Safe zones in knee alignment, does it matter?

Sébastien LUSTIG MD, PhD

J. Shatrov, E. Sappey Marinier, C. Batailler, E. Servien.

Orthopaedic surgery and sport medicine department

Lyon University Hospital, France

In search of the « ideal » walking man

Knee

EOR | VOLUME 1 | JAN 2016
DOI: 10.1302/2058-5241.1.000002
www.efort.org/openreviews

EFORT open reviews

Coronal alignment after total knee arthroplasty

Timothy Lording[1]
Sébastien Lustig[2]
Philippe Neyret[2]

Anatomy and deformity

To describe the anatomy and coronal alignment of the leg, a number of descriptive terms are used.[2] The anatomical axis of each bone refers to a line drawn along the centre of

THE BONE & JOINT JOURNAL

■ INSTRUCTIONAL REVIEW: KNEE

Coronal alignment in total knee replacement

HISTORICAL REVIEW, CONTEMPORARY ANALYSIS, AND FUTURE DIRECTION

M. P. Abdel,
S. Oussedik,
S. Parratte,
S. Lustig,
F. S. Haddad

From Mayo Clinic, Rochester, Minnesota, United States

Substantial healthcare resources have been devoted to computer navigation and patient-specific instrumentation systems that improve the reproducibility with which neutral mechanical alignment can be achieved following total knee replacement (TKR). This choice of alignment is based on the long-held tenet that the alignment of the limb post-operatively should be within 3° of a neutral mechanical axis. Several recent studies have demonstrated no significant difference in survivorship when comparing well aligned *versus* malaligned TKRs. Our aim was to review the anatomical alignment of the knee, the historical and contemporary data on a neutral mechanical axis in TKR, and the feasibility of kinematically-aligned TKRs.

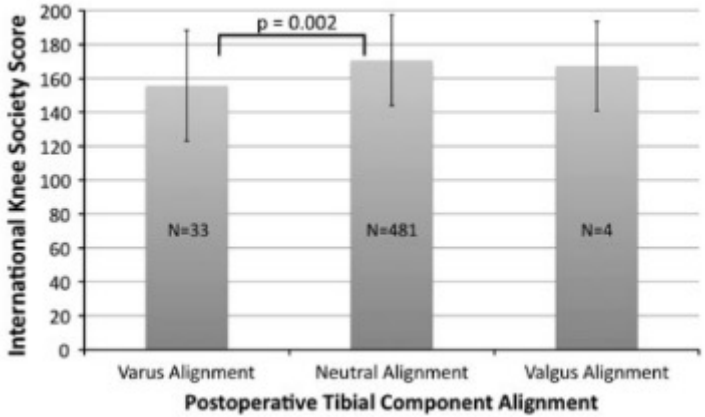
Review of the literature suggests that a neutral mechanical axis remains the optimal guide to alignment.

Clin Orthop Relat Res
DOI 10.1007/s11999-011-1988-6

CLINICAL RESEARCH

Residual Varus Alignment does not Compromise Results of TKAs in Patients with Preoperative Varus

Robert A. Magnussen MD, Florent Weppe MD, Guillaume Demey MD, Elvire Servien MD, PhD, Sébastien Lustig MD, PhD



Long Follow–up !

We should not rely on 5 or 10Y FU

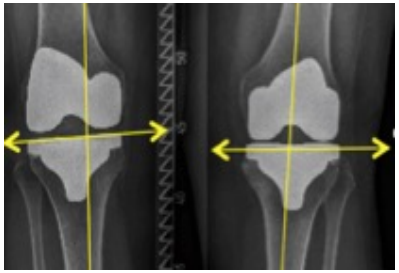
19Y. FU

Editorial > Knee Surg Sports Traumatol Arthrosc. 2022 Feb;30(2):365-367.
doi: 10.1007/s00167-021-06844-w. Epub 2022 Jan 20.

A safe transition to a more personalized alignment in total knee arthroplasty: the importance of a "safe zone" concept

Rüdiger von Eisenhart-Rothe [1], Sebastien Lustig [2], Heiko Graichen [3], Peter P Koch [4], Roland Becker [5], Arun Mullaji [6], Michael T Hirschmann [7] [8]

Tibial loading and alignment ?



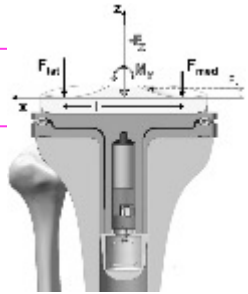
Influence of Limb Alignment on Mediolateral Loading in Total Knee Replacement

In Vivo Measurements in Five Patients

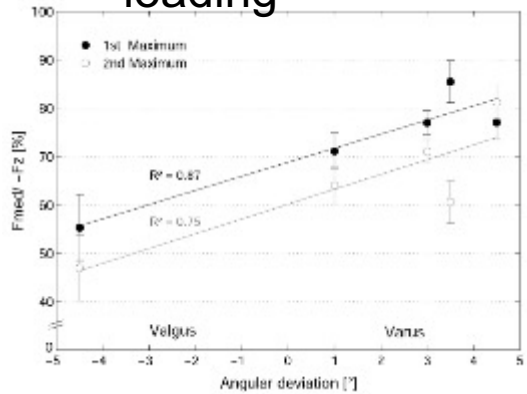
Andreas Halder, MD, PhD, Ines Kutzner, Friedmar Graichen, PhD, Bernd Heinlein, Prof., Alexander Beier, MD, and Georg Bergmann, Prof.

Investigation performed at Klinik für Endoprothetik Sommerfeld, Sommerfeld, Germany

5 instrumented TKA



1° varus =5% loading



BJR

KNEE

The effects of kinematically aligned total knee arthroplasty on stress at the medial tibia

A CASE STUDY FOR VARUS KNEE

S. Nakamura,*
Y. Tian,*
Y. Tanaka,
S. Kuriyama,
H. Ito,
M. Furu,
S. Matsuda

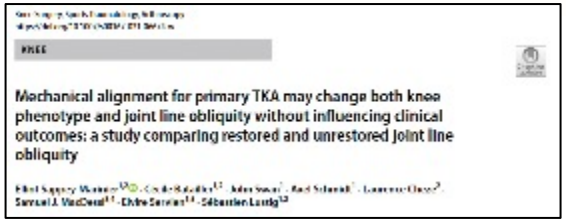
« ... » However, KA TKA increased the contact force, stress and bone strain at the medial side for moderate and severe varus knee models. The application of KA TKA for severe varus knees may be inadequate. « ... »

Systematic alignment

ORTHOPÉDIE Lyon Croix Rousse

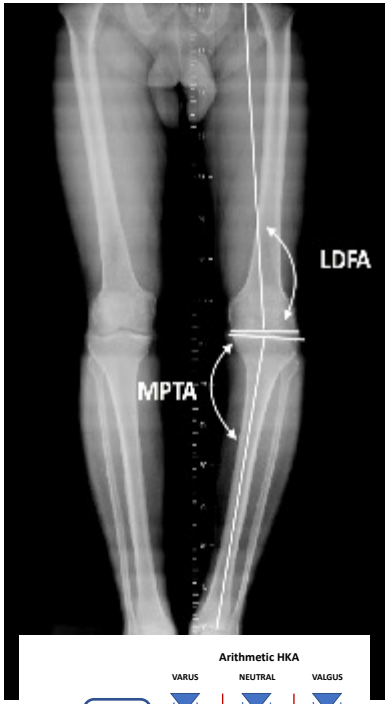
1078 osteoarthritic knees

=> Arithmetic HKA
=> Joint line obliquity



S. J. MacDessi,

n=1078 TKAs

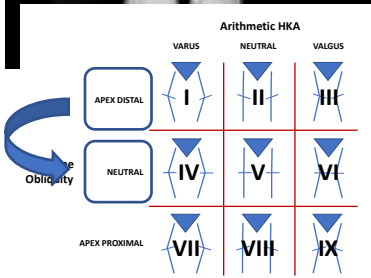


Preoperative CPAK classification

		MPTA - LDFA (aHKA)			Total
		< -2°	-2° to 2°	> 2°	
MPTA + LDFA (Joint Line Obliquity)	< 177°	**360** (33.4%)	**210** (19.5%)	**115** (10.6%)	**685**
	177° to 183°	**110** (10.2%)	**204** (18.9%)	**68** (6.3%)	**382**
	> 183°	**4** (0.4%)	**6** (0.6%)	**1** (0.1%)	**11**
Total		**474**	**420**	**184**	**1078**

Postoperative CPAK classificatio

		MPTA - LDFA (aHKA)			Total
		< -2°	-2° to 2°	> 2°	
MPTA + LDFA (Joint Line Obliquity)	< 177°	**36** (3.3%)	**32** (3.0%)	**24** (2.2%)	**92**
	177° to 183°	**184** (17.1%)	**623** (57.8%)	**76** (7.0%)	**883**
	> 183°	**75** (7.0%)	**22** (2.0%)	**6** (0.6%)	**103**
Total		**295**	**677**	**106**	**1078**

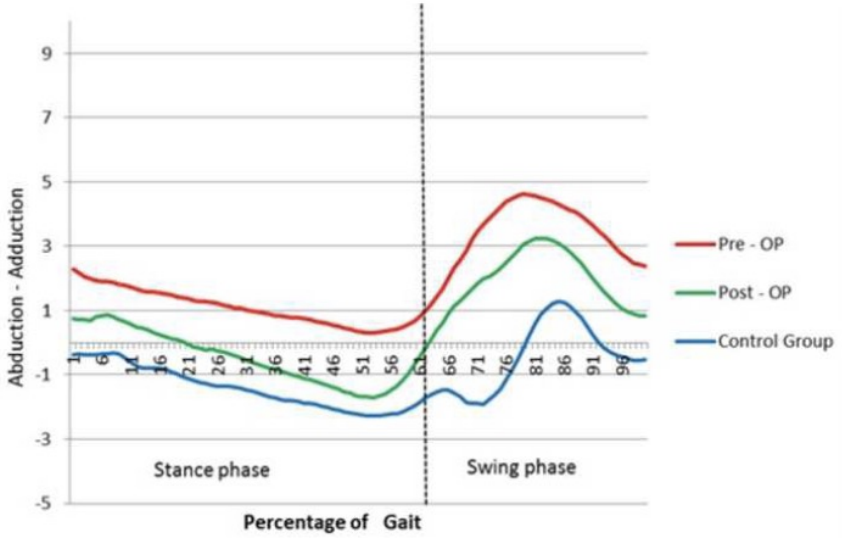


Arch Orthop Trauma Surg
DOI 10.1007/s00402-017-2629-7

KNEE ARTHROPLASTY

Does a third condyle TKA restore normal gait kinematics in varus knees? In vivo knee kinematic analysis

