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Knee  
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# Alignments in robotic surgery: is «functional alignment» the new gold standard?

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# Alignments nowadays

- 1) Systematic alignment:
  - mechanical (MA)
  - anatomical (AA)
  - HKA of  $180^\circ$  (neutral coronal alignment)
- 2) Patient-specific alignment:
  - kinematic alignment (KA)
  - native limb alignment
- 3) Hybrid alignment:
  - adjusted mechanical alignment (aMA)
  - restricted kinematic alignment (rKA)
  - native coronal alignment with HKA safe zone of  $177^\circ$  to  $183^\circ$
- 4) Functional alignment (robot): personalization to the knee ????

## Individualized alignment and ligament balancing technique with the ROSA<sup>®</sup> robotic system for total knee arthroplasty

Stefano Marco Paolo Rossi<sup>1</sup>  · Francesco Benazzo<sup>1,2</sup>

The ROSA robotic system have been recently introduced in the market and presents specific and peculiar features to optimize ligament balancing and an individualized alignment of the implant in a three dimensional prospective.



## Individualized alignment and ligament balancing technique with the ROSA<sup>®</sup> robotic system for total knee arthroplasty

Stefano Marco Paolo Rossi<sup>1</sup>  · Francesco Benazzo<sup>1,2</sup>

- The system is showing a favourable gap balancing technique and the possibility to create an individualized alignment
- Preliminary results are promising both in terms of accuracy of the system and of clinical outcomes



KNEE ARTHROPLASTY

## A new robotically assisted technique can improve outcomes of total knee arthroplasty comparing to an imageless navigation system

Fabio Mancino<sup>1,2,3</sup> · Stefano Marco Paolo Rossi<sup>1</sup> · Rudy Sangaletti<sup>1</sup> · Ludovico Lucenti<sup>1</sup> · Flavio Terragnoli<sup>4</sup> · Francesco Benazzo<sup>1,5</sup>

Robotic assisted total knee arthroplasty (RTKA) has shown improved knee alignment and reduced radiographic outliers. However, there remains debate on functional outcomes and patient-reported outcomes (PROMs).

This study compares the 1-year clinical outcomes of a new imageless robotically assisted technique (ROSA Knee System) with an imageless navigated procedure (iAssist Knee)

Functional outcomes and PROMs of 50 imageless RTKA with 47 imageless NTKA at 1-year follow-up



- Baseline characteristics, intraoperative and postoperative information (including complications), revisions
- Knee Society Score (KSS), Knee injury and Osteoarthritis Outcome Score (KOOS) score, and Forgotten Joint Score (FJS-12)
- Radiographic analysis of preoperative and postoperative images (HKA)

