Patient Specific Instrumentation ®

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1.Why do I use PSI ?

2.How does it work ?

3.Is it worth?

1. Why do I use PSI

THA and Navigation: CAS

Validation and Usefulness of a Computer-Assisted Cup-Positioning System in Total Hip Arthroplasty. A Prospective, Randomized, Controlled Study

Sebastien Parratte and Jean-Noel A. Argenson
J Bone Joint Surg Am. 2007;89:494-499. doi:10.2106/JBJS.F.00529

The use of ultrasound in acquisition of the anterior pelvic plane in computer-assisted total hip replacement
A CADAVER STUDY

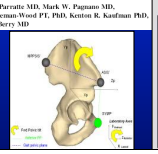
S. Parratte, P. Kilian, V. Pauly, P. Champsaur, J.-N. A. Argenson

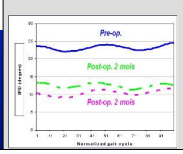
The 2008 Frank Stinchfield Award

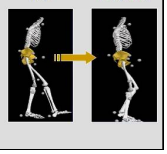
Clin Orthop Relat Res

Variation in Postoperative Pelvic Tilt May Confound the Accuracy of Hip Navigation Systems

Sebastien Parratte MD, Mark W. Pagnano MD, Krista Coleman-Wood PT, PhD, Kenton R. Kaufman PhD, Daniel J. Berry MD

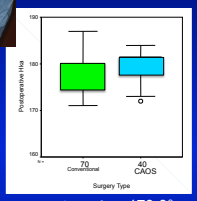






TKA and Navigation

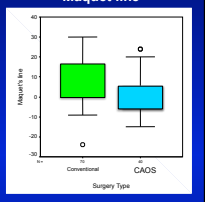
HKA



177.5° 179.3°

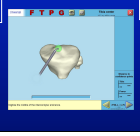
P=0.031

Maquet line



8 mm 2.3mm

P=0.027



Navigation

Basic promise of CAS in TKA

THE JOURNAL OF BONE & JOINT SURGERY [BR]

Alignment in total knee arthroplasty

A COMPARISON OF COMPUTER-ASSISTED SURGERY WITH THE CONVENTIONAL TECHNIQUE

H. Bäthis, L. Perlick, M. Tingart,

Restoration of neutral alignment of the leg is an important factor affecting the long-term results of total knee arthroplasty (TKA). Recent developments in computer-assisted surgery have focused on systems for improving TKA.

G. Matz

TKA CAS

Imp
Mec

Axial alignment of the limb with restoration of the mechanical axis is a determinant of the outcome. A mechanical axis within a range of ±3° varus/valgus is thought to be associated with a better outcome.[6-11] However, in previous

Lotke PA and Ecker ML, JBJS Am 1977: Short X-rays

Hvid I and Nielsen S, Acta Orthop Scand, 1984: Short X-rays

Rand JA and Coventry MB, Clin Orthop, 1988: Short X-rays

Bargren JH et al., CORR, 1983: Short X-rays

Moreland J, CORR, 1988: Review

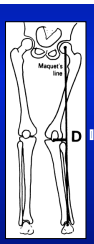
Berend ME et al., CORR, 1988: Short X-rays

Jeffery RS et al., JBJS Br, 1991: **Full-length X-rays**

CORONAL ALIGNMENT
AFTER TOTAL KNEE REPLACEMENT

J Bone Joint Surg [Br] 1991; 73-B:709–14.

ROBERT S. JEFFERY, RICHARD W. MORRIS, ROBIN A. DENHAM



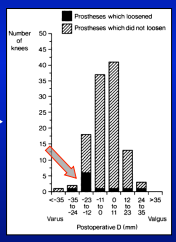
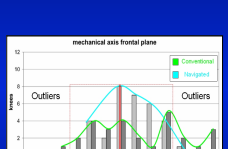


Fig. 1

The tibial component with a removable intramedullary guide rod, and two views of the femoral component.