Dafina Bytyqi[1,2,3] · Bujar Shabani[1,2,3] · Laurence Cheze[1] · Philippe Neyret[1,2] · Sebastien Lustig[1,2]

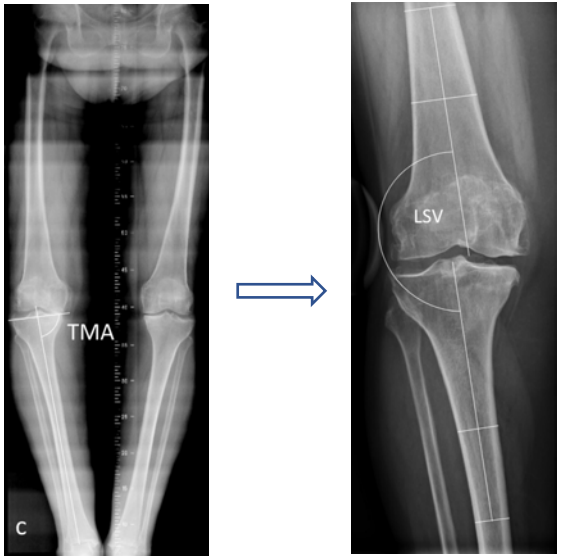


n = 2285
(Min 2y FU)

IKS Knee score = 100
16 %

No pain
48 %

2015 à 2017
n= 749 PTG (Varus)



KNEE

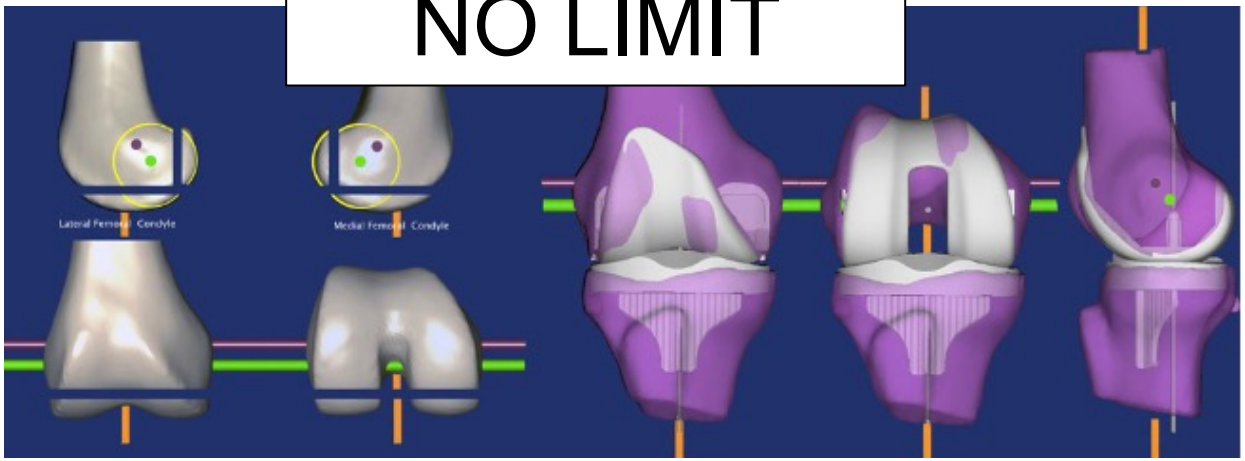
Kinematic alignment matches functional alignment for the extension gap: a consecutive analysis of 749 primary varus osteoarthritic knees with stress radiographs

E. Sappey-Marinier[1,2] · P. Meynard[1] · J. Shatrov[1,3,4,5] · A. Schmidt[1] · L. Cheze[2] · C. Batailler[1,2] · E. Servien[1,6] · S. Lustig[1,2]

Personalized alignment = before OA

Kinematic alignment

NO LIMIT



Results

Studies	Location	Study design	Minimum follow-up (m)	Sample size		Mean age		Female		BMI (mean)		Prosthesis design	Operative method	Clinical measurements	Radiological measurements	Other measurements
				KA	MA	KA	MA	KA	MA	KA	MA					
Dossett et al. [18]	United States	PRCT	24	44	44	66	66	41	38	29	32	KA: Vanguard, CR, FB, SR, cemented, all PR MA: Vanguard, CR, FB, SR, cemented, all PR	KA: PSI MA: Conventional	OKS, WOMAC, KSS, ROM	HKA, AKA, JLOA, FMA, TMA	Complications
Yeo et al. [39]	South Korea	PRCT	96	30	30	72	74	27	25	27	26	KA: NexGen, CR, FB, MR, cemented, partial PR MA: NexGen, CR, FB, MR, cemented, partial PR	KA: ROBDOC system, robotic aassisted MA: Robotic aassisted	HSS, WOMAC, KSS, ROM	HKA, FMA, TMA, TS	Gait analysis
Laende et al. [40]	Canada	PRCT	24	24	23	64	63	16	17	36	34	KA: Triathlon, CR, FB, SR, cemented, all PR MA: Triathlon, CR, FB, SR, cemented, all PR	KA: PSI MA: Computer navigation	OKS, satisfaction, UCLA	HKA, MPTA	Tibial migration
McEwen et al. [41]	Australia	PRCT	24	41	41		65	NA			31	KA: Triathlon, CR, FB, SR, cementless femur, cemented tibia, partial PR MA: Triathlon, CR, FB, SR, cementless femur, cemented tibia, partial PR	KA: computer navigation MA: computer navigation	OKS, FJS, KOOS, JR, ROM	HKA, FMA, TMA, TS, JLOA, JLCA, PTA	Intraoperative gap laxity, soft tissue release, 4 specific clinical questions, complications
Young et al. [38]	New Zealand	PRCT	60	47	48	72	70	25	26	30	31.5	KA: Triathlon, CR, FB, SR, cemented, partial PR MA: Triathlon, CR, FB, SR, cemented, partial PR	KA: PSI MA: Computer navigation	OKS, WOMAC, FJS, KSS, VAS	HKA, FMA, TMA, TS	Intraoperative gap laxity, soft tissue release, complications

Kinematic versus mechanical alignment for primary total knee arthroplasty with minimum 2 years follow-up: a systematic review

Elliot Sappey-Marinier[1,*], Adrien Pauvert[1], Cécile Batailler[1], John Swan[1], Laurence Cheze[2], Elvire Servien[1,3], and Sébastien Lustig[1,2]

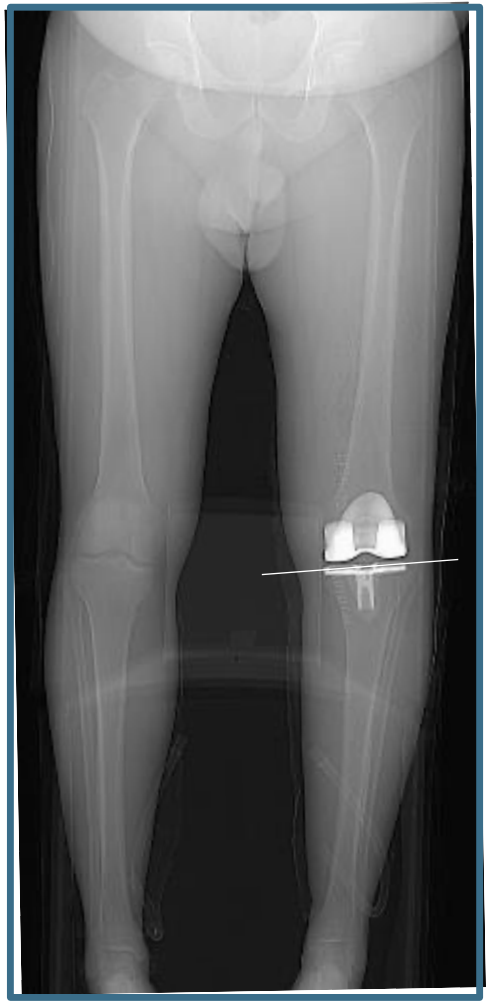
[1] FIFA medical center of excellence, Orthopaedics Surgery and Sports Medicine Department, Croix-Rousse Hospital, Hospices Civils de Lyon, 103 Grande rue de la Croix Rousse, 69004 Lyon, France
[2] Univ Lyon, Claude Bernard Lyon 1 University, IFSTTAR, LBMC UMR_T9406, 69622 Lyon, France
[3] LIBM – EA 7424, Interuniversity Laboratory of Biology of Mobility, Claude Bernard Lyon 1 University, 69100 Villeurbanne, France

Received 23 April 2020, Accepted 24 April 2020, Published online 17 June 2020

« … » In conclusion, we found that KA in TKA achieved **clinical and radiological results similar to those of MA**. « … » The complication rate was not increased for KA TKAs. The present review suggests that ***KA is an acceptable and alternative alignment to MA.*** « … »

The real question ….

Residual varus ?



