethe MYKLEBUST, Kathrin STEFFN & Ben CLARSEN
OSLO

Hamstring Stretching
Hamstring strenghtening



Strict criteria for RTP

No PAIN	Clinical examination
No EFFUSION	Clinical examination
Full ROM	Physio assesment
STABLE KNEE	GnRB & Pivot
HEALED graft & meniscus	MRI at FU
Good muscular STRENGHT	Isokinetiq (& Rachet's chair hamstring test?)
Good functionnal STABILITY	JUMP landing – JUMP tests
No psychologic apprehension	Recorded videos of trauma ?
	Psychologisc support ?

Martin R, Gard S, Besson C, Menetrey J et al Rev Med Suisse 2013

How to make decision ?
Every day …

Quantify the residual growth potential

Knee = area high growth potential

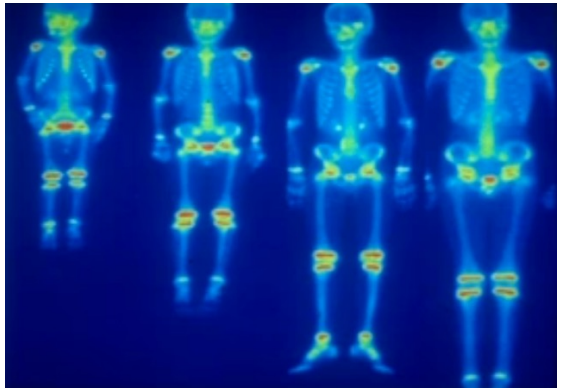
- Femur = **1,2 cm / year**
- Tibia = 0,8 cm / year

Bony age : residual growth

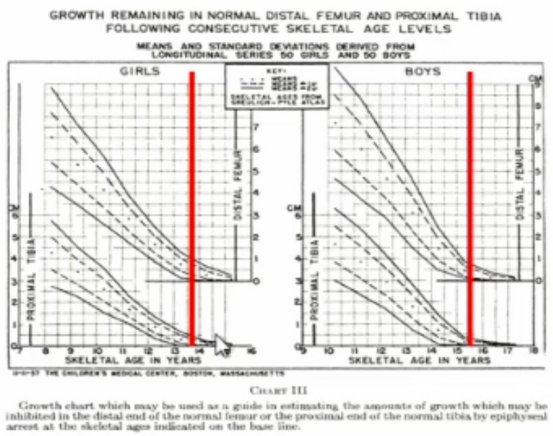
- X-rays : hand-wrist / elbow
- Centrifugal closing of growth-plate