# Rosa vs iAssist

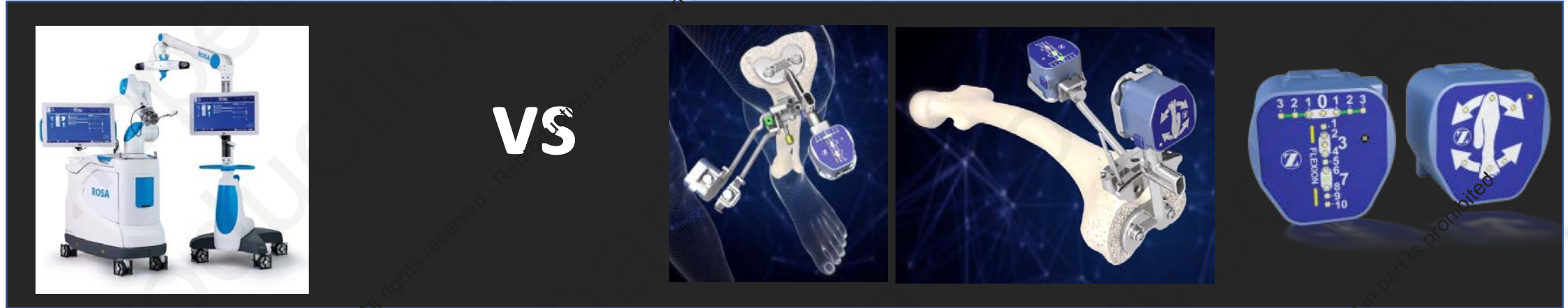
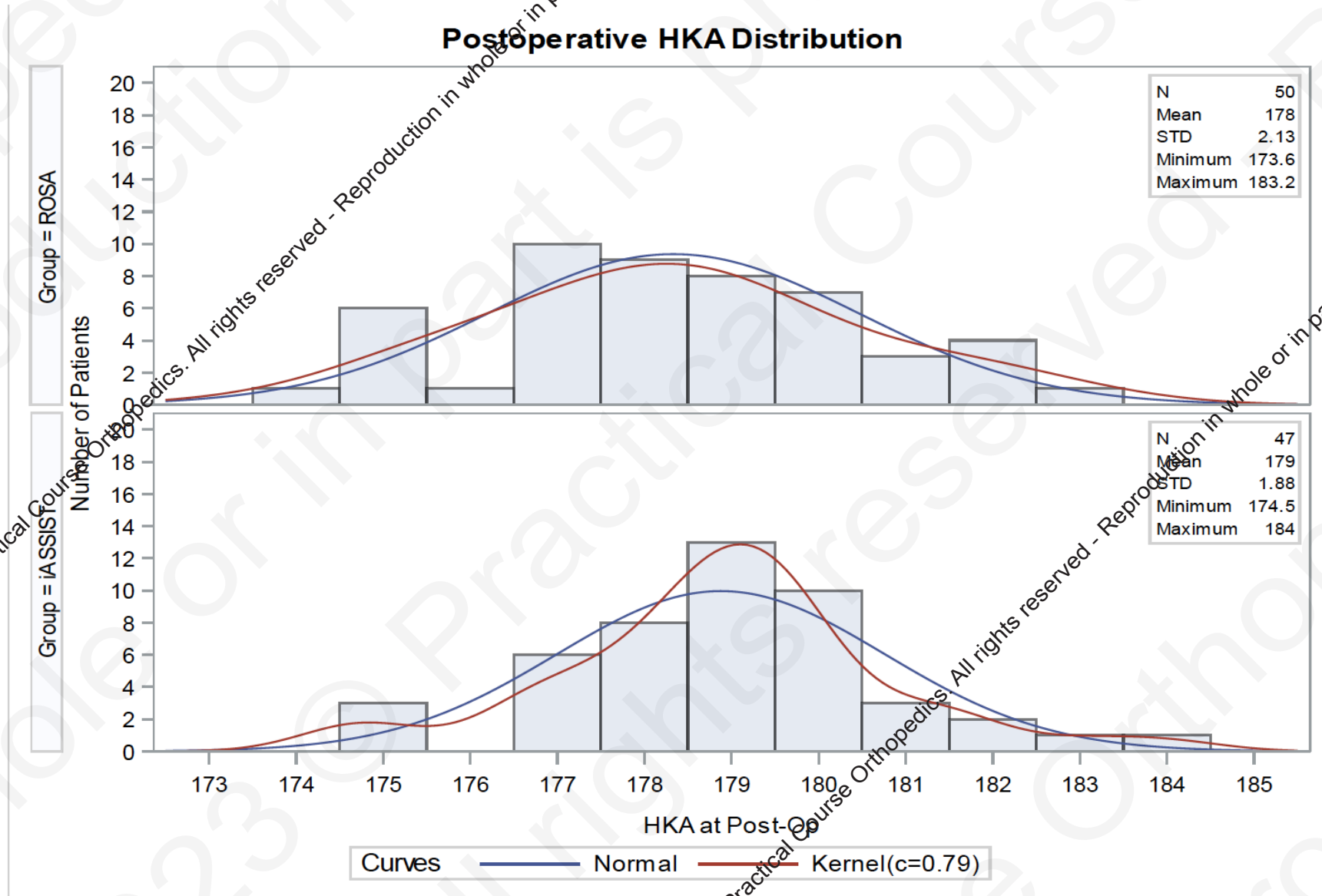