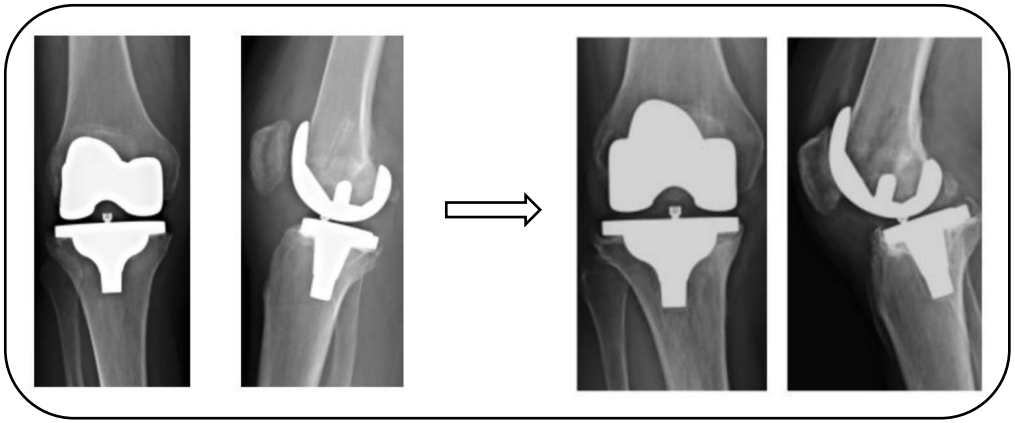
Knee Surgery, Sports Traumatology, Arthroscopy
https://doi.org/10.1007/s00167-021-06714-5

KNEE

Restricted kinematic alignment may be associated with increased risk of aseptic loosening for posterior-stabilized TKA: a case–control study

Elliot Sappey-Marinier[1,2] · Jobe Shatrov[3,4,5] · Cécile Batailler[1,2] · Axel Schmidt[1] · Elvire Servien[1,6] · Emmanuel Marchetti[7] · Sébastien Lustig[1,2]

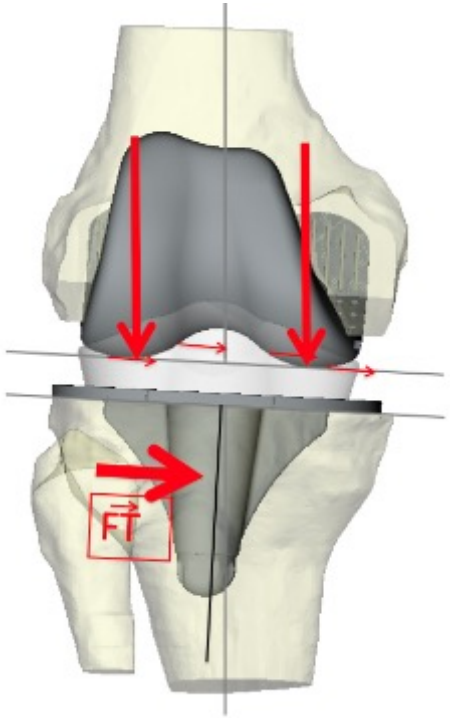
KA 4ys FU → 84% Survival rate….

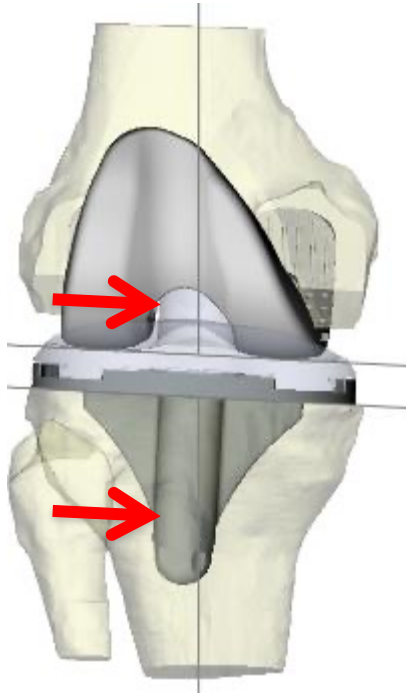


Limits ?…

Which implant ?

CS

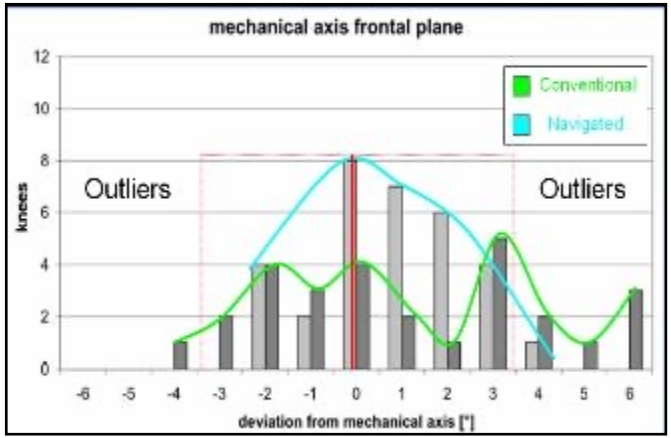


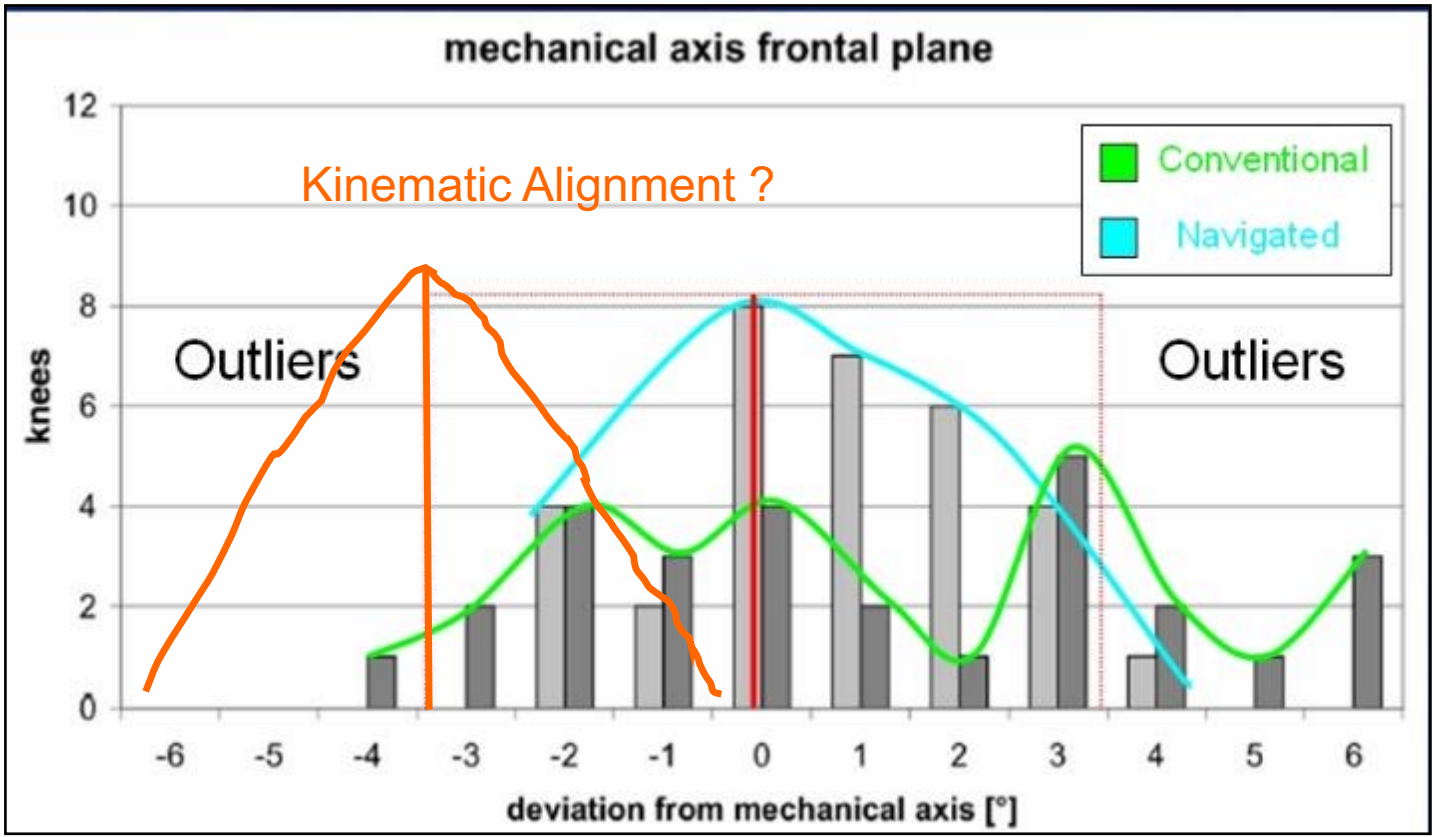


PS

Risk of Malposition ?

Mechanical alignment Camel Curve




mechanical axis frontal plane
Kinematic Alignment ?
Conventional
Navigated
Outliers
Outliers
knees
12
10
8
6
4
2
0
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
deviation from mechanical axis [°]

Fact n°1 :
Smart tools mandatory

Vs

Safe zone ?