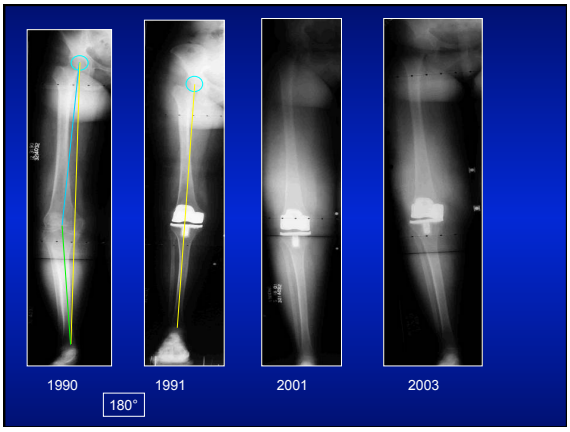
The limit of the concept

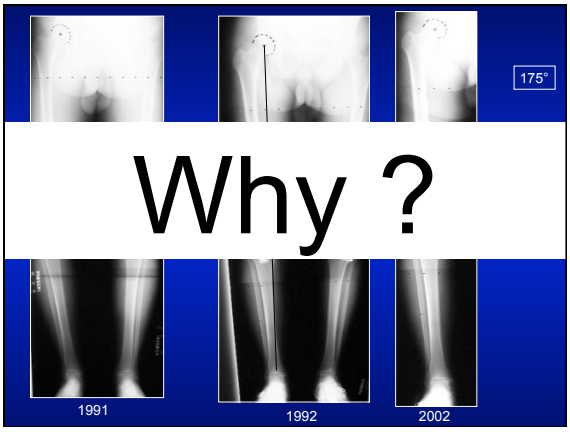
- Unable to confirm the CAO TKA assumption



Effect of Postoperative Mechanical Axis Alignment on the Fifteen-Year Survival of Modern, Cemented Total Knee Replacements

Sebastien Parratte, Mark W. Pagnano, Robert T. Trousdale and Daniel J. Berry
J Bone Joint Surg Am. 2010;92:2143-2149. doi:10.2106/JBJS.I.01398





TKA: Basic requirement

"Just enough but not too much "

- **Mobility**
- **Stability**

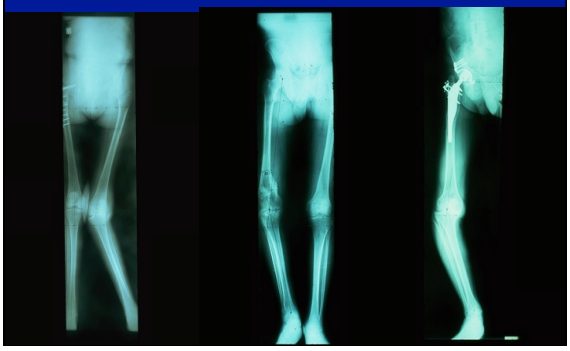
→ **Constrain**

Best compromise

- **Alignment**
- **Fixation**

→ **Stem**

Evaluation in TKA: 2-D

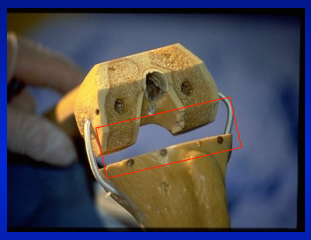


Knee=> An AP view way of thinking?

Rotational alignment and the knee AP envelope

Parratte, Argenson, Zingde, Lesko, Komistek, In Press

TKA: 3D spaces



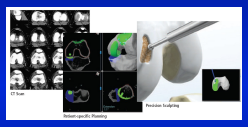
Frontal: the « known one »
Sagittal : the forgotten
Rotation: the mistery

I'm not sure to be good everytime

Solutions in 2013 Smart tools

Navigation
NO ROTATION

Robot: Not for TKA/COST



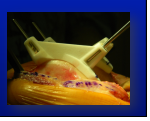
Patient Specific Instrumentation

Solution ?

2. How does it work ?

Basic Principle

MRI or CT are used to generate a specific model of the patient knee with a rapid model sampling and the integration of a 3-D printing technology that allowed to produce a patient specific instrumentation



Comment cela se passe?

