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Phenotypic Differences In Coronal Alignment In Robot-Assisted Total Knee Arthroplasty Do Not Affect Patient-Reported Outcome Measurements In A Three-Dimensional Computed Tomography Analysis : A Single-Center Cohort Study

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Disclosure

No relevant disclosures of conflict of interest

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Introduction. 1

35% of cases of early revision after TKA

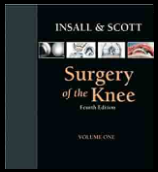
“ soft tissue imbalance ”

- **Instability** — Fehring TK et al. *Clin Orthop* 2001
- **limitation of ROM** — Sharkey PF et al. *Clin Orthop* 2002
- **loosening** — Berger R et al. *Clin Orthop* 2001

「***TKA is a Soft Tissue Procedure***」

Scott N.W.

Insall & Scott Surgery of the Knee. Fifth Edition



Introduction. 2

- **The variability in component alignment** is well **tolerated** as long as the soft tissues are balanced — Lonner JH et al. *Int Orthop* 2022

Image-free handheld robotic-assisted (RA) surgery with the *Blue Belt Navio* and *CORI surgical system* (Smith & Nephew, Plymouth, MN, USA)

Intraoperatively with "*consideration with soft tissue envelope of each patient*" over the full range of motion (ROM)

↓

Decision of component alignment and amount of bone resection (Indivisualized approach)

↓

Kaneko T et al. *Knee* 2021
Kaneko T et al. *J Robotic Surgery* 2022

Personalized alignment — Lustig S et al. *SICOT* 2021

Aim

- **The purposes of this study**

  (1) to evaluate whether patients undergoing RA-TKA develop *a variety of postoperative phenotypes* in coronal alignment

  (2) to compare *postoperative patient reported outcome measurements (PROMs)* among these phenotypes

- **Our hypothesis**

  Postoperative PROMs would not be affected by phenotypic differences in coronal alignment using RA technique

Materials and Methods.1

2019. 5 ～ 2022. 8

Patients flow diagram

Enrollment

Patients with varus and valgus osteoarthritis of the knee
(Kellgren-Lawrence: grade 4 , Ahlback: grade 3 or 4 (n= 163)

Preoperative analysis

Prediction of femoral and tibial component alignment and osteotomy volumes according to the neutral mechanical axis by 3DCT

Intraoperative evaluation

Decision the prosthetic positioning and volume bone resections through consideration of soft tissue laxity in individual patients using imageless RA technology

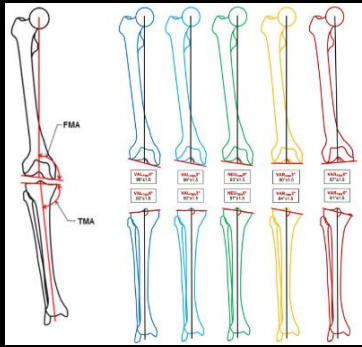
Postperative analysis

Study patients (n= 50)
measurement femoral and tibial component alignment using plain 3DCT and cases older than 1 year

Materials and Methods.2

- Hirschmann proposed “ Phenotype”
  - 5 FMA (Femoral mechanical angle)
  - 5 TMA (Tibial Mechanical angle)
  - 7 HKA (Hip Knee ankle angle)

Hirschmann MT et al. *KSSTA* 2019



- Patient reported outcome measurements
  - 2011 Knee Society Score (patient satisfaction and advanced activities)

Scuderi GR et al. *Clin Orthop* 2012

  - 12 items of the Forgotten Joint Score

Behrend H et al. *J Arthroplasty* 2012

  - Patella score

Fellar JA et al. *BJJ* 1996

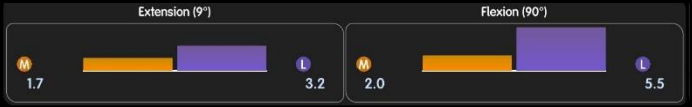
at a mean of 15.1 months (12～25) postoperatively

Gap assessment (bone gap ≠ component gap)

- **BCS: gap balance using balancer due to improve PROMs**
  - ***Medial slightly laxity*** **from 0° to 90° of flexion**
  - ***Lateral looseness*** **at 90° of flexion**

Kaneko T et al. *JOO* 2017

Inui H et al. *J Knee Surgery* 2019



- **Extension**
  - **Medial 1.0 - 2.0 mm**
    - **(depending on the size of MTP posterior spur)**
  - **Lateral 2.5 - 3.5 mm**
- **Flexion**
  - **Medial 2.0 - 2.5 mm**
    - **(depending on the size of MFC posterior clearance)**
  - **Lateral 4.5 - 6.0 mm**

Gap adjustment boundary

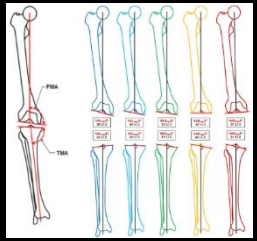
- **Maintain joint line**
- **Up to 2 ° varus to femur**
- **＋/－ external rotation femur**
- **Do not over tighten lateral gap in flexion**

Results

∗ Preoperative demographic data

Preoperative characteristics	
Age (year)	76.9 (SD 6.9; 51 ~ 90)
Gender (male:female)	13:37
BMI (kg/m^2)	25.5 (SD 4.5; 20.2 ~ 41.5)
Extension (°)	8 (SD 3.1; 0 ~ 16)
Flexion (°)	114 (SD 8.2; 95 ~ 128)
Deformity (°) (+ : varus, - : valgus)	8.0 (SD 8.2; -5 ~ 22)
Follow up periods (month)	15.1 (SD 5.4; 12 ~ 25)