Restricted Kinematic Alignment

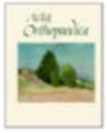
HKA + /- 3°
Femoral & Tibia max 5°

Since 2011

The Journal of Arthroplasty 32 (2017) 2133–2140

The Impact of Mechanical and Restricted Kinematic Alignment on Knee Anatomy in Total Knee Arthroplasty

Abdulaziz M. Almaawi, MD, MSc, FRCSC [a], Jonathan R.B. Hutt, MA, MBBS, FRCS (Tr+Orth) [b], Vincent Masse, MD, FRCSC [a], Martin Lavigne, MD, MSc, FRCSC [a], Pascal-Andre Vendittoli, MD, MSc, FRCSC [a,*]



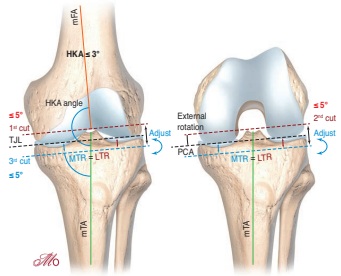
Less gap imbalance with restricted kinematic alignment than with mechanically aligned total knee arthroplasty: simulations on 3-D bone models created from CT-scans

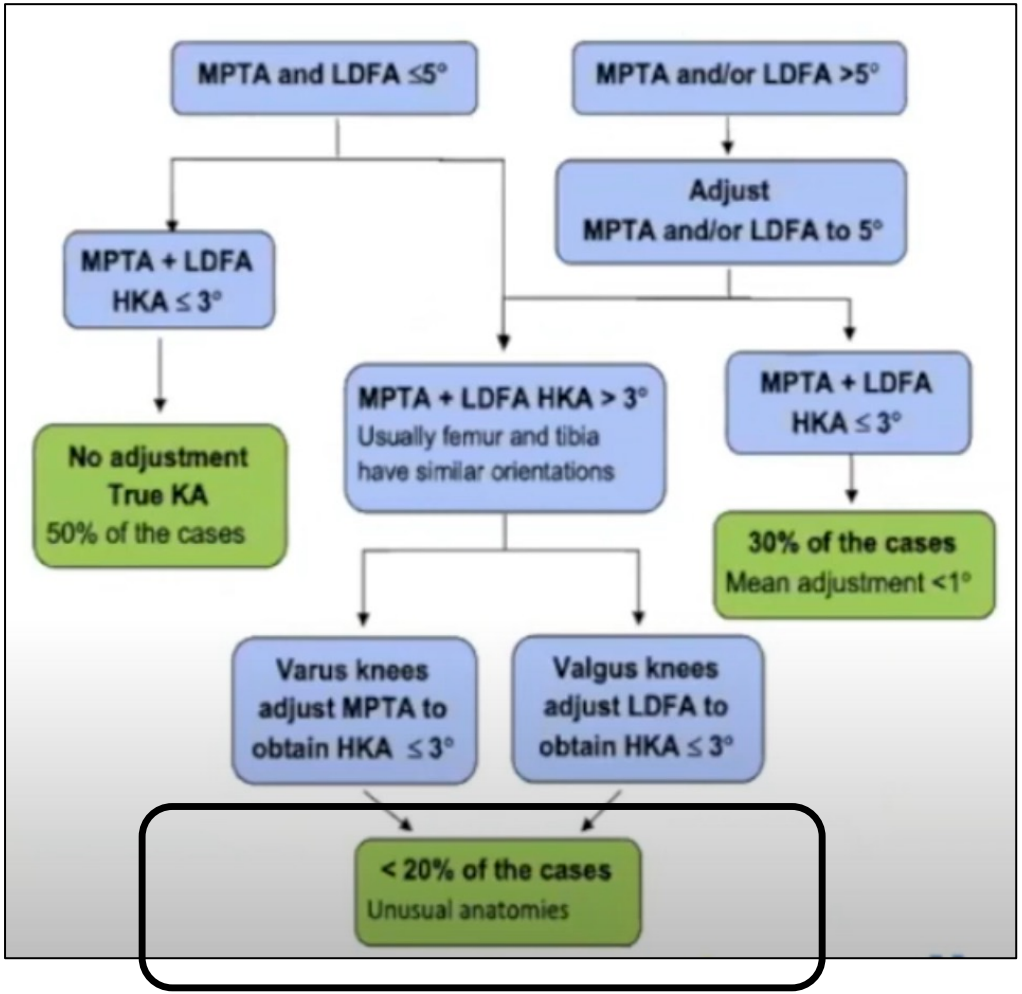
William Blakeney, Yann Beaulieu, Marc-Olivier Kiss, Charles Rivière & Pascal-André Vendittoli

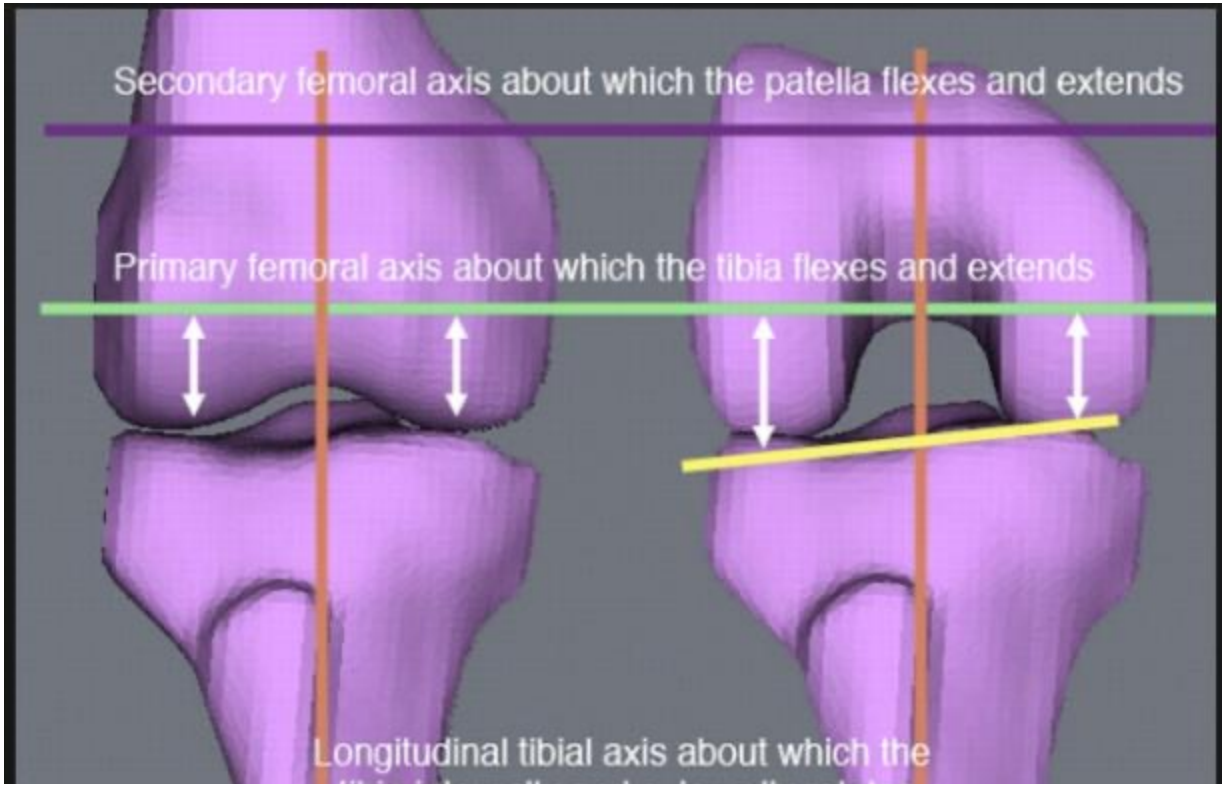
Hôpital Maisonneuve-Rosemont
Centre affilié à l'Université de Montréal

Université de Montréal

"…" "safe zones" for TKA alignment and suggested the use of a restricted KA protocol "…"




MPTA and LDFA ≤5°
MPTA and/or LDFA >5°
Adjust
MPTA and/or LDFA to 5°
MPTA + LDFA
HKA ≤ 3°
No adjustment
True KA
50% of the cases
MPTA + LDFA HKA > 3°
Usually femur and tibia
have similar orientations
MPTA + LDFA
HKA ≤ 3°
30% of the cases
Mean adjustment <1°
Varus knees
adjust MPTA to
obtain HKA ≤ 3°
Valgus knees
adjust LDFA to
obtain HKA ≤ 3°
< 20% of the cases
Unusual anatomies

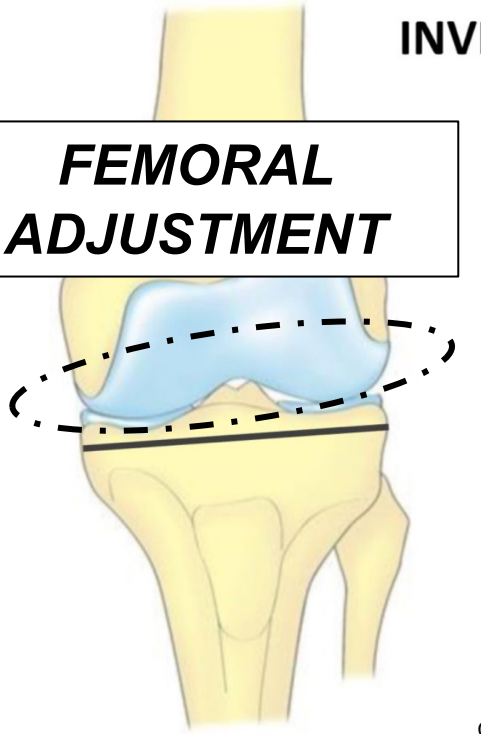


Varus Tibial
Femur internal rotation (/ ATE)


DEBOUT
SCHUSS

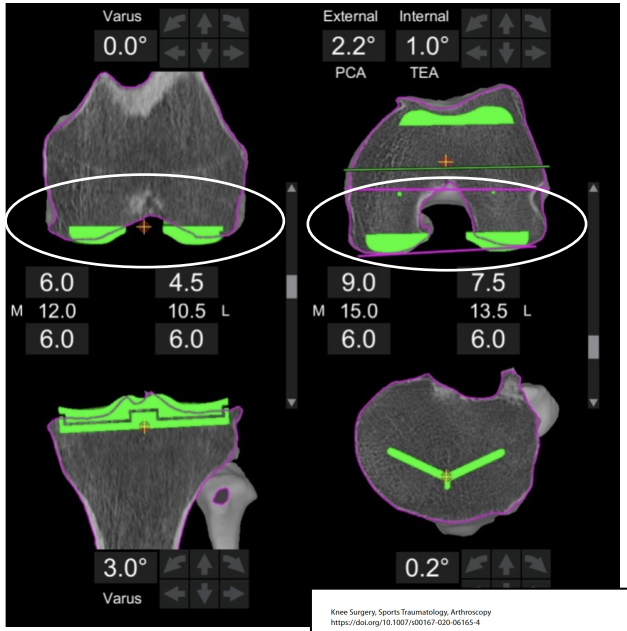
INVERSE KINEMATIC ALIGNMENT

FEMORAL ADJUSTMENT



FEMUR

TIBIA



Courtesy Philip Winnock de Grave, MD

Knee Surgery, Sports Traumatology, Arthroscopy
https://doi.org/10.1007/s00167-020-06165-4