- INDICATION ⇔ Standard screening
- MRI

=>Hip, Knee, Ankle

- Segmentation

=>Proposed planning

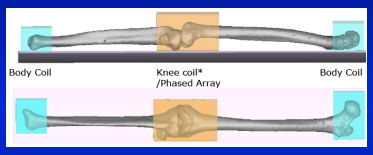
- Surgeon valid the planning

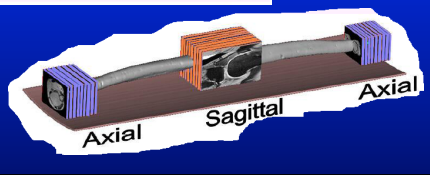
=>Guide preparation= 3-D printing

- Surgery

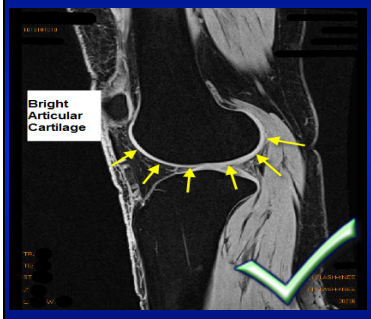
Based on MRI

- Mechanical axis





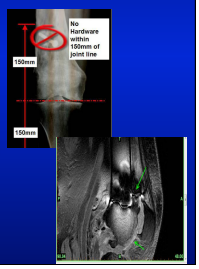
Cartilage extraction



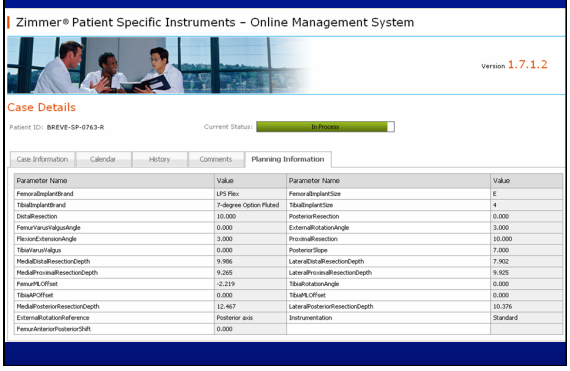
Opitimal image quality

Qualify the MRI

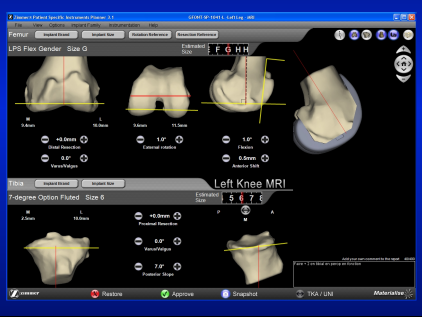
Qualified center
Specific protocol
Images up-load according to the specific protocol



Online Managment system

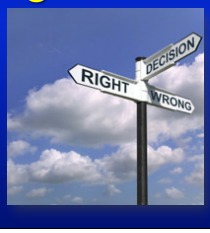


Segmentation performed By the engineers



Planning is proposed to the surgeon

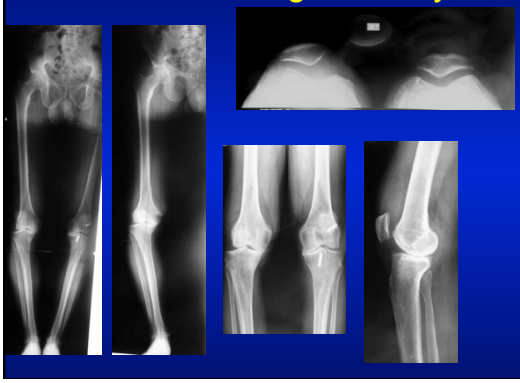
The surgeon remains the surgeon, not the Engineers !