Table 1. Baseline Characteristics of Robotic and Navigated Patients

Continuous Baseline Characteristics Summarized by mean±std (min – max)			
	ROSA N=50	iASSIST N=47	Wilcoxon Rank Sum Test P Value
Age (year)	69.2±7.3 (49-82)	72.4±7.7 (55-87)	0.0622
Weight(kg)	77.8 ± 14.7 (49-112)	81.5 ± 12.7 (55-121)	0.1547
Height(m)	1.6 ± 0.1 (1.5-1.9)	1.7 ± 0.1 (1.5-1.9)	0.0244
BMI (Kg/m <sup>2</sup> )	29.5±5 (19.9-48)	30.1±4.9 (21-42.1)	0.4504
Follow-up	13.4±1.3 (12-15)	13.7±1.2 (12-15)	.
Subject Gender Summarized by n(%)			
Female	32 (64.00%)	28 (59.57%)	0.6808
Male	18 (36.00%)	19 (40.43%)	.
ROM Range Pre-operative	92.9±11.2 (55-120)	94.9±10 (75-120)	0.4360

ROM Range of motion; BMI Body mass index

# Rosa vs I-Assist



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From University  
College London  
Hospitals NHS Trust

## ■ ANNOTATION

# Alignment in total knee arthroplasty

## WHAT'S IN A NAME?

Dissatisfaction following total knee arthroplasty is a well-documented phenomenon. Although many factors have been implicated, including modifiable and nonmodifiable patient factors, emphasis over the past decade has been on implant alignment and stability as both a cause of, and a solution to, this problem. Several alignment targets have evolved with a proliferation of techniques following the introduction of computer and robotic-assisted surgery. Mechanical alignment targets may achieve mechanically-sound alignment while ignoring the soft tissue envelope; kinematic alignment respects the soft tissue envelope while ignoring the mechanical environment. Functional alignment is proposed as a hybrid technique to allow mechanically-sound, soft tissue-friendly alignment targets to be identified and achieved.

Cite this article: *Bone Joint J* 2020;102-B(3):276–279.

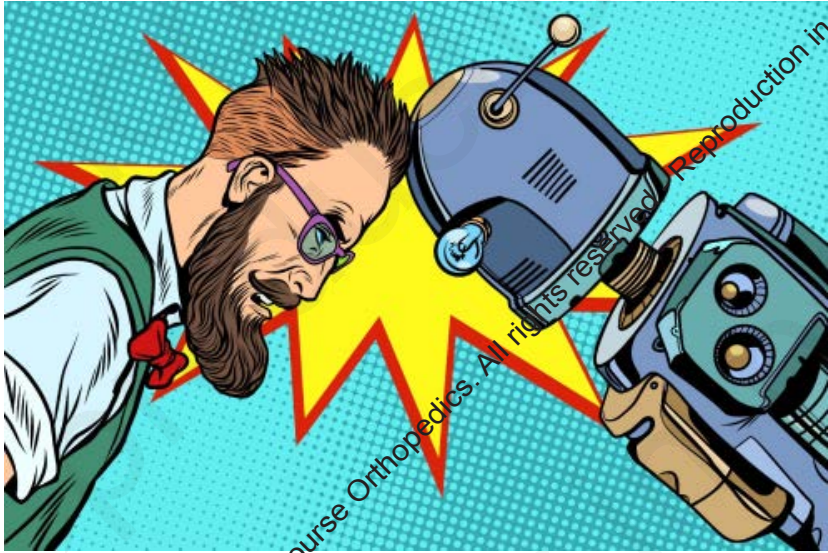
Alignment: cause and solution of dissatisfied patients