KNEE

Higher satisfaction after total knee arthroplasty using restricted inverse kinematic alignment compared to adjusted mechanical alignment

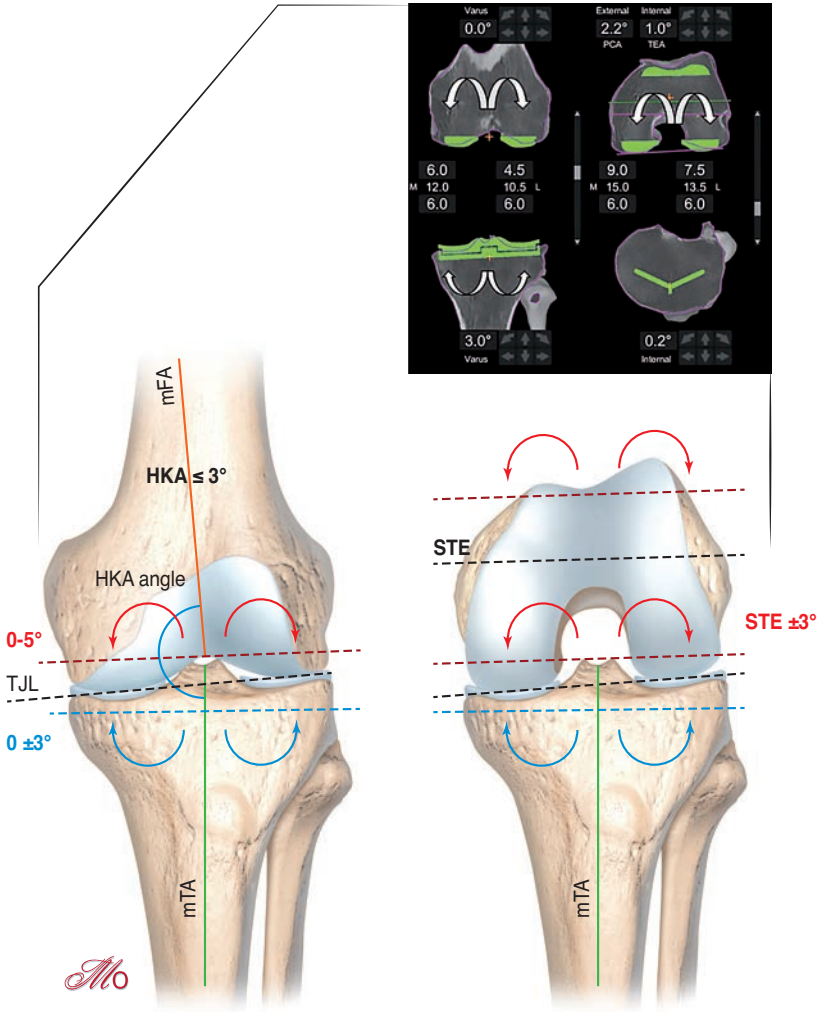
Philip Winnock de Grave[1] · Thomas Luyckx[1,2] · Kurt Claeys[3] · Thomas Tampere[1,4] · Jonas Kellens[1,2] · Jacobus Müller[5] · Paul Gunst[1]

Functional alignment

Review > Bone Joint J. 2020 Mar;102-B(3):276-279.
doi: 10.1302/0301-620X.102B3.BJJ-2019-1729.

Alignment in total knee arthroplasty

Sam Oussedik [1], Matthew P Abdel [2], Jan Victor [3], Mark W Pagnano [2], Fares S Haddad [4]


Varus
0.0°
External
Internal
2.2°
1.0°
PCA
TEA
6.0
4.5
M 12.0
10.5 L
6.0
6.0
9.0
7.5
M 15.0
13.5 L
6.0
6.0
3.0°
Varus
0.2°
Internal
mFA
HKA ≤ 3°
HKA angle
0-5°
TJL
0 ±3°
mTA
STE
STE ±3°
mTA

SICOT-J 2022, **8**, 11

https://doi.org/10.1051/sicotj/2022010

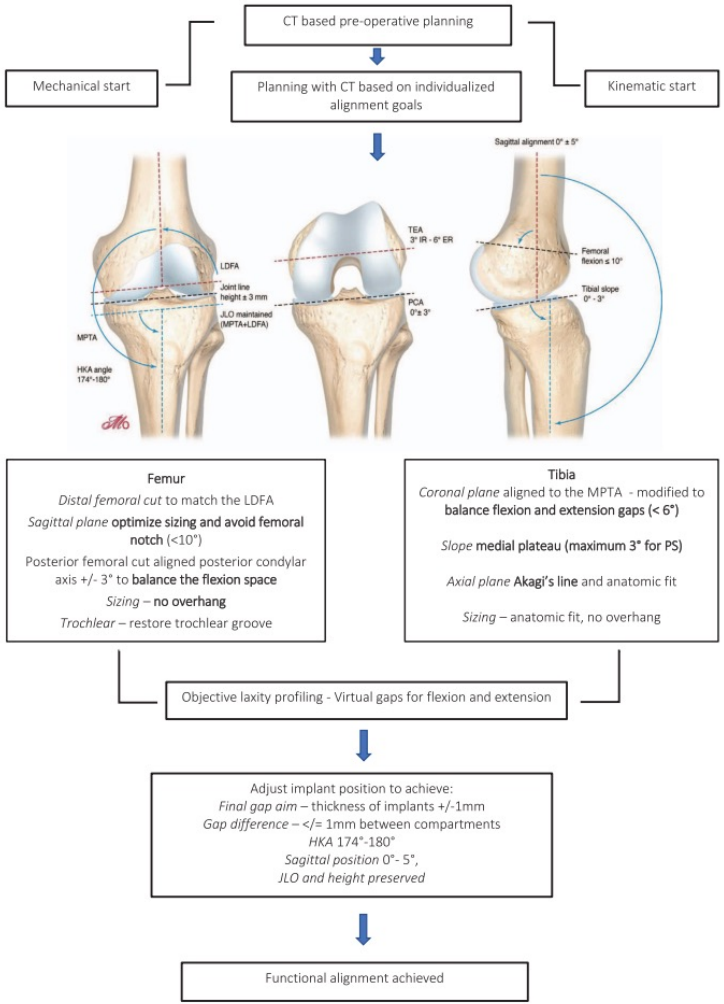
SICOT-J

Available online at:
www.sicot-j.org

ORIGINAL ARTICLE OPEN ACCESS

Functional Alignment Philosophy in Total Knee Arthroplasty – Rationale and technique for the varus morphotype using a CT based robotic platform and individualized planning

Jobe Shatrov[1,2], Cécile Battelier[1,3], Elliot Sappey-Marinier[1,3], Stanislas Gunst[1,3], Elvire Servien[1,3], and Sebastien Lustig[1,3,*]



Femur

Distal femoral cut to match the LDFA

Sagittal plane **optimize sizing and avoid femoral notch** (<10°)

Posterior femoral cut aligned posterior condylar axis +/- 3° to **balance the flexion space**

Sizing – **no overhang**

Trochlear – restore trochlear groove

Tibia

Coronal plane aligned to the MPTA - modified to **balance flexion and extension gaps (< 6°)**

Slope **medial plateau (maximum 3° for PS)**

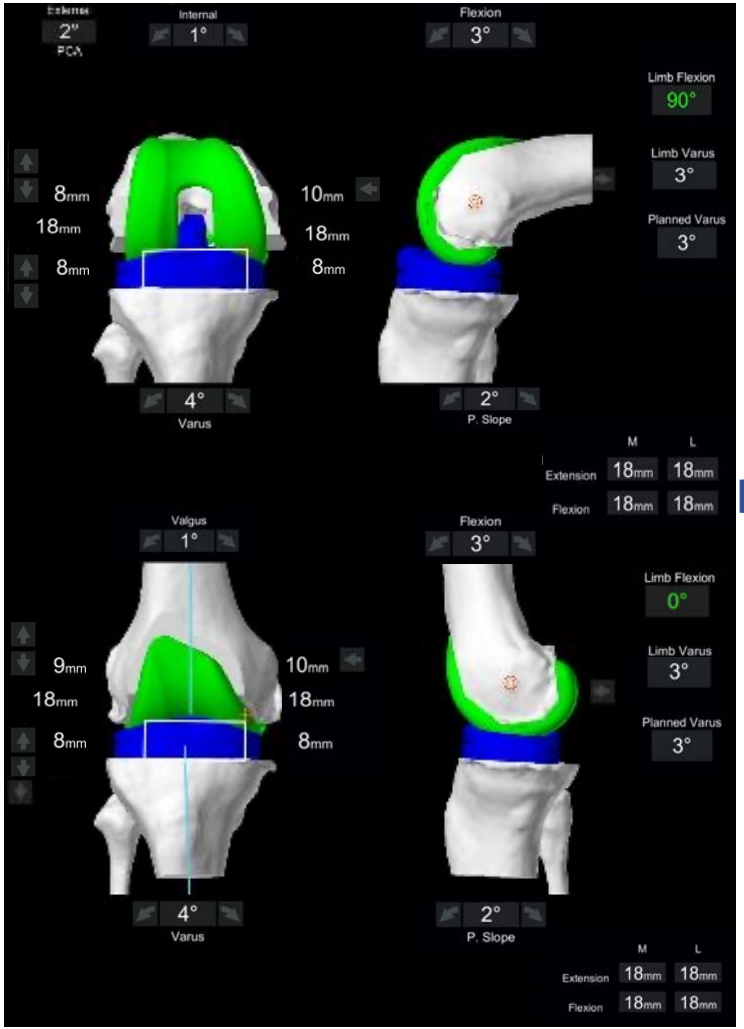
Axial plane **Akagi's line** and anatomic fit