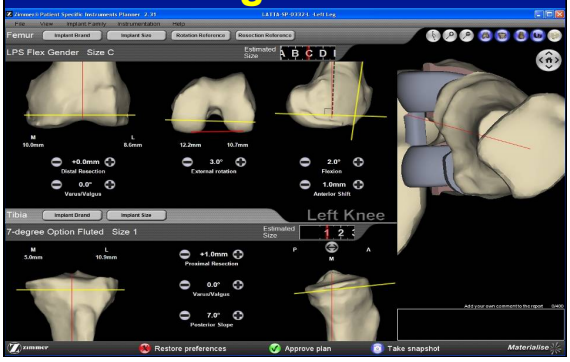
Back to the case

- Patient
- Indication
- Standing Alignement on the full-length x-rays
- Analysis of the patello-femoral joint on the sky-line views=> choose the rotation

Basic radiological analysis



Planning is the KEY

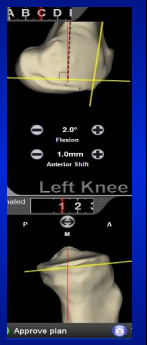


Virtual Surgery

1. Extension Space
   - Distal femoral cut
   - Tibial cut

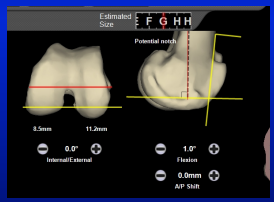
Frontal

Sagittal



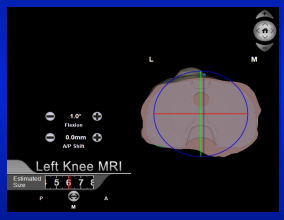
Virtual Surgery

Flexion Space
- Femoral sizing
- Femoral rotation



Virtual Surgery

– Tibial sizing
– Tibial Rotation

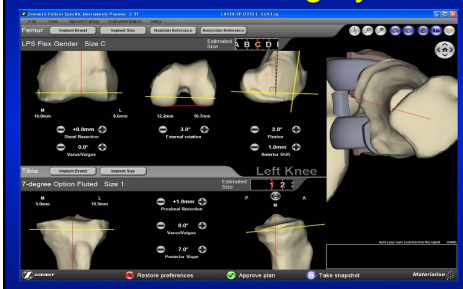


Check and valid

6 weeks after the MRI

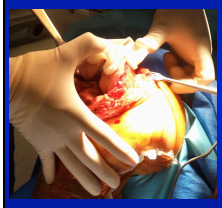
- Guides +/-Knee model
- Guides are not sterilized => sterilisation process

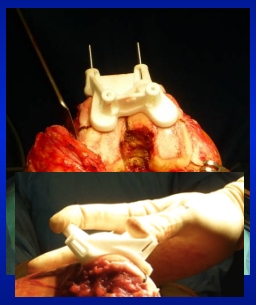
Back to the planning just before the surgery



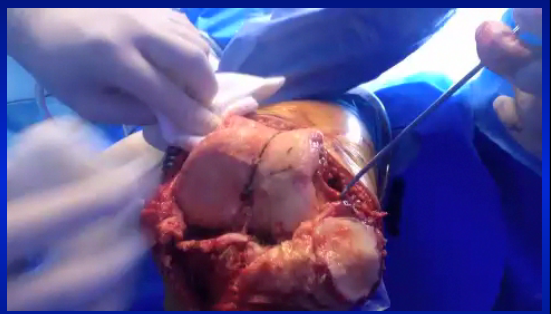
Print and sterilized the planning

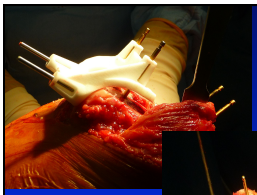
Femur first: five cuts
4 hands: 2 for the guide/ 2 for the pins