Alignment targets evolved with CAOS and Robotic surgery

1. Mechanical alignment: mechanically sound alignment ignoring soft tissue envelope
2. Kinematic alignment: respect of soft tissue ignoring the mechanical environment
3. Functional alignment: hybrid technique to merge mechanical and soft-tissue friendly targets – Still to be identified and univoquely described



# NEW ROBOT-SPECIFIC ALIGNMENT



## 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<sup>1,2</sup>, Cécile Battelier<sup>1,3</sup>, Elliot Sappey-Marinier<sup>1,3</sup>, Stanislas Gunst<sup>1,3</sup>, Elvire Servien<sup>1,3</sup>, and Sebastien Lustig<sup>1,3,\*</sup>

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**robotics is changing the**

***first specific alignments for robotic surgery***

## **Functional alignment**

*is an emerging philosophy that aims to reconstruct 3-dimensional constitutional alignment while respecting the behavior of the soft*

*tissue envelope with the assistance of a robotic platform*

***While its concept has been described, rationale and technique are***

***yet to be defined.***

”Soft tissue procedure implemented by bone cuts”

”Bone cuts procedure (intraarticular corrections)  
recreating/respecting the ligaments functions : robotic  
assisted surgery allows to personalize the surgery aiming  
to recreate the pristine ligaments tension and function  
and therefore a dedicated alignment

Alignment as a  
global concept



Individualized  
alignment options



New technologies  
helpful for  
achieving targets

# Current concepts in total knee arthroplasty

MECHANICAL, KINEMATIC, ANATOMICAL, AND FUNCTIONAL ALIGNMENT

F. A. Begum, B. Kayani,  
A. A. Magan, J. S. Chang, F. S. Haddad

*Bone Jt Open* 2021

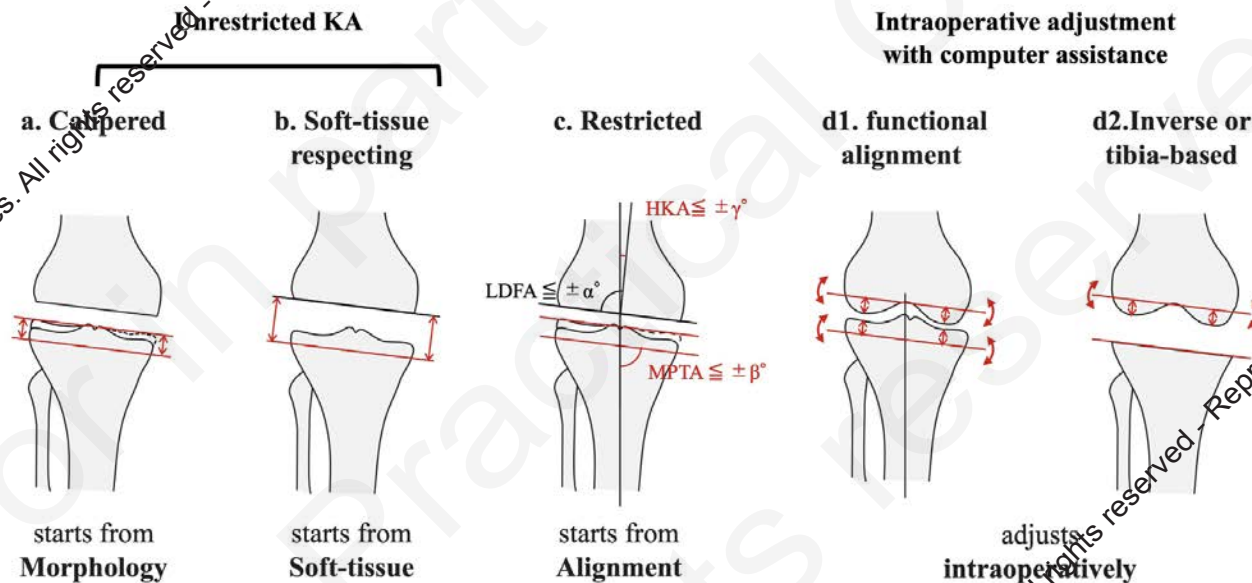
- 1) Neutral mechanical alignment facilitates knee flexion and symmetrical component wear but forces the limb into an unnatural position that alters native knee kinematics through the arc of knee flexion.
- 2) Kinematic alignment aims to restore native limb alignment, but the safe ranges with this technique remain uncertain and the effects of this alignment technique on component survivorship remain unknown.
- 3) Anatomical alignment aims to restore predisease limb alignment and knee geometry, but existing studies using this technique are based on cadaveric specimens or clinical trials with limited follow-up times.
- 4) Functional alignment aims to restore the native plane and obliquity of the joint by manipulating implant positioning while limiting soft tissue releases, but the results of high-quality studies with long-term outcomes are still awaited.