Sizing – anatomic fit, no overhang

Objective laxity profiling - Virtual gaps for flexion and extension

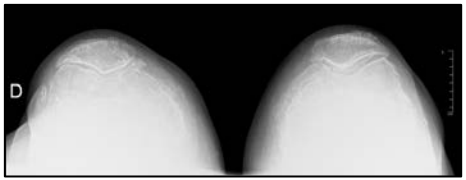
Adjust implant position to achieve:

Final gap aim – thickness of implants +/-1mm


Internal
1°
Flexion
3°
Limb Flexion
90°
Limb Varus
3°
Planned Varus
3°
8mm
18mm
8mm
10mm
18mm
8mm
4°
Varus
2°
P. Slope
M
L
Extension
18mm
18mm
Flexion
18mm
18mm
Valgus
1°
Flexion
3°
Limb Flexion
0°
Limb Varus
3°
Planned Varus
3°
9mm
18mm
8mm
10mm
18mm
8mm
4°
Varus
2°
P. Slope
M
L
Extension
18mm
18mm
Flexion
18mm
18mm

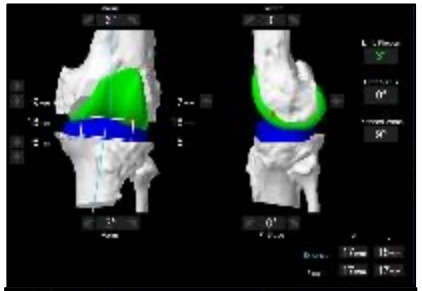

D
D

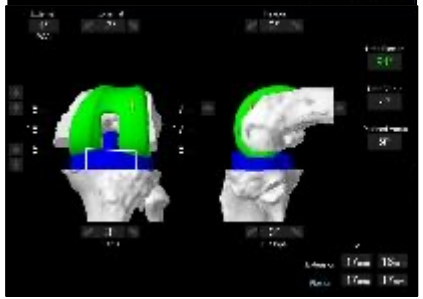

GAU
AFTm GAUCHE
∠1: 166°
AFm GAUCHE
∠2: 84°
ATm GAUCHE
∠3: 87°

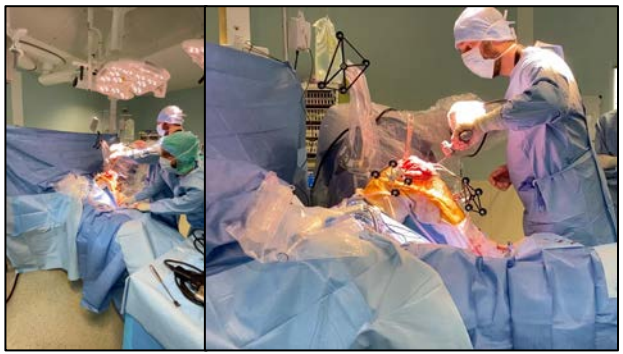

D

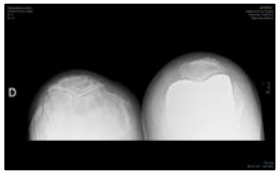

G


G



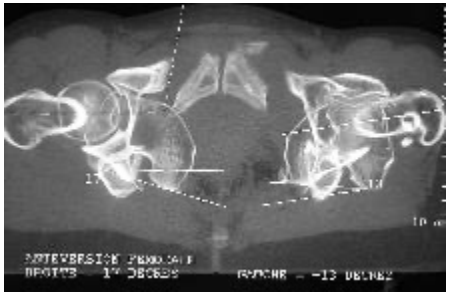


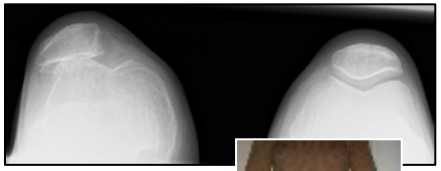


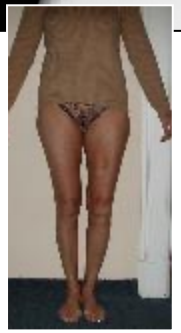

D


G
G

Sagittal / Rotational







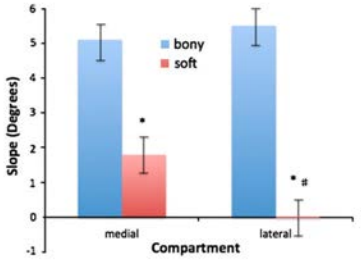
Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-012-1990-x

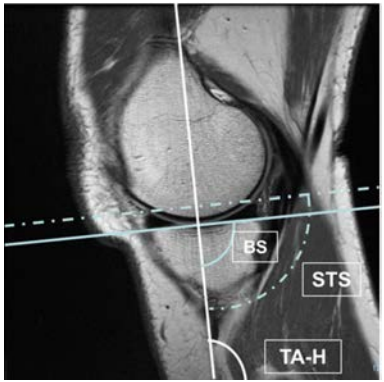
KNEE

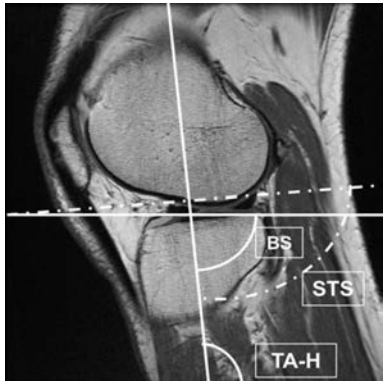
Influence of soft tissues on the proximal bony tibial slope measured with two-dimensional MRI

Sébastien Lustig · Corey J. Scholes ·
Sean P. M. Leo · Myles Coolican · David A. Parker