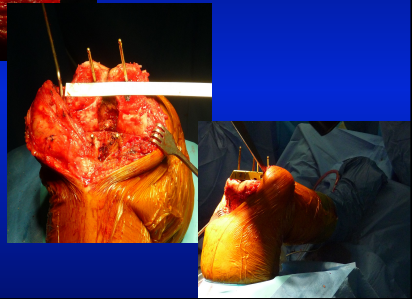


Dry the surfaces

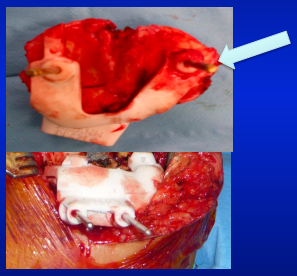




Control of the rotation

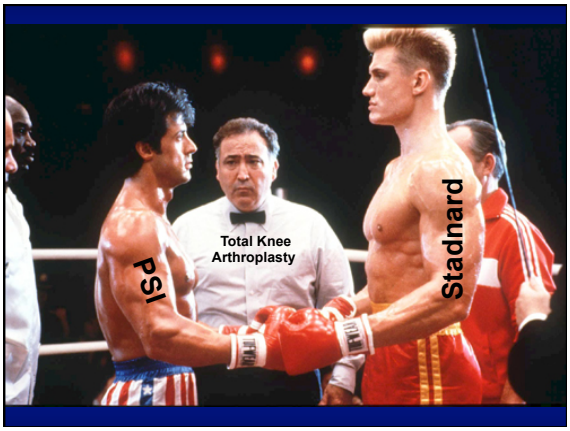


Then tibial cut



Is it worth?

Stories are nice but we do need data



Study 1: Prospective comparative randomized Study : PSI in TKA

Standard: 20 Knees

X-Ray and MRI Screening → Surgery → 2 Surgeons: JNA / SP → Evaluation

PSI : 20 Knees

Marseille
Gait analysis
Static Alignement
Dynamic Alignement
CT-Scann rotation

Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-013-2623-8

KNEE

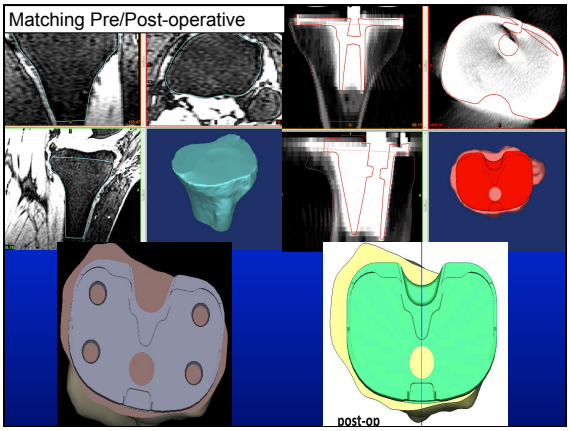
Rotation in total knee arthroplasty: no difference between patient-specific and conventional instrumentation

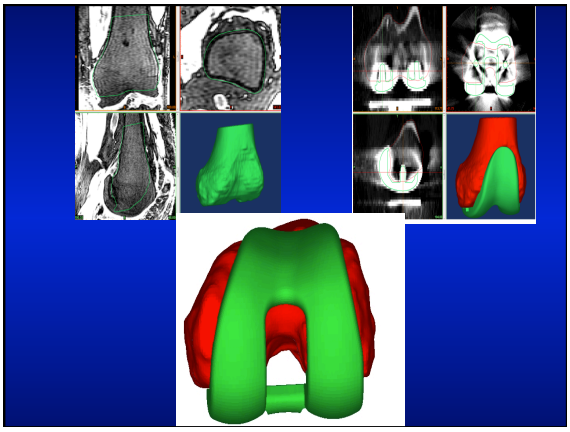
Sébastien Parratte · Guillaume Blanc · Thomas Boussemart · Matthieu Ollivier · Thomas Le Corroller · Jean-Noël Argenson

Received: 22 July 2013 / Accepted: 3 August 2013

Paper Accepted AAOS 2014 and CORR

No functional benefit after TKA performed with Patient Specific Instrumentation: Results of a prospective controlled randomized study based on gait analysis and patient rated outcomes