- Because of the intraarticular corrections, in the vast majority of knees, different alignments can be targeted:
- mechanical
- Kinematic (unrestricted)
- Inverse restricted kinematic
- Adjusted mechanical

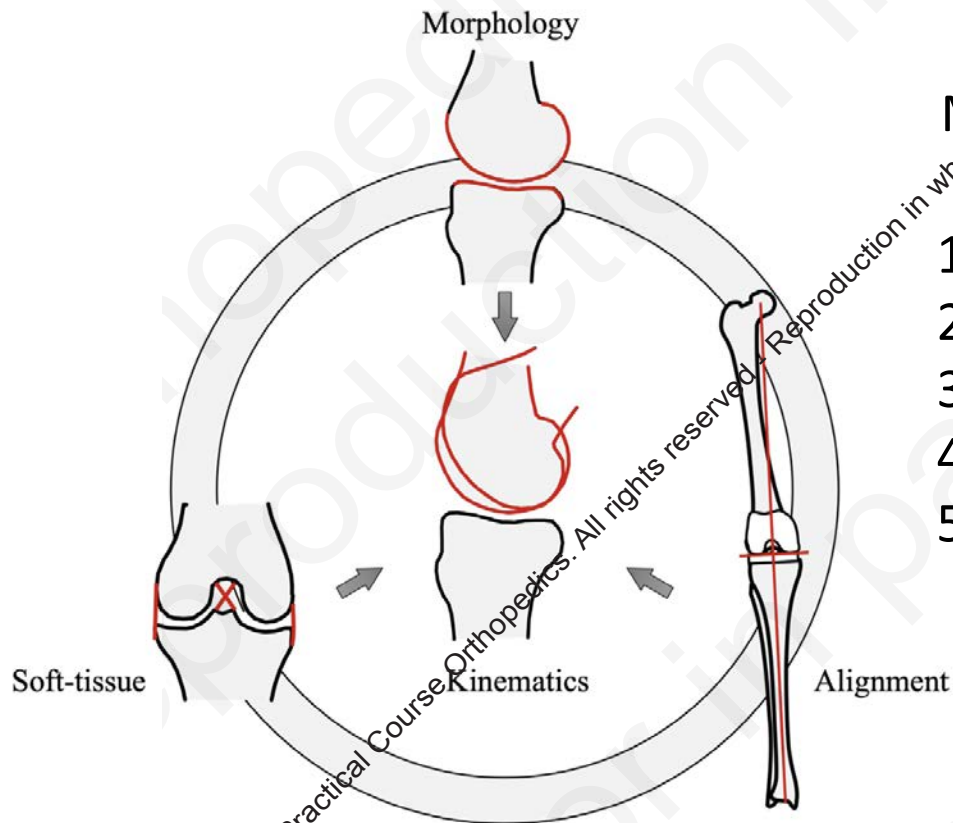
Can we describe all of them as «functional» because achieved with robotic surgery?