Variability

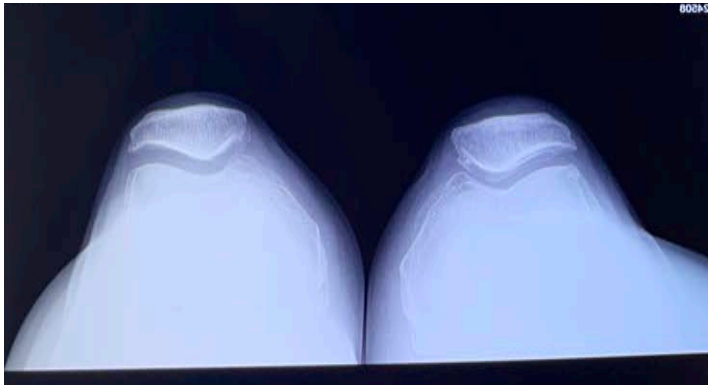


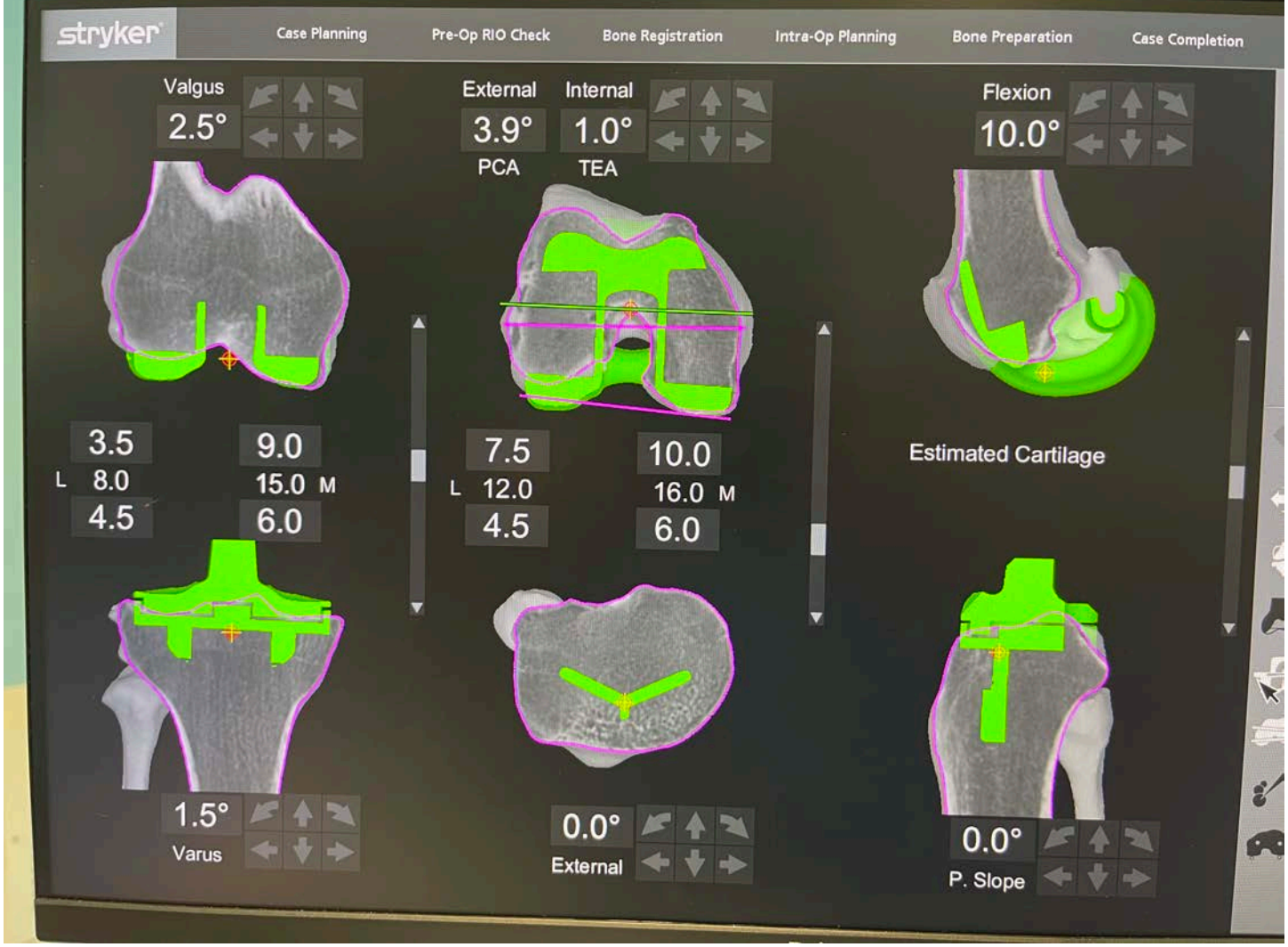


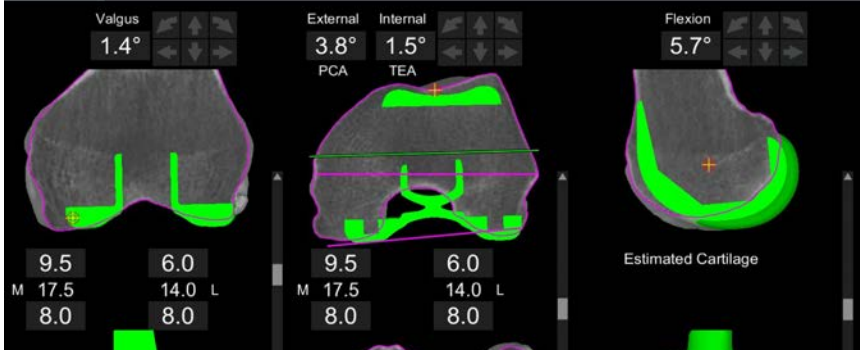


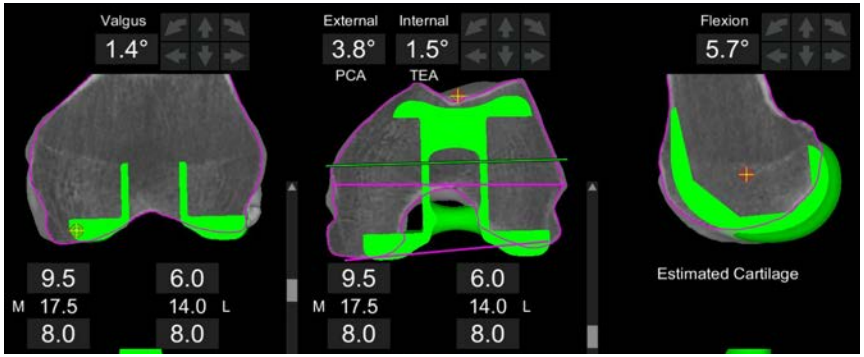

RAD_Genou F Dte
G +0.20
DF +0.50 / 7
H +0.25 / 255

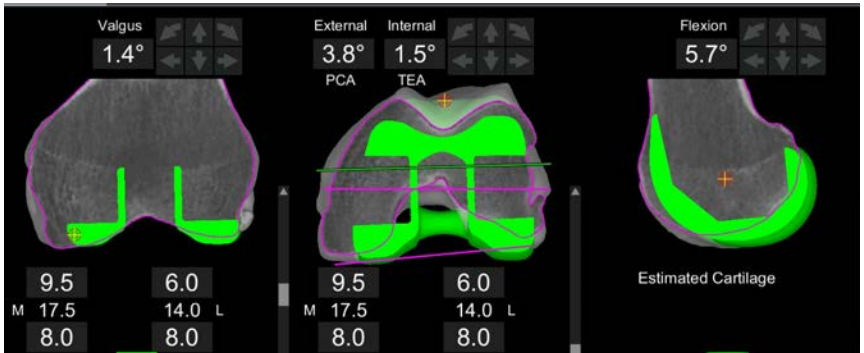

MA 1
Time: 17/02/2023
DROIT




stryker
Case Planning
Pre-Op RIO Check
Bone Registration
Intra-Op Planning
Bone Preparation
Case Completion
Valgus
2.5°
External
3.9°
PCA
Internal
1.0°
TEA
Flexion
10.0°
3.5
L 8.0
4.5
9.0
15.0 M
6.0
7.5
L 12.0
4.5
10.0
16.0 M
6.0
Estimated Cartilage
1.5°
Varus
0.0°
External
0.0°
P. Slope


Valgus
1.4°
External
3.8°
PCA
Internal
1.5°
TEA
Flexion
5.7°
9.5
6.0
M 17.5
14.0 L
8.0
8.0
9.5
6.0
M 17.5
14.0 L
8.0
8.0
Estimated Cartilage


Valgus
1.4°
External
3.8°
PCA
Internal
1.5°
TEA
Flexion
5.7°
9.5
6.0
M 17.5
14.0 L
8.0
8.0
9.5
6.0
M 17.5
14.0 L
8.0
8.0
Estimated Cartilage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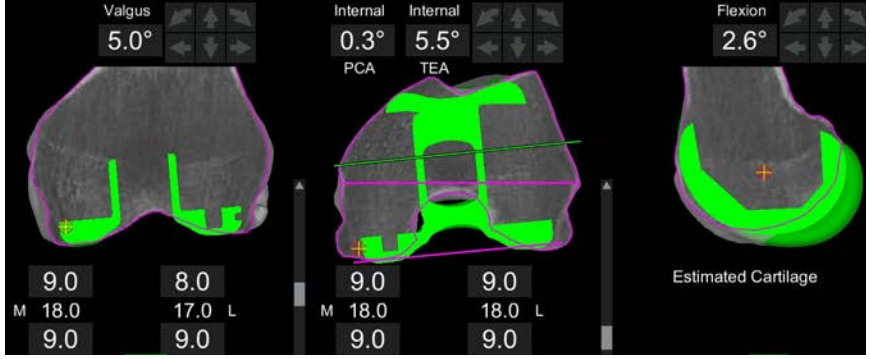
1.4°
External
3.8°
PCA
Internal
1.5°
TEA
Flexion
5.7°
9.5
6.0
M 17.5
14.0 L
8.0
8.0
9.5
6.0
M 17.5
14.0 L
8.0
8.0
Estimated Cartilage


Valgus
5.0°
Internal
0.3°
PCA
Internal
5.5°
TEA
Flexion
2.6°
9.0
8.0
M 18.0
17.0 L
9.0
9.0
9.0
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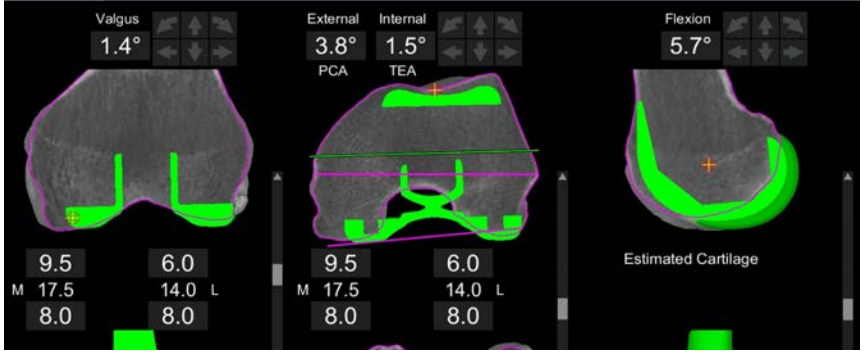
M 18.0
18.0 L
9.0
9.0
Estimated Cartilage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3.8°
PCA
Internal
1.5°
TEA
Flexion
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9.5
6.0
M 17.5
14.0 L
8.0
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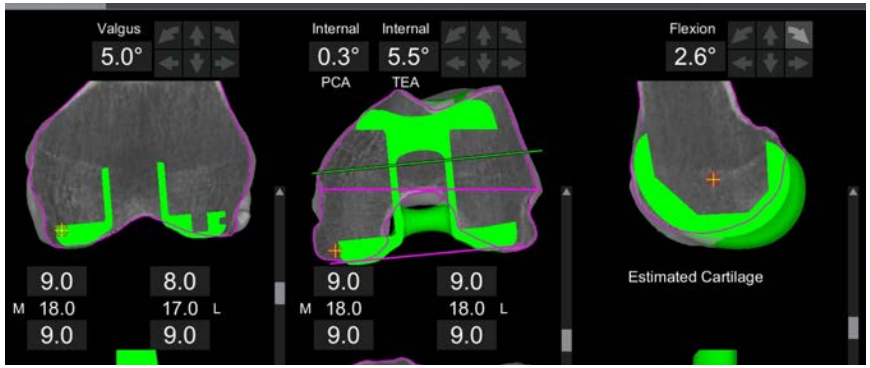
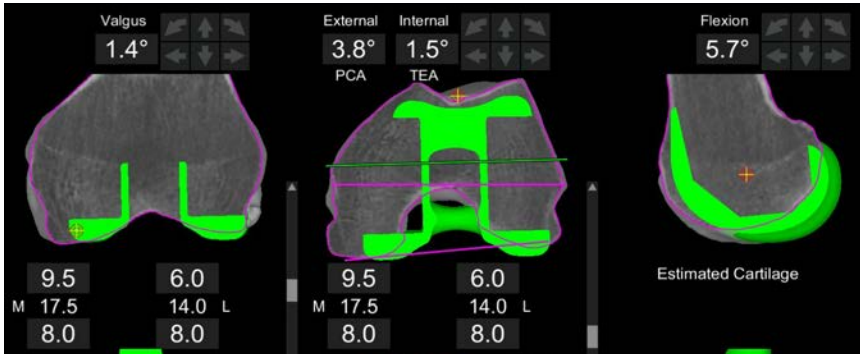
9.5
6.0
M 17.5
14.0 L
8.0
8.0
Estimated Cartilage