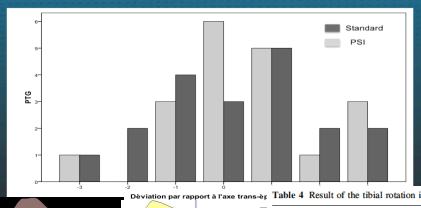
Results : Matching Pre/Post

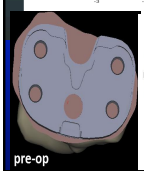
Difference pre/post-op	Mean	Max	Mini	SD	95 % CI
Femur					
Distal cut varus angle (°)	1.4	−2.9	4.1	1.1	0.5
Distal cut flexion angle (°)	2.6	−0.8	6.8	1.8	0.9
Distal cut (mm)	1.1	−2.6	2.6	0.9	0.4
Posterior cut (mm)	1.1	−2.0	2.8	0.7	0.4
Femoral rotation (°)	0.9	−3.4	2.2	0.9	0.5
Tibia					
Tibial slope angle (°)	2.2	−2.5	5.6	1.5	0.8
Tibial proximal cut (°)	1.2	−2.9	3.6	1.0	0.5
Tibial rotation (°)	6.8	−4.1	12.6	4.1	2.1

Differences are expressed in degrees for the angles and in mm for the measure of resection

Pre pre-operatively, *Post-op* post-operatively

Results for Rotation





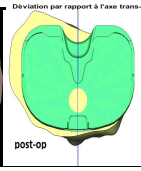
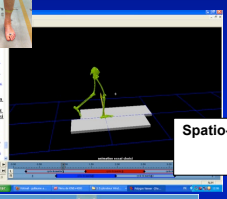
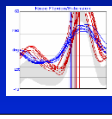


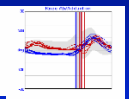
Table 4 Result of the tibial rotation in both groups

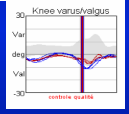
	Tibial rotation (°)	PSI group		Control group	
		nTKA	%	nTKA	%
External rotation	10–15	3	15	1	5
	5–9	1	5	0	0
	0–4	1	5	0	0
Internal rotation	0–4	0	0	1	5
	5–9	3	15	1	5
	10–14	4	20	4	20
	15–20	8	40	13	65

Gait Analysis









Spatio-temporal Analysis
Kinetics
Kinematics

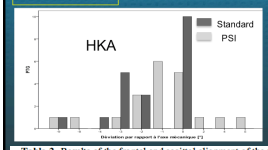
No Benefit of Minimally Invasive TKA on Gait and Strength Outcomes

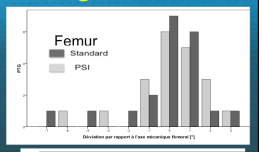
Julien Wegrzyn MD, PhD, Sebastien Parratte MD, PhD, Krista Coleman-Wood PhD, PT, Kenton R. Kaufman PhD, PE, Mark W. Pagnano MD

Clin Orthop Relat Res

Radiological results

Frontal Plane





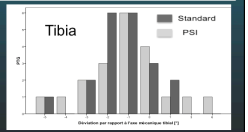


Table 2 Results of the frontal and sagittal alignment of the tibial and femoral implants in the two groups

	Group PSI	Control group	*p*
Mean HKA (°)	179 (171–185)	178.3 (171–180)	n.s
Number of outliers	4	2	n.s
FFC angle (°)	90.1 (84–83)	89.8 (83–93)	n.s
FTC angle (°)	89.1 (85–96)	88.6 (85–91)	n.s
LFC angle (°)	8.15 (2–14)	9.1 (7–11)	n.s
Notching	2	2	n.s
LTC angle (°)	84.1 (81–87)	84.15 (82–86)	n.s
Tibial slope (°)	5.9 (3–9)	5.85 (4–8)	n.s

AAOS 2014

Clinical results

New Knee Society Score

	Groupe 1 (PSI)	Groupe 2 (IM)	p
Marqueurs objectifs (sur 50)	47,50 (40-50)	46,9 (38-50)	0,963
Symptômes (sur 25)	18,9 (10-25)	20 (13-25)	0,479
Satisfaction (sur 40)	26,6 (14-40)	28,4 (16-36)	0,404
Attentes (sur 15)	10,4 (6-15)	11,4 (6-15)	0,083
Activités fonctionnelles (sur 100)	60 (40-87)	62 (37-89)	0,786