# Current concept of kinematic alignment total knee arthroplasty and its derivatives

T. Hiranaka, Y. Suda, A. Saitoh, A. Tanaka, *Bone Jt Open* 2022  
 A. Arimoto, M. Koide, T. Fujishiro, K. Okamoto



1. Calipered: tibia cut parallel to the surface, and femur as well
2. Soft tissue: tibia cut parallel to femur under traction, and parallel to femur in estension and flexion
3. Restricted: tibia cut at  $<5^\circ$ . Enabling technologies needed to adjust femur
4. Functional: tibia and femoral cuts according to intraoperative informations
5. Inverse: tibial cut decided first (tibia based) and femoral cut consequently



## Morphology, alignment, soft tissue: 3 elements of knee

1. Mechanical approach changes all, KA reproduces all
2. KA: calipered technique starts from morphology
3. KA: soft tissue approach starts from soft tissue balance
4. KA: restricted approach from morphology
5. FA: image based planning, intraoperative measurements

- Kinematically aligned total knee arthroplasty aims to restore the patients' individual harmony of three knee elements (morphology, soft-tissue balance and alignment) and eventually replicate the patient's own kinematics.
- The respective approaches start from different points corresponding to one of the three elements, yet aim for the same goal, although existing implants and techniques have not yet perfectly fulfilled the goal.

1. Planning of intra-articular corrections with bone resections
2. Tibia resection first → validation and data implementing in the planning
3. Re-evaluation of the ligament compliance with FuZion → planning
4. Distal femoral resection according to the ligaments and after the tibial cut
5. FuZion for rotational final alignment
6. 4 in 1 femoral cuts, tibia, patella and cementing