Valgus
5.0°
Internal
0.3°
PCA
Internal
5.5°
TEA
Flexion
2.6°
9.0
8.0
M 18.0
17.0 L
9.0
9.0
9.0
9.0
M 18.0
18.0 L
9.0
9.0
Estimated Cartilage


Valgus
1.4°
External
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PCA
Internal
1.5°
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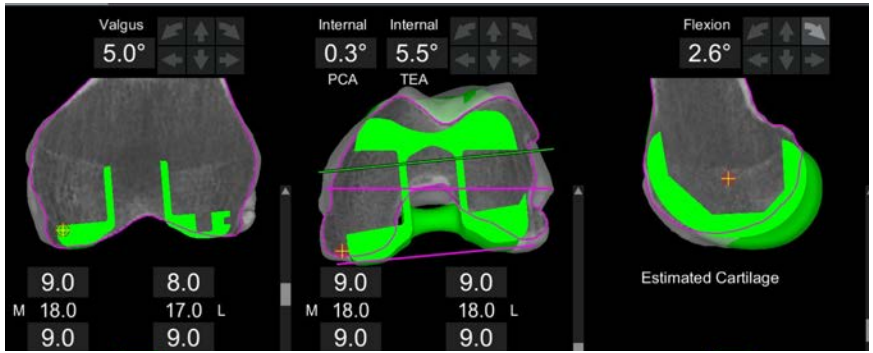
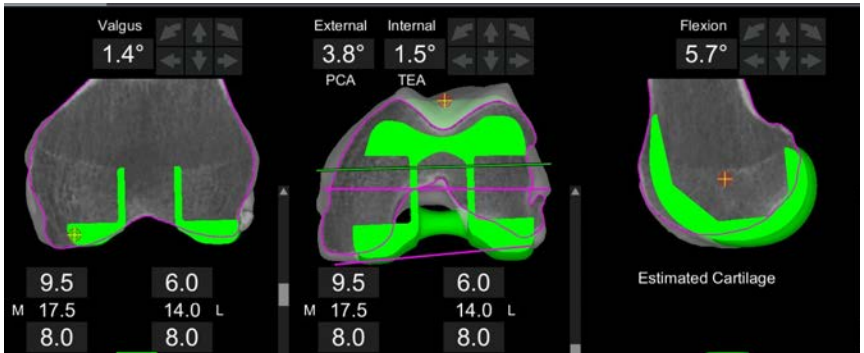
Flexion
5.7°
9.5
6.0
M 17.5
14.0 L
8.0
8.0
9.5
6.0
M 17.5
14.0 L
8.0
8.0
Estimated Cartilage


Valgus
5.0°
Internal
0.3°
PCA
Internal
5.5°
TEA
Flexion
2.6°
9.0
8.0
M 18.0
17.0 L
9.0
9.0
9.0
9.0
M 18.0
18.0 L
9.0
9.0
Estimated Cartilage


Valgus
1.4°
External
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PCA
Internal
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Flexion
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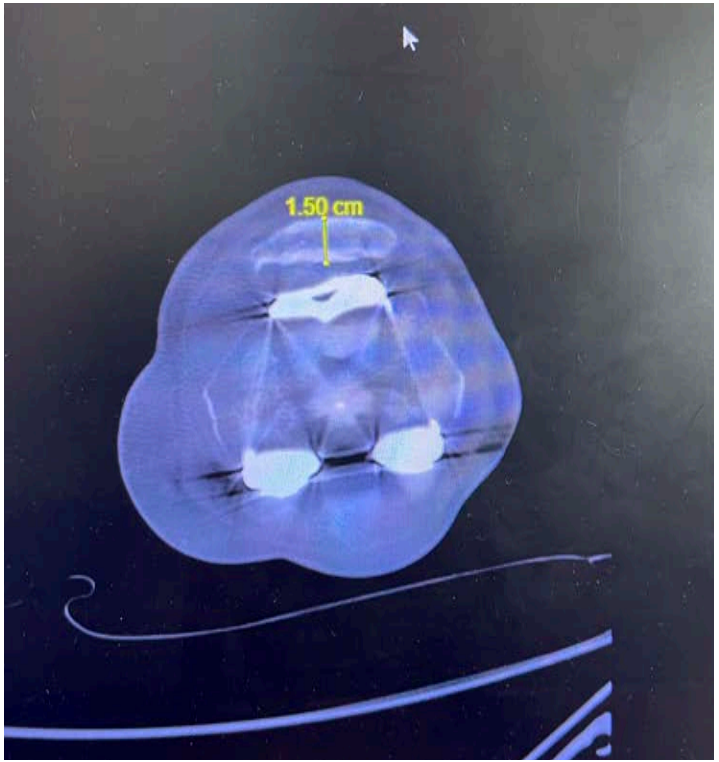
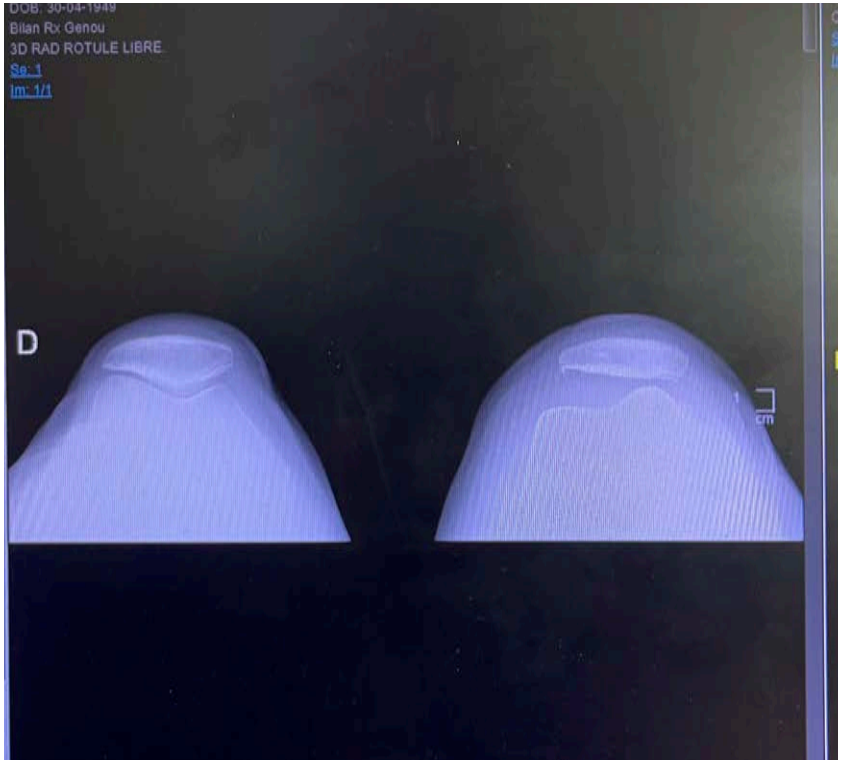
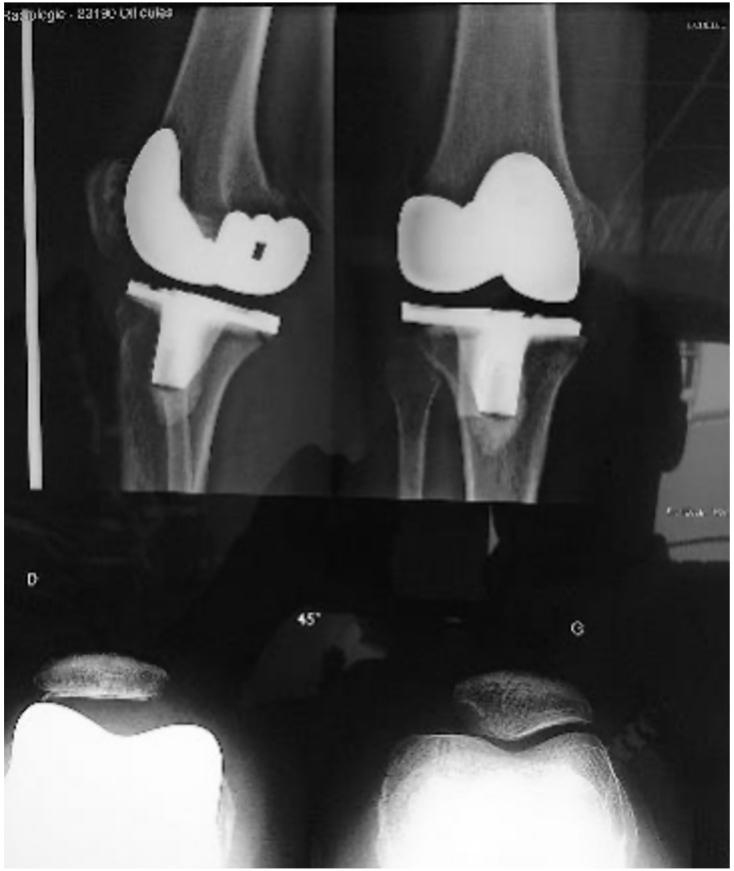
6.0
M 17.5
14.0 L
8.0
8.0
9.5
6.0
M 17.5
14.0 L
8.0
8.0
Estimated Cartilage

Potentiel issue with KA… and no bounderies







Patellar problems ?

Nedopil AJ, Howell SM, Hull ML: ***Does Malrotation of the Tibial and Femoral Components Compromise Function in Kinematically Aligned Total Knee Arthroplasty***
Orthop Clin North Am. 2016 Jan;47(1):41-50. ***?***

TAKE HOME MESSAGE

- ***Need for personalized alignment***
- ***Define safe zones***
- ***For coronal alignment***
- ***But also rotational and sagittal (Patella ++)***

« It ain't what you don't know that gets you into trouble,

it's what you know for sure that just ain't so »

Mark twain

Safe Invidual functional positioning
for each patient