Gait Analysis

Paramètres		Groupe1 (PSI)	Groupe 2(IM)	p
Paramètres Spatio-temporels	Double limb support (%)	45 (28-90)	43 (28-58)	NS
	Single limb support (%)	44 (34-74)	43 (30-54)	NS
	Walking speed (m/s)	0,75 (0,28-1)	0,76 (0,55-1,1)	NS
	Cadence (steps/min)	93 (54-117)	95 (75-122)	NS
	Stride length (m)	0,95 (0,62-1,16)	0,96 (0,1-1,14)	NS
Paramètres Cinématiques/Cinétiques	Knee varus angle (°)	6,3 (-6-16)	6 (-3-16)	NS
	Knee valgus angle (°)	-4,5 (-17-5)	-5,8 (-12-4)	NS
	Knee varus moment (Nm/kg)	0,4 (0,2-0,7)	0,38 (0,15-0,7)	NS
	Knee valgus moment (Nm/kg)	-0,05 (-0,2-0)	-0,1 (-0,2-0)	NS
	Knee power generation (W/kg)	0,2 (0,02-0,5)	0,2 (0,01-0,7)	NS
	Ankle power generation	2,3 (0,4-3,6)	2,2 (0,9-4,1)	NS

Discussion

No significant difference for standard cases

In the literature: No Proven benefit

Lustig S et al: J Arthroplasty. 2013
Unsatisfactory accuracy as determined by computer navigation of VISIONAIRE patient-specific instrumentation for total knee arthroplasty.

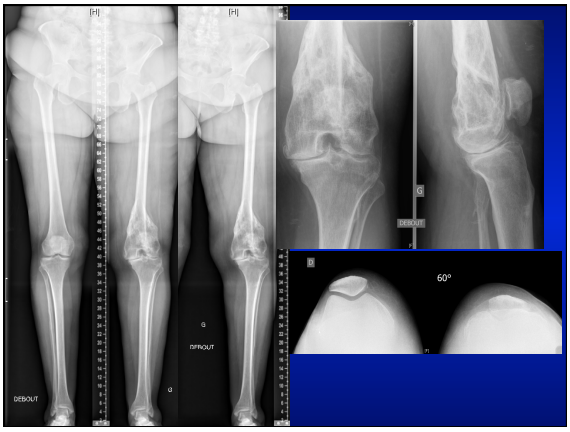
Study 2:
PSI in post-traumatic TKA

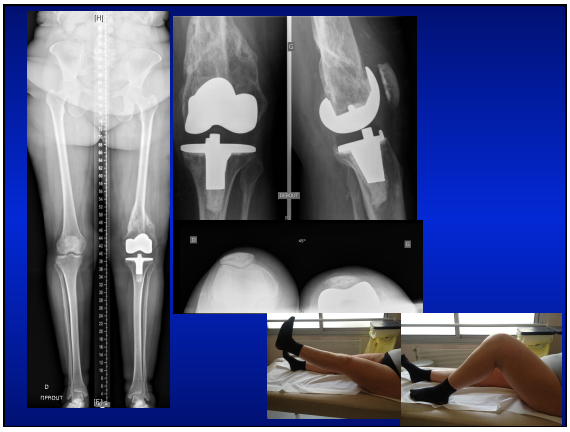
Gait Pre-op
3D rotational evaluation
MRI or CT-scann

Surgery

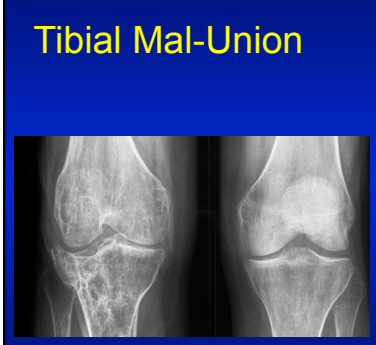
Evaluation
Marseille
Static Alignement
CT-Scann rotation

