Gap balancing in TKA: computer assisted balancing

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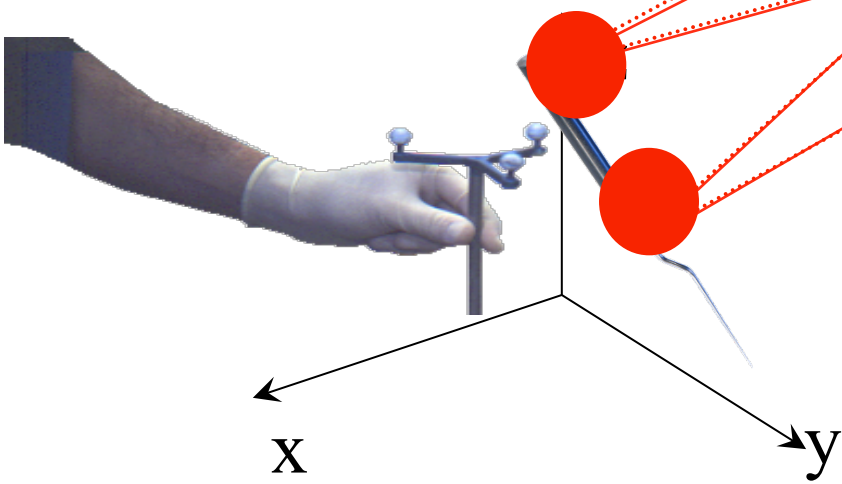
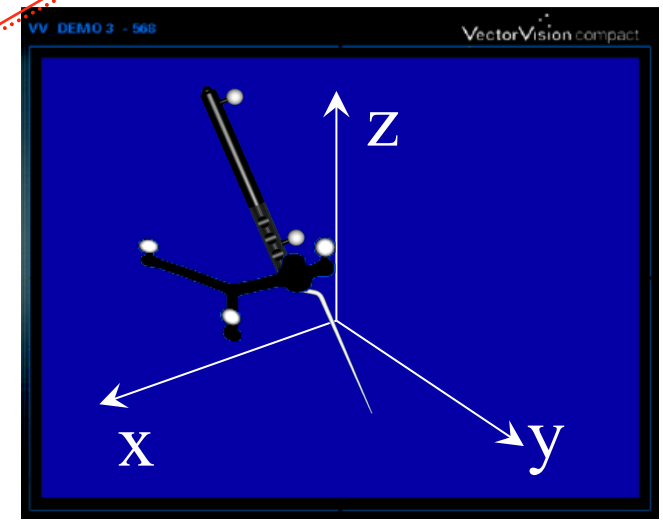
CAS as a quality control tool

Computer assisted surgery

- Active system: robotics
- Passive system





Principles

- Production of a digital image which serves as a map to guide the surgeon during the intervention
  - Surgical instruments can be incorporated into the map and their position, attitude and progress can be controlled to an accuracy of a millimeter or degree

Principles

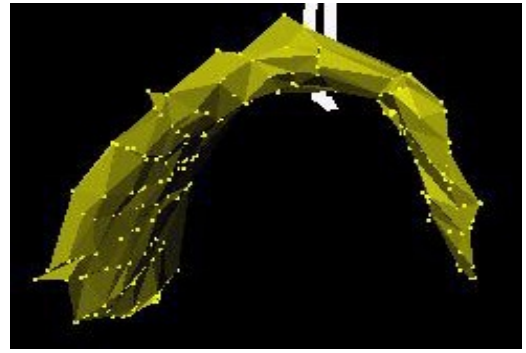
- Instrumented landing of an aircraft

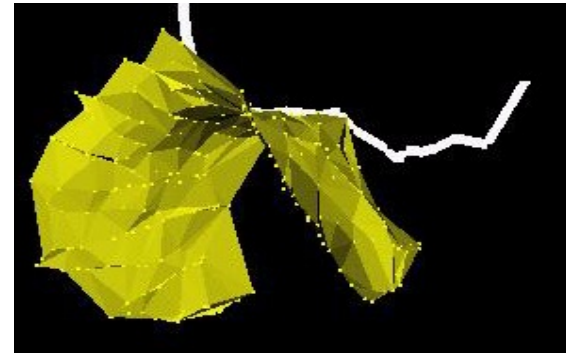
- Driving a car using a ground-positioning satellite system (GPS)

Principles

- Image based systems:
  - Pre-operatively imaged: Ct-scan - MRI
  - Per-operatively imaged: fluoroscopy

- Image-free system:
  - Anatomical model embedded in the software
  - Direct registration of key anatomical landmarks





CAS (Computer assisted surgery)