## 2. Tibia resection first → validation and data implementing in the planning



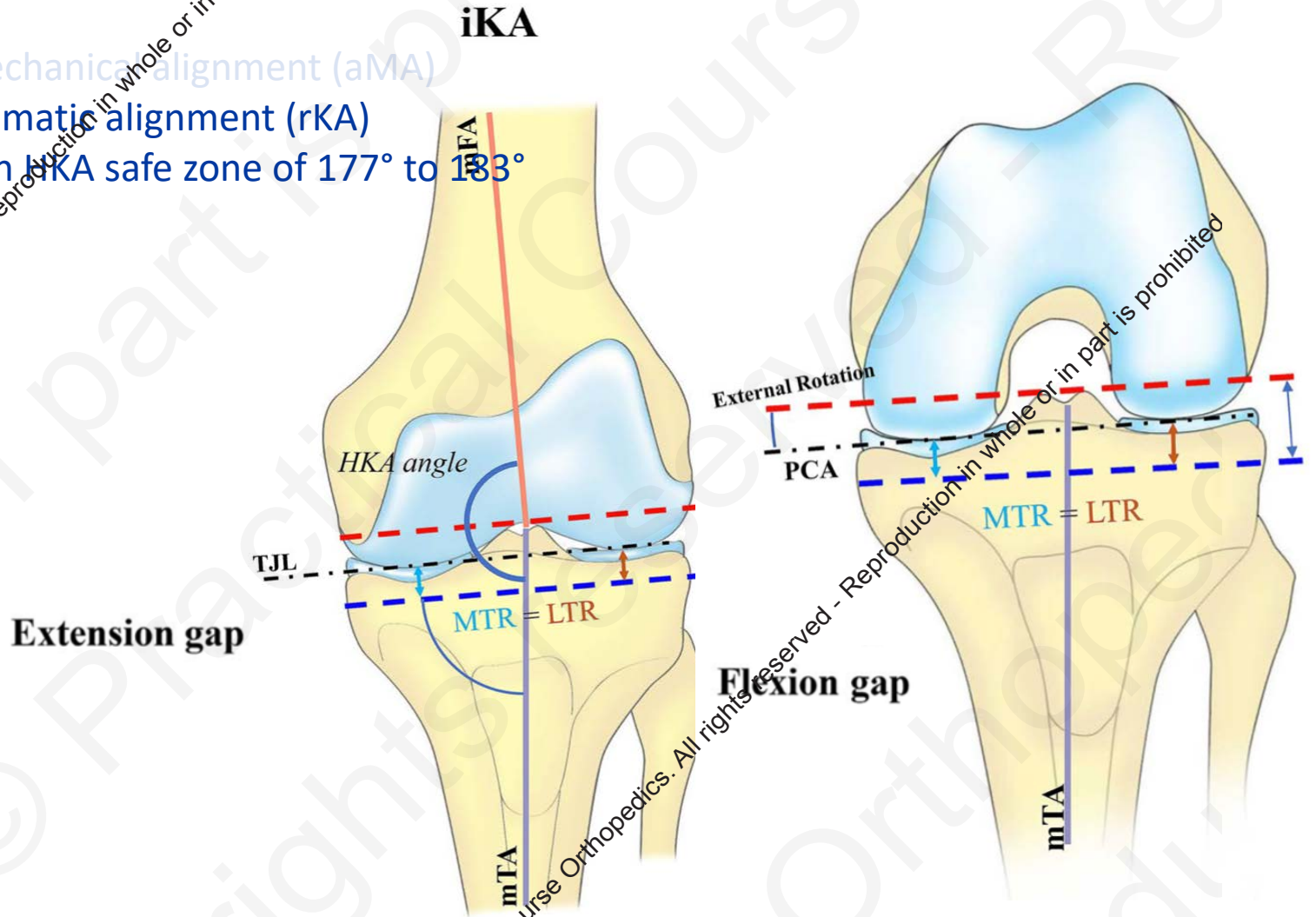
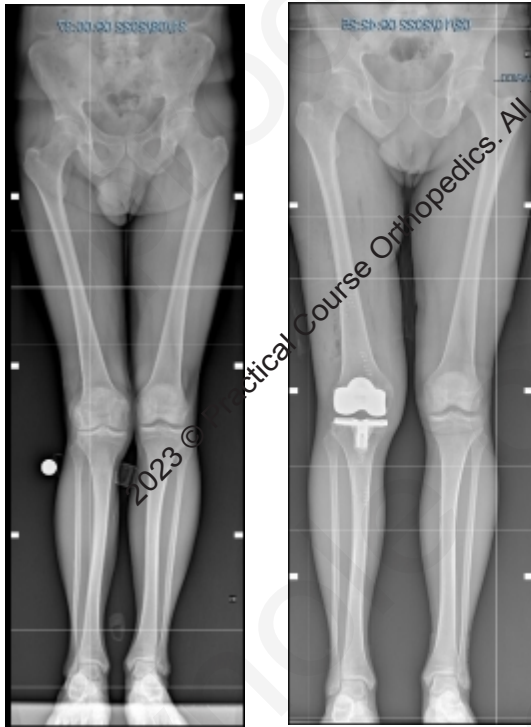