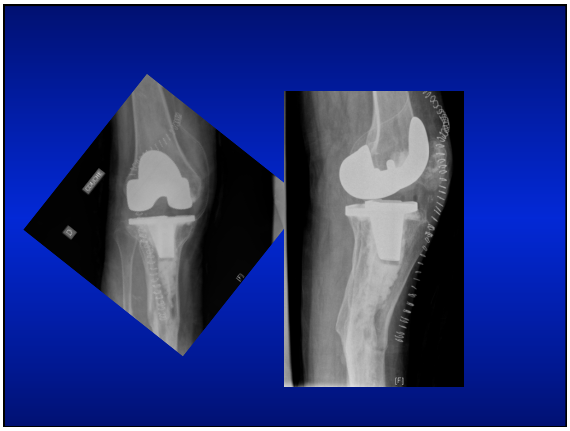
10 Knees included
Restitution of the HKA
No canal

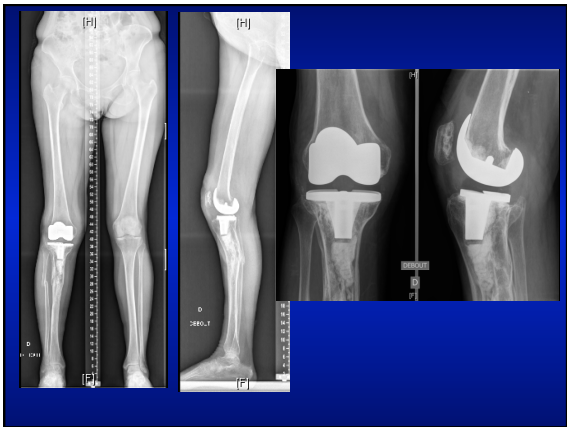




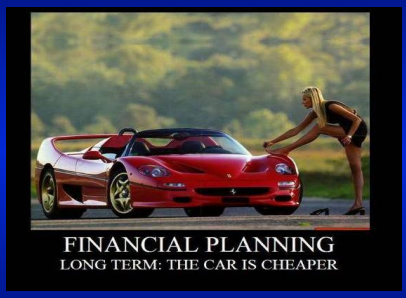
Tibial Mal-Union



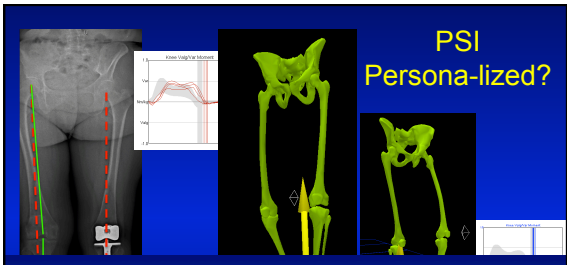




Discussion: COST ?



Knee in a box



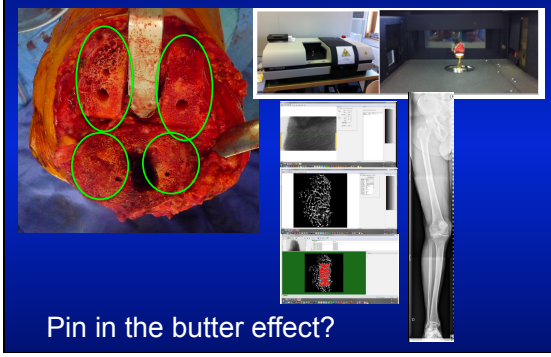
PSI
Persona-lized?

Static ≠ Dynamic conditions

Radio 2D
Radio 3D EOS

Does not represent the in vivo conditions

Alignement and constrains



Pin in the butter effect?

Comple
dynami
Rotatio
Contrai
Bone
Patient

Conclusion

PSI: Smart tool
Need a smart Surgeon
It's not an approve and go technique

Key point message

PSI: planning

Standard cases: as good as standard

Complex cases: team work for the planning

To reach a target, you first need to define the target