- Real time navigation
- Three dimensions
- Precision
- Reliability
- Reproducibility

CAS (Computer assisted surgery)

- Quality control
- Teaching tool
- Research tool
- Expected improve function
- Expected reduce failure
- Expected facilitate rehabilitation

Objective

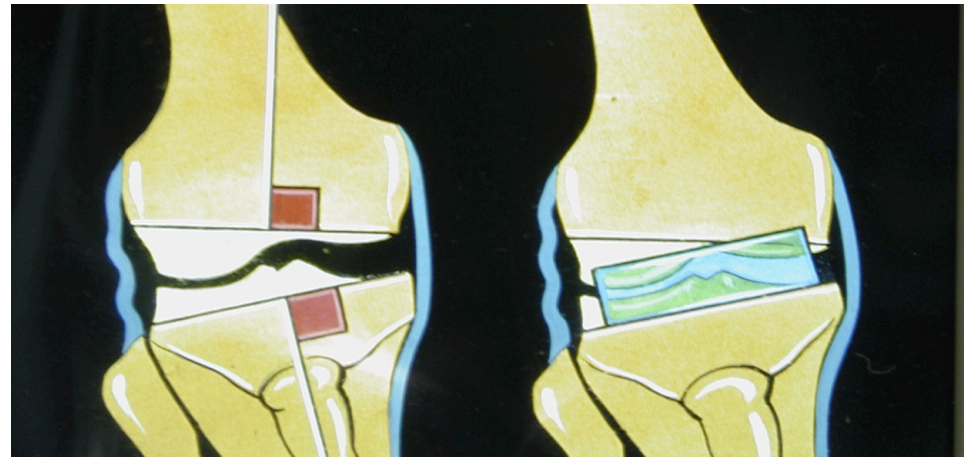
- The goal of total knee arthroplasty (TKA) is to achieve stable and well-aligned tibiofemoral and patello-femoral (PF) joints.

- To accomplish this successfully, accurate alignment of knee implants and balancing of soft tissues are essential

Objective

Adequate ligament balancing avoids instability by preventing:

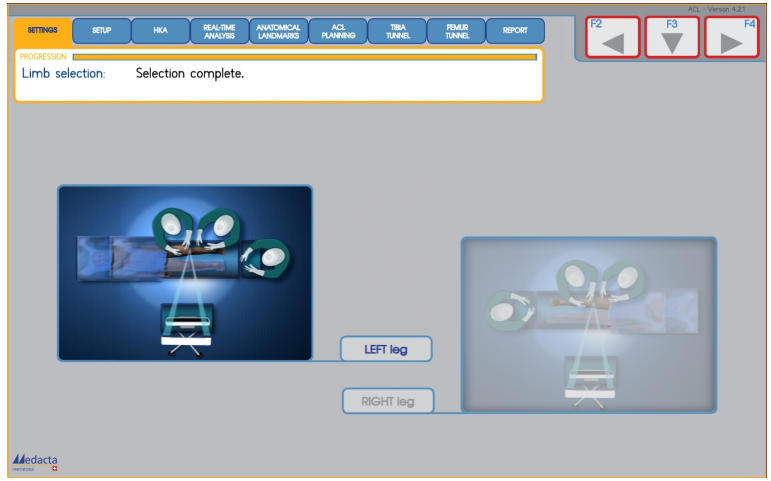
- Gap inequality or flexion/extension mismatch
- Gap asymmetry or collateral ligament imbalance



Hypothesis

- The management of soft tissue balancing remains difficult, and, without any objective guides, this portion of the procedure is often left to the surgeon's "feeling" and experience.

- Computer-assisted gap balancing may compensate this subjective part and be more accurate



Questions:

- Is computer-assisted gap balancing technique is more accurate than conventional measured resection technique?

- In computer-assisted gap balancing TKA, which technique is the best:

- Ligament-balancing technique ?
- Measured resection technique ?

Computer-assisted gap balancing

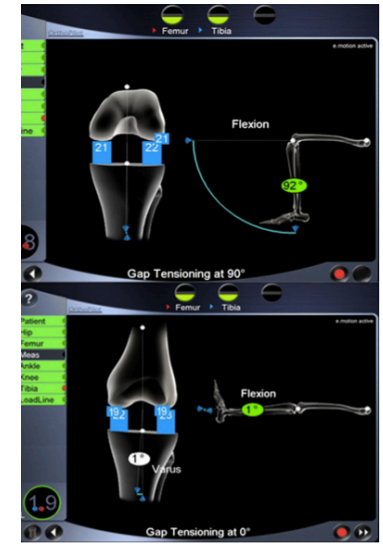
- Navigation systems now provide femoral planning based on initial flexion and extension gap measurements.