END of bone GROWTH in the knee

- Female **13,5 y.**
- Male **15,5 y.**

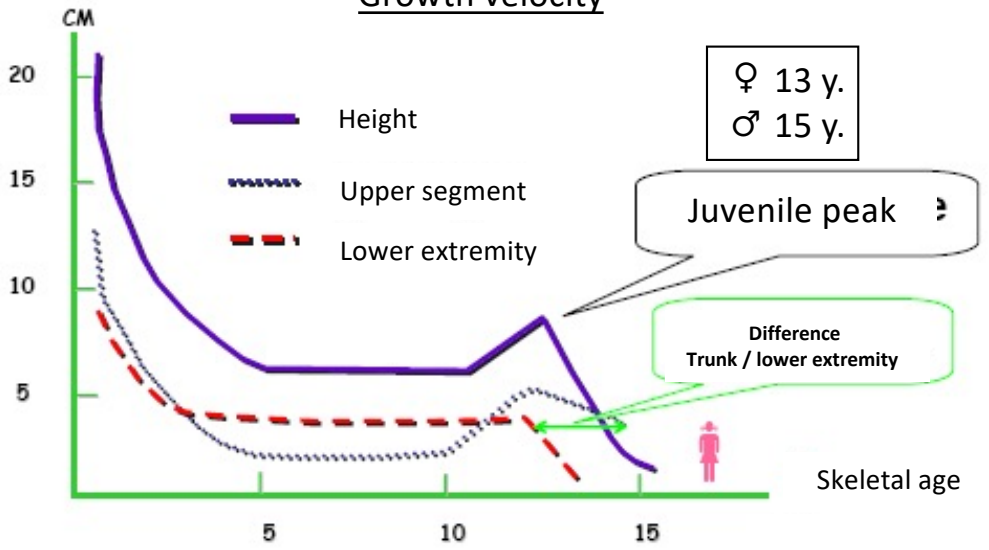


Growth of upper & lower segment not proportional



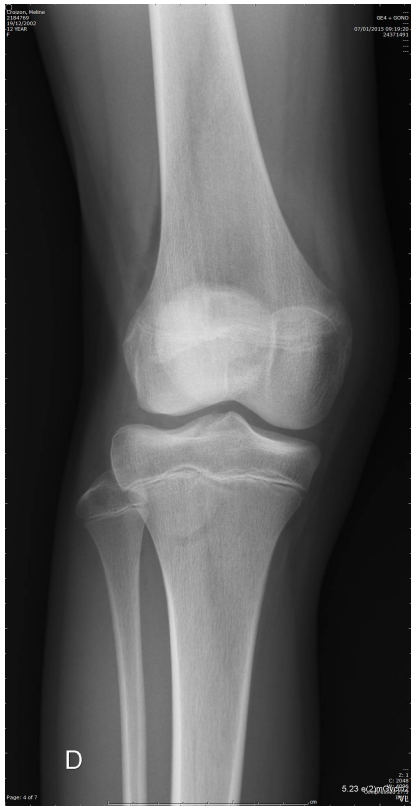
Anderson JBJS 1963

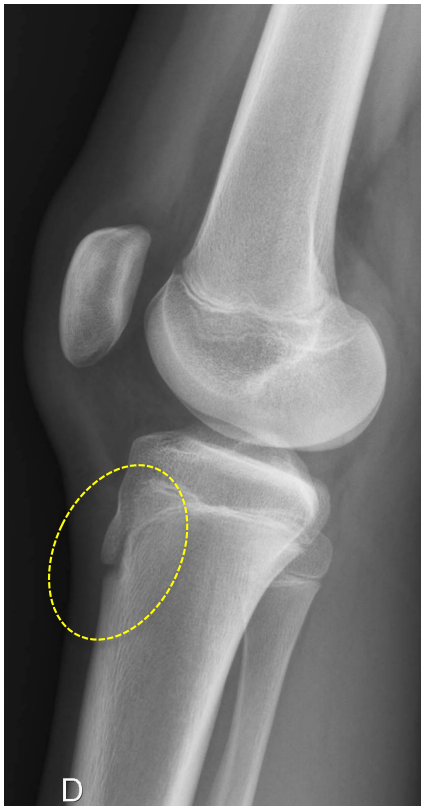
Growth velocity



Gicquel P, Rev Chir Orthop 2007

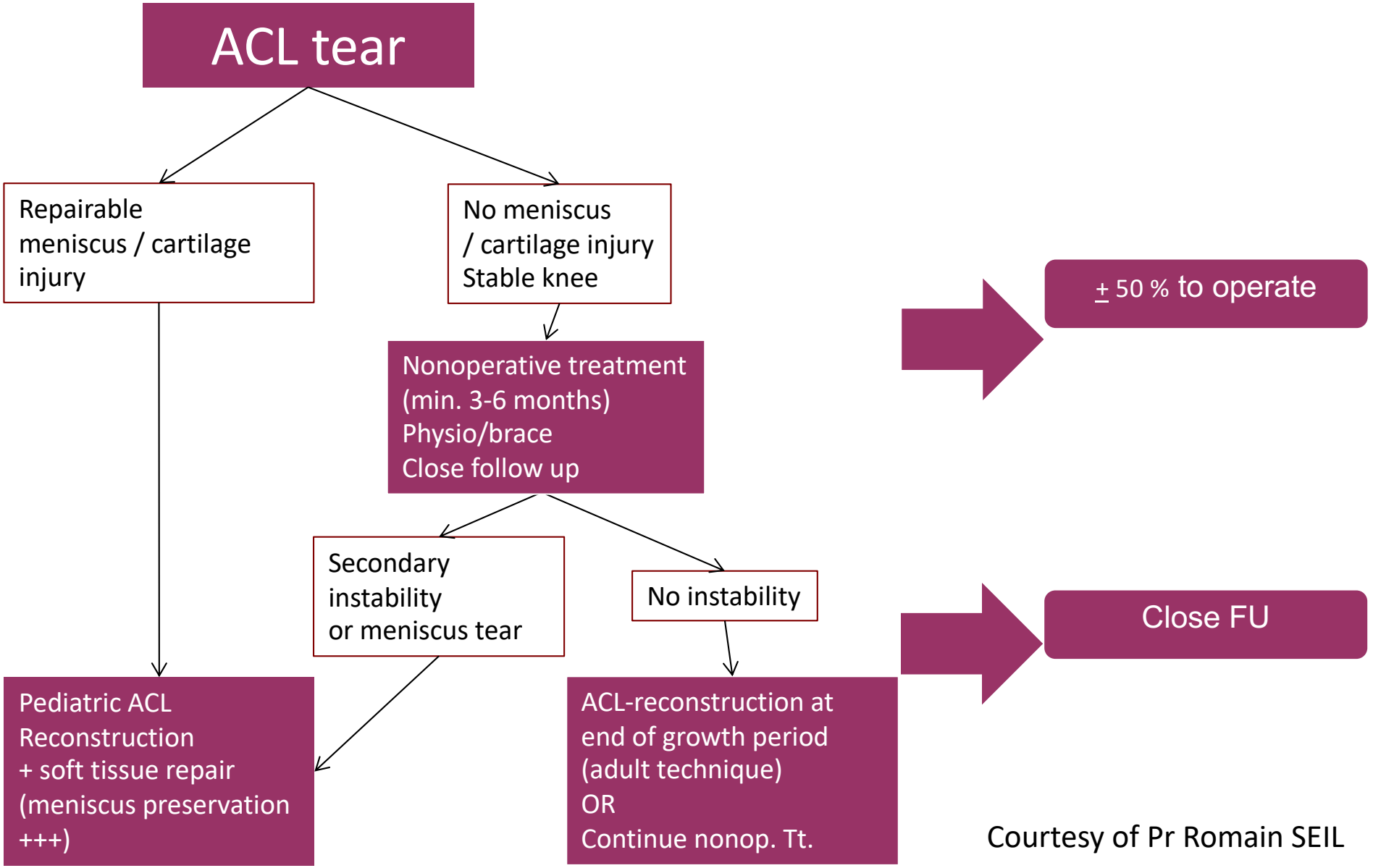
Quantify the residual growth potential





MANDATORY +++

« SFA » ALGORYTHM



Courtesy of Pr Romain SEIL

Associated lesions :
It makes change the decision algorythm

Old fashion:

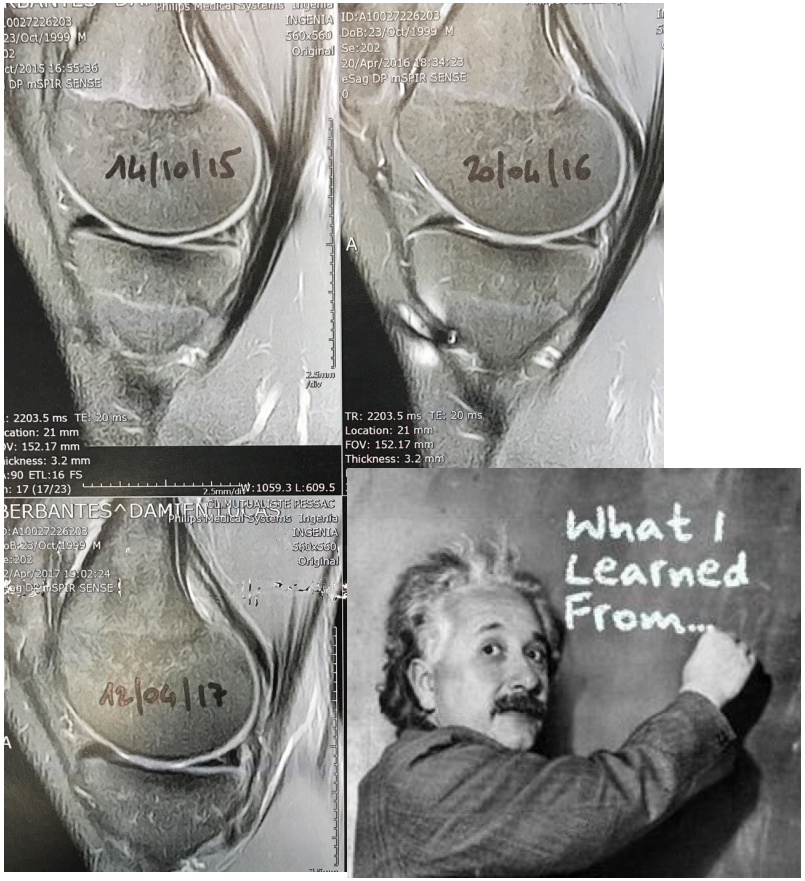
Abstention

» Never operate on childrens »

v. « systematic » surgery

Take Home messages

« Kids & adolescents are special »



- Instability is rarely reported by childrens
- Physiologic hyperlaxity (≠instability)
- Easy access to MRI
- BONY AGE
- **Screening for meniscal lesions**
- **CLOSE follow-up +++**
- Dedicated teams

CONCLUSIONS :
What we know … and ignore

- Natural history of pediatric ACL DEFICIENT and RECONSTRUCTED knee not fully understood = long FU is needed to the end of the growth (at least)
- FAILURE rate after ACL-r is higher than in adults
- No evidence that subsequent meniscal lesions and ARTHRITIS could be avoided by early ACL reconstructions
- CONSERVATIVE treatment is sometimes an option
- Different techniques depending of children's characteristic in experienced surgical centers