### 3. Re-evaluation of the ligament compliance with FuZion → updating the spaces



**Hybrid alignment:** - adjusted mechanical alignment (aMA)  
 - restricted kinematic alignment (rKA)

→ native coronal alignment with iKA safe zone of 177° to 183°



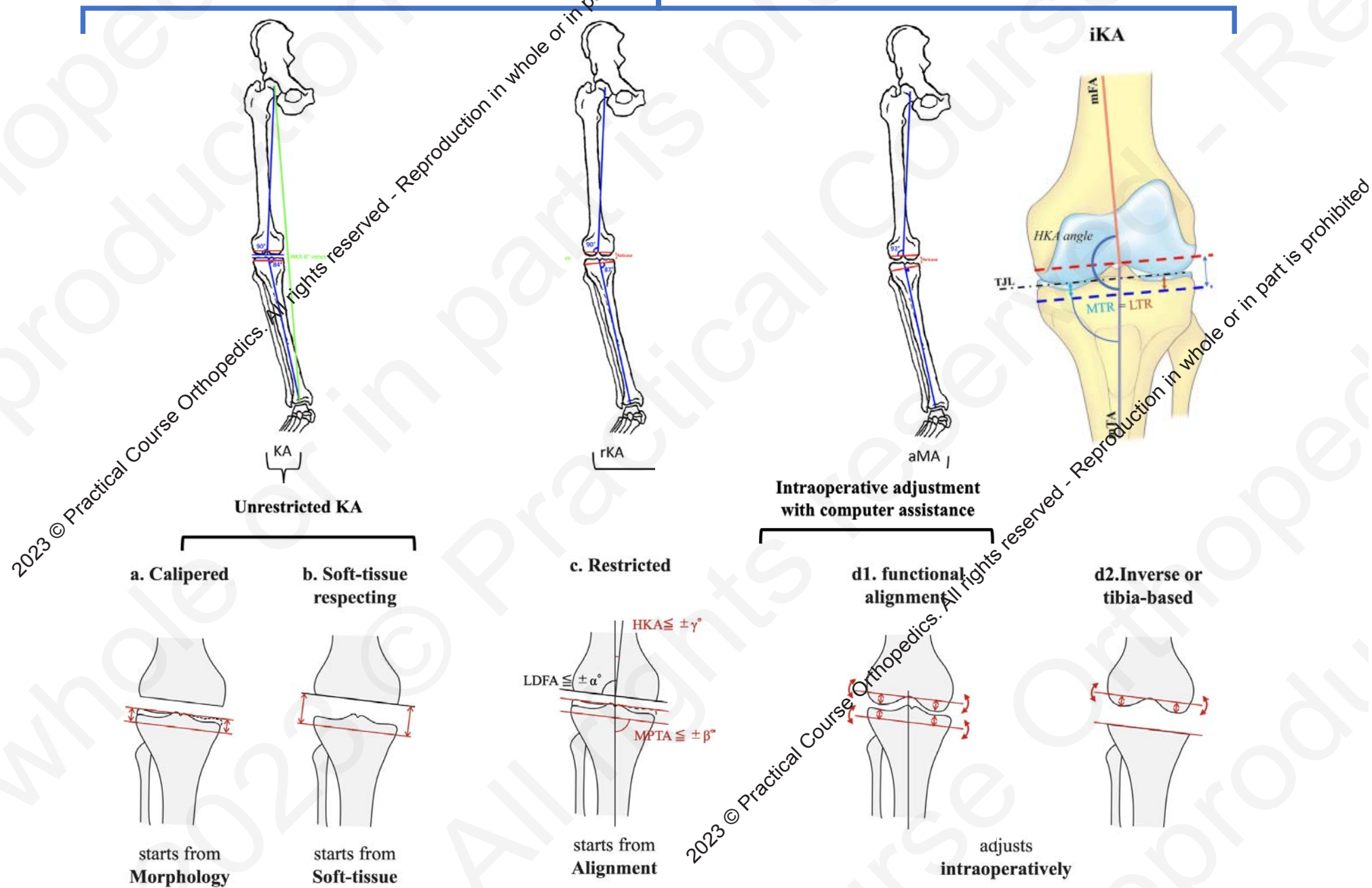
Philip Winnock de Grave · Thomas Luyckx · Kurt Claeys · Thomas Tampere · Jonas Kellens · Jacobus Müller · Paul Gunst

Knee Surgery, Sports Traumatology, Arthroscopy (2022)

# Alignments nowadays

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- 4) Functional alignment (robot): mix of concepts (personalized al.)

# Functional alignments



# Conclusions

- The new gold standard: it is not a single alignment, it is rather a concept including:
  - enabling technologies to «understand» the knee we are dealing with
  - adaptation to the soft tissue environment and evaluation of hard tissue loss to be substituted to mimic (regain?) the pristine function