- Based on gap differences, distal femur cutting and posterior condylar cutting depth can be planned and femoral component size and rotation adjustments can be simulated to achieve flexion and extension gap balance.

Computer-assisted gap balancing

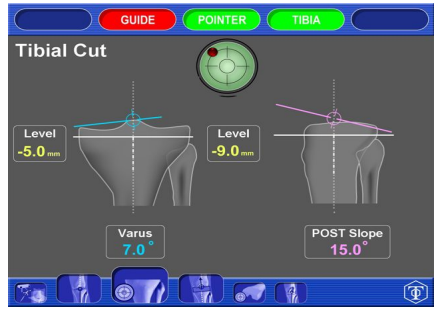
- Furthermore, final extension gaps can be adjusted during navigation-assisted TKA by modifying the distal femur cutting depth and flexion gap configuration.

- However, in cases with excessive ER of the femoral component, the specific portion of soft tissue responsible for the tight flexion gap must be released to avoid patellofemoral problem

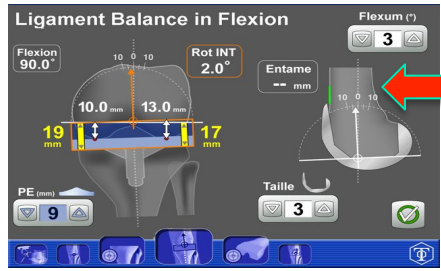


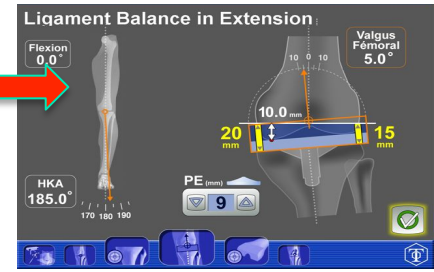
Navigation Dependent with simulation

One tibial cut



Balancing
Cuts Simulation





2nd and 3rd Cuts

Femoral GAP	Femoral GAP
Tibial GAP	Tibial GAP

Flexion ⟷ Extension

Courtesy of Philippe Neyret

WORFLOW –Tibial Cut

Setup

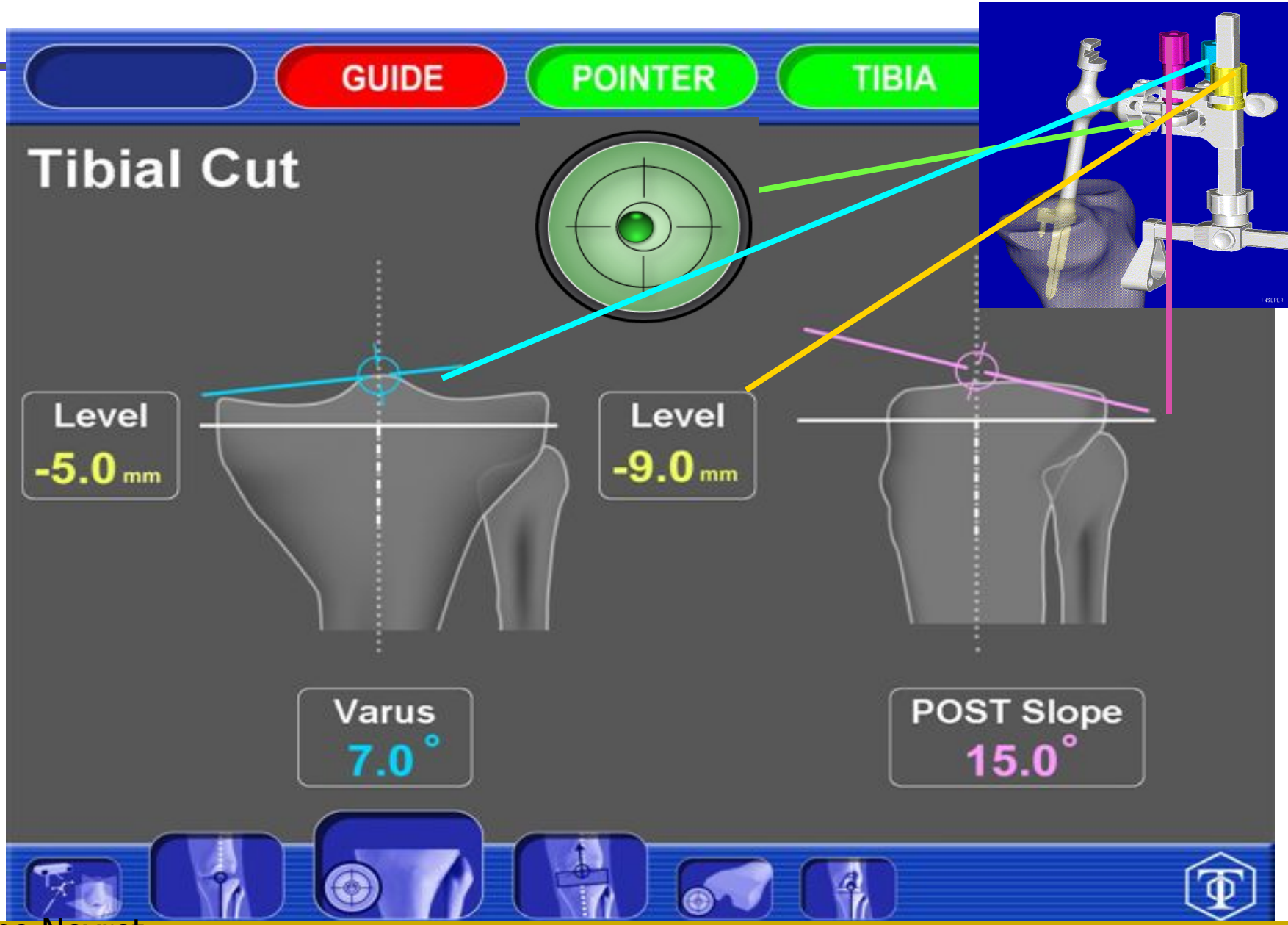
Control

Tibia

Simulation/ Balancing

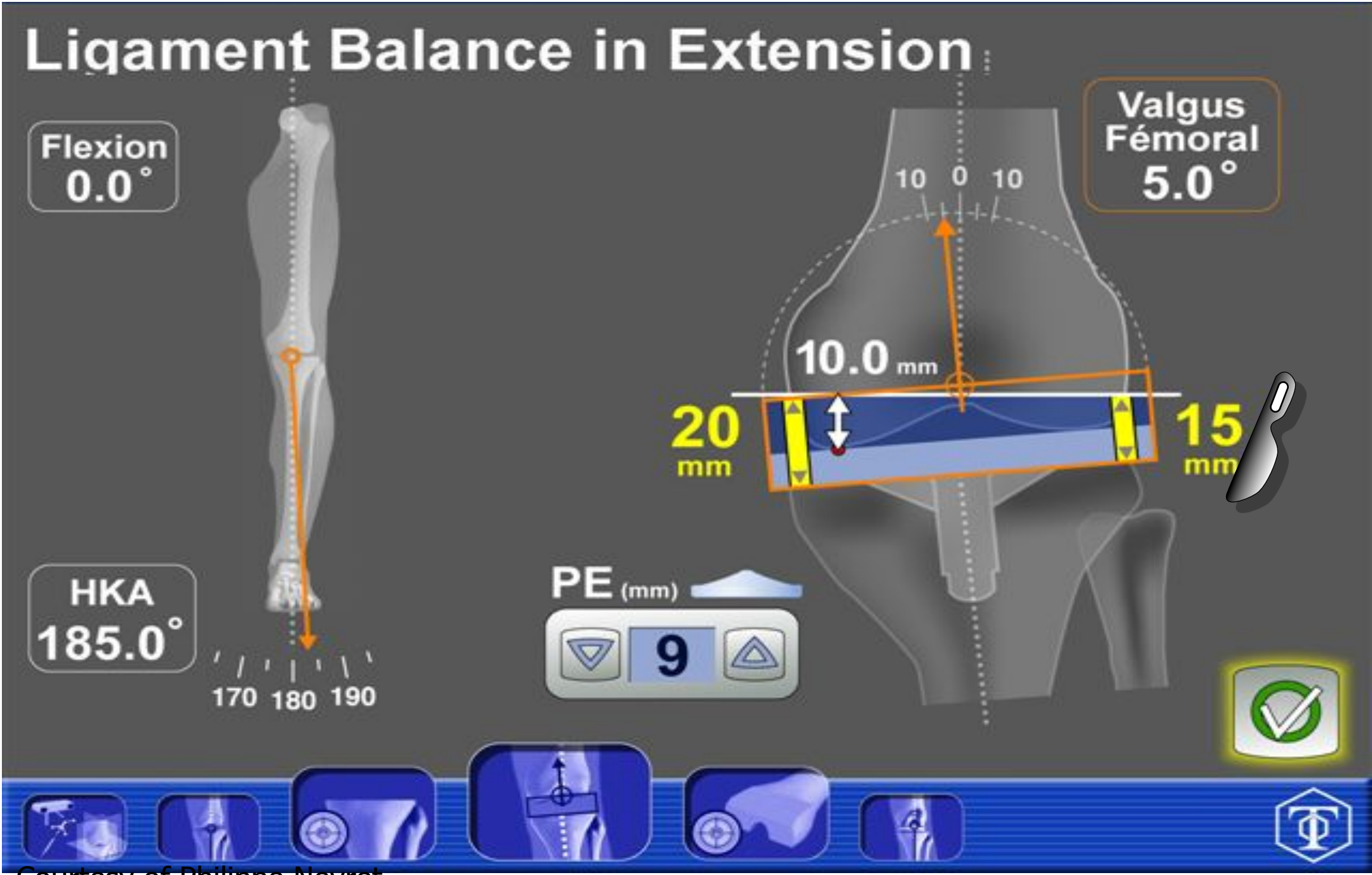
Femur

Control

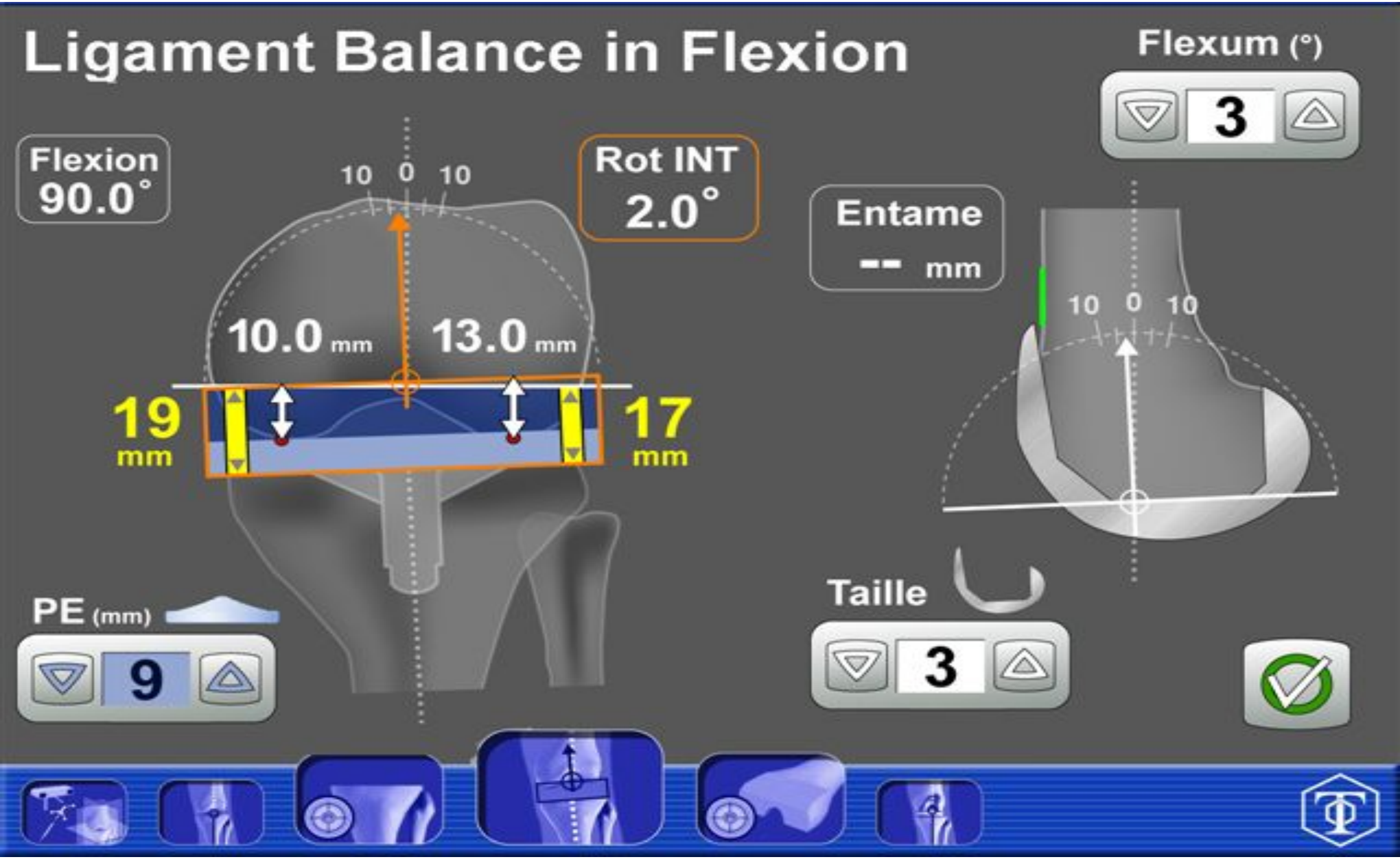


position time Open

Courtesy of Philippe Neyret

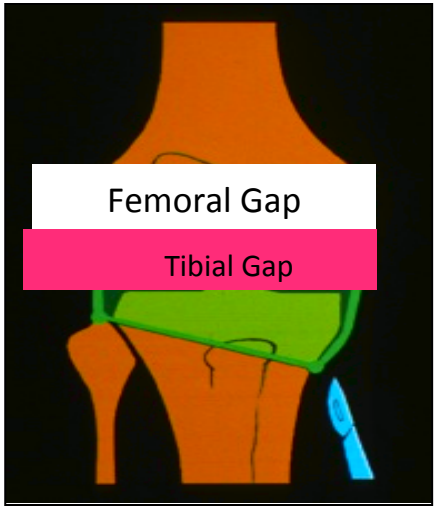


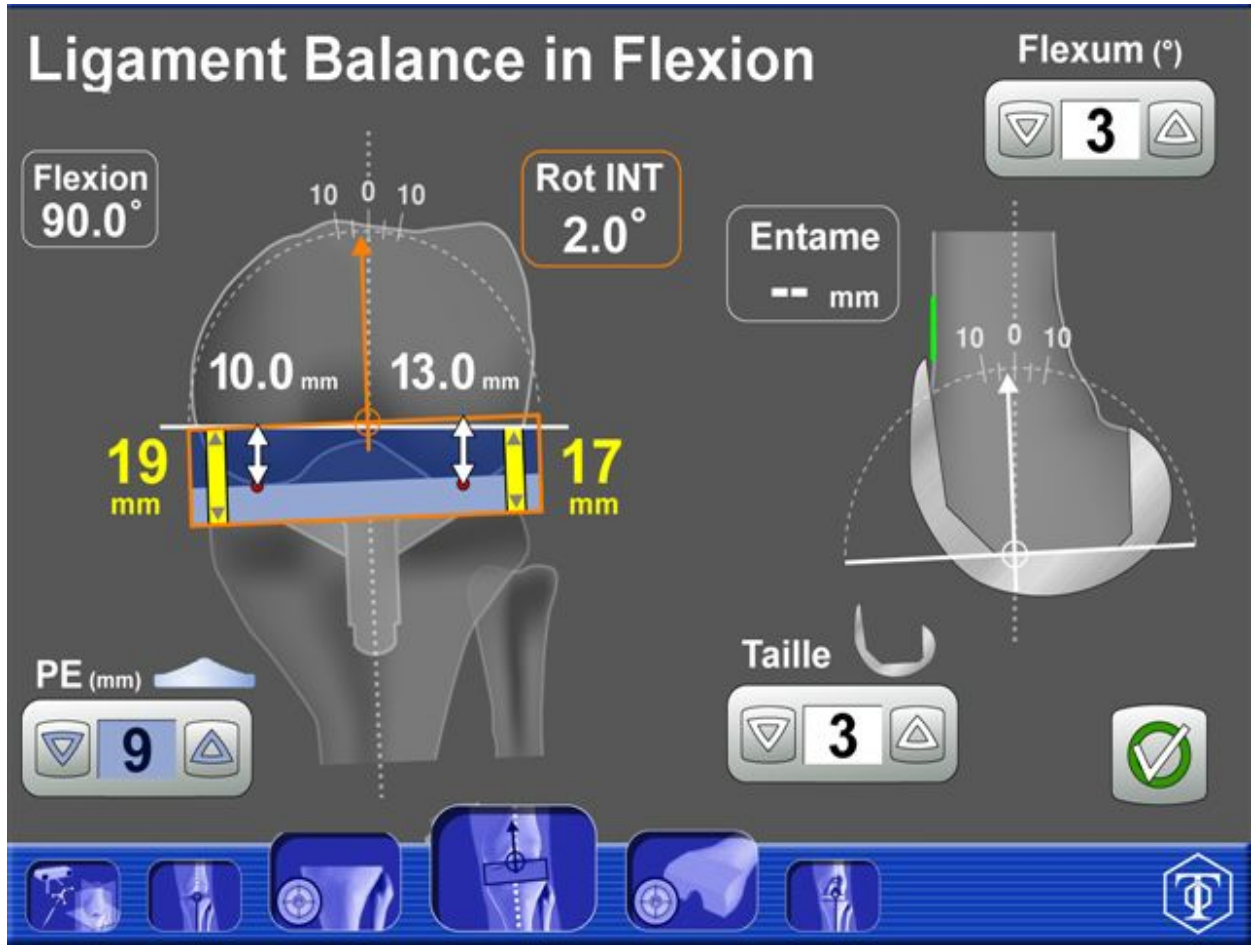
Courtesy of Philippe Neyret



Courtesy of Philippe Neyret

Navigation may allow a better control of joint line





Courtesy of Philippe Neyret

Computer-assisted gap balancing: proof-of-principle

- Amount of femoral bone cutting and external rotations of femoral components were found to depend on initial gaps.
- Patients with a final rectangular gap had greater knee flexion angles preoperatively and at 1 year after TKA.
- However, no differences were observed between the clinical and radiologic outcomes of knees with rectangular and nonrectangular gaps at 1 or 4 years after TKA.

→ The study shows that the navigation-assisted modified gap balancing technique provides an effective means of achieving rectangular flexion and extension gaps during TKA.

Seon J.K et al. *J Arthop* 2011

Computer-assisted balancing versus tensor

The Journal of Arthroplasty Vol. 24 No. 3 2009

Soft Tissue Balance Measurement in Posterior-Stabilized Total Knee Arthroplasty With a Navigation System

Tomoyuki Matsumoto, MD,* Hirotsugu Muratsu, MD,* Nobuhiro Tsumura, MD,†
Kiyonori Mizuno, MD,* Masahiro Kurosaka, MD,* and Ryosuke Kuroda, MD*

Fig. 1. New TKA tensor with CT-free navigation system.

- Tensor for TKA designed to facilitate soft tissue balance measurements with a reduced patello-femoral joint
- Joint gap and ligament balance measured in 30 osteoarthritic knees at 0° and 90° flexion, with the patella both everted and reduced
- Same measurements with a navigation system

→ correlations between navigation system and the tensor.

Muratsu H, et al. Trans Orthop Res Soc 2003
Matsumoto T, et al. J Biomech Eng 2006
Matsumoto T, et al. KSSTA 2007

Computer-assisted balancing versus tensor

Soft tissue measurements with the navigation system are well correlated with the direct measurements with the tensor, suggesting that the measurements with the navigation system are accurate and useful for assessment of soft tissue balancing.

Soft tissue balance measurements with the tensor and the navigation system are more accurate with a reduced PF joint than with an everted PF joint.

Table 1. Joint Component Gap and Ligament Balance With Patellar Eversion and Reduction

	Patellar eversion		PF joint reduction	
Flexion	TKA tensor	Navigation	TKA tensor	Navigation
Joint component gap				
0°	11.4 ± 0.6	11.5 ± 0.6	11.7 ± 0.6	11.8 ± 0.7
90°	20.2 ± 0.8*	18.1 ± 1.1*	17.1 ± 0.7*†	15.8 ± 0.8*†
Ligament balance				
0°	3.2 ± 0.6	3.8 ± 0.6	3.1 ± 0.6	3.7 ± 0.6
90°	1.9 ± 1.1*	1.6 ± 1.2*	−1.1 ± 1.0*†	−1.2 ± 1.1*†

Values are shown as mean ± SE (mm).
*Statistical difference between 0° and 90° ($P < .01$).
†Statistical difference between patellar eversion and PF joint reduction ($P <. 01$ vs patellar eversion).

Matsumoto T. et al. *J Arthop* 2009

Computer-assisted gap balancing versus conventional measured resection technique

- Unitt et al. measured flexion-extension gaps in 218 TKAs using the measured resection technique: balanced flexion and extension gaps during TKA were achieved using the measured resection technique in 175 knees (80.3%)

- Seon et al. obtained a final rectangular gap in 105 knees (94%) using the navigation-assisted gap balancing technique

→ TKA using the navigation-assisted gap balancing technique produced better balanced flexion and extension gaps than TKA using the measured resection technique.

Unitt L et al. *J Bone Joint Surg Br* 2008
Seon et al. *J Arthoplasty* 2011

Computer-assisted gap balancing versus conventional measured resection technique

Knee Surg Sports Traumatol Arthrosc (2010) 18:381–387
DOI 10.1007/s00167-009-0983-x

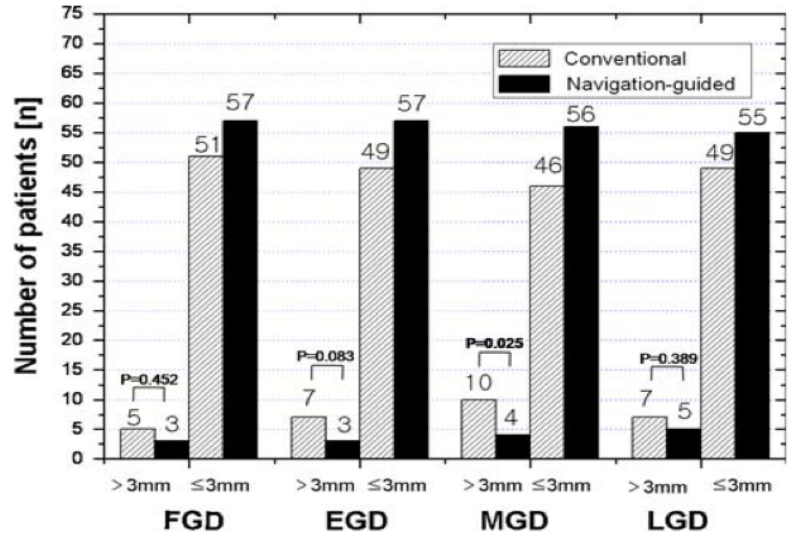
KNEE

Accuracy of soft tissue balancing in TKA: comparison between navigation-assisted gap balancing and conventional measured resection

Dae-Hee Lee · Jong-Hoon Park · Dong-Ik Song · Debabrata Padhy · Woong-Kyo Jeong · Seung-Beom Han

Between 2004 and 2006, 120 patients scheduled for unilateral TKA in a prospectively randomized clinical trial.

Computer-assisted gap balancing versus conventional measured resection technique



Navigation-assisted soft tissue balancing during TKA

- Reduced postoperative alignment outliers
- Reduced inadvertent medial soft tissue release
- Permitted the achievement of a more rectangular flexion and extension gap than offered by conventional TKA.

However, the clinical and radiological outcomes between two groups were similar.

Lee D.H. et al. *KSSTA* 2010
Lee H.J. et al. *KSSTA* 2011

Computer-assisted gap balancing versus conventional measured resection technique

Knee Surg Sports Traumatol Arthrosc (2011) 19:1496–1503
DOI 10.1007/s00167-011-1483-3

KNEE

Computer-assisted gap balancing technique improves outcome in total knee arthroplasty, compared with conventional measured resection technique

Hee-Nee Pang · Seng-Jin Yeo · Hwei-Chi Chong · Pak-Lin Chin · Johnny Ong · Ngai-Nung Lo

140 patients randomized into two groups:

Group 1: Conventional measured resection technique without computer navigation

Group 2: Computer-assisted gap balancing

Computer-assisted gap balancing versus conventional measured resection technique

- Group 1 (conventional measured resection technique):
  - Significantly more patients (7%) with flexion contractures > 5°
  - Significantly more outliers (11%) with anterior tibial translation

- Group 2 (computer-assisted gap balancing)
  - Significantly better limb alignment with fewer outliers (> 3° varus/valgus)
  - Better outcome in the Total Oxford Score (0.030)

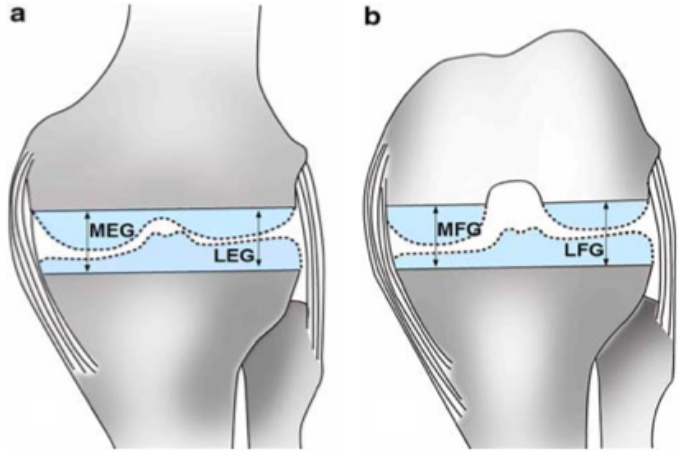
→ Computer-assisted gap balancing technique was able to achieve more precise soft tissue balance and restoration of limb-alignment with better knee scores as compared to the conventional measured resection technique in TKA

Pang H.N et al. *KSSTA* 2011

Conclusions

The navigation systems used for TKA provide

- Excellent restoration of the mechanical axis and precise component positioning
- More objective and quantitative measures of flexion and extension gaps: improves the accuracy of the balancing procedure
- No evidence of better clinical outcome



Clemens U. et al. *Orthopedics* 2005
Matsumoto T et al. *J Arthroplasty* 2009

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16th ESSKA Congress

May 14-17, 2014

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