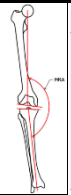
∗ Absolute (N) and relative distribution (%) of FMA and TMA



FMA			
Groups (°)	Phenotypes	N	(%)
87°±1.5°	VAR$_{FMA}$6° (85.5°<FMA<88.5°)	0	0
90°±1.5°	VAR$_{FMA}$3° (88.5°<FMA<91.5°)	0	0
93°±1.5°	NEU$_{FMA}$0° (91.5°<FMA<94.5°)	12	24
96°±1.5°	VAL$_{FMA}$3° (94.5°<FMA<97.5°)	29	58
99°±1.5°	VAL$_{FMA}$6° (97.5°<FMA<100.5°)	9	18

TMA			
Groups (°)	Phenotypes	N	(%)
81°±1.5°	VAR$_{TMA}$6° (79.5°<TMA<82.5°)	0	0
84°±1.5°	VAR$_{TMA}$3° (82.5°<TMA<85.5°)	6	12
87°±1.5°	NEU$_{TMA}$0° (85.5°<TMA<88.5°)	11	22
90°±1.5°	VAL$_{TMA}$3° (88.5°<TMA<91.5°)	30	60
93°±1.5°	VAL$_{TMA}$6° (91.5°<TMA<94.5°)	3	6

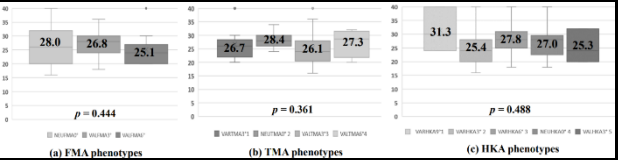
∗ Absolute (N) and relative distribution (%) of HKA



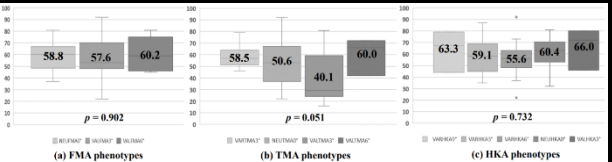
Coronal alignment			N	(%)
Limb phnocyte(HKA)	VARHKA	VARHKA9° 169.5°<HKA<172.5°	3	6
		VARHKA6° 172.5°<HKA<175.5°	13	26
		VARHKA3° 175.5°<HKA<178.5°	19	38
	NEUHKA	NEUHKA0° 178.5°<HKA<181.5°	12	24
	VALHKA	VALHKA3° 181.5°<HKA<184.5°	3	6
		VALHKA6° 184.5°<HKA<187.5°	0	0
		VALHKA9° 187.5°<HKA<190.5°	0	0

∗ Comparison of Phenotypes for PROMs

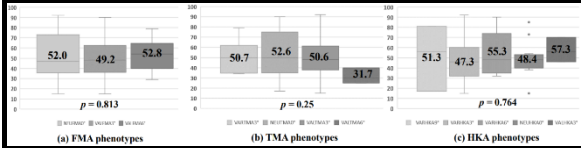
(1) *2011 KSS patient satisfaction (40)*



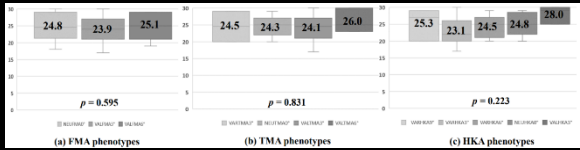
(2) *2011 KSS advanced activities (100)*



(3) *FJS-12 (100)*



(4) *Patella score (30)*



PROMs were *not statistically different* between the FMA, TMA, and HKA phenotypes

nonparametric Wilcoxon/Kruskal-Wallis test

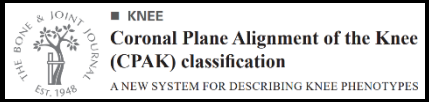
Discussion. 1

The principal findings of the present study

- RA techniques that finalize component alignment intraoperatively based on each individual's soft tissue envelope over full ROM led to valgus 3° , valgus 3° , and varus 3° as the most common FMA, TMA, and HKA phenotypes.

- The phenotypic differences in the coronal plane obtained did not affect postoperative PROMs.

A wide variability in coronal alignment

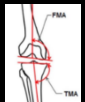


MacDessi SJ et al. *BJJ* 2021
n = 250 (plain X-P)

vs

Phenotyping the knee in young non-osteoarthritic knees shows a wide distribution of femoral and tibial coronal alignment

Hirschmann MT et al. *KSSTA* 2019
n = 160 (CT scan)



Discussion. 2

Reoperations are few and confined to the most valgus phenotypes 4 years after unrestricted calipered kinematically aligned TKA

Howell SM et al. *KSSTA* 2022

- **KA 198 TKAs**

FMA		
Phenotypes	*N*	%
$VAL_{FMA}6°$	7	3.5
$VAL_{FMA}3°$	43	21.7
$NEU_{FMA}0°$	98	49.5
$VAR_{FMA}3°$	42	21.2
$VAR_{FMA}6°$	8	4.1
Total	198	100

TMA		
Phenotypes	*N*	%
$VAL_{TMA}6°$	4	2
$VAL_{TMA}3°$	53	26.8
$NEU_{TMA}0°$	111	56.1
$VAR_{TMA}3°$	29	14.6
$VAR_{TMA}6°$	1	0.5
Total	198	100

HKA		
Phenotypes	*N*	%
$VAL_{HKA}6°$	15	7.6
$VAL_{HKA}3°$	48	24.2
$NEU_{HKA}0°$	74	37.4
$VAR_{HKA}3°$	47	23.7
$VAR_{HKA}6°$	14	7.1
Total	198	100

- ***FJS-12 score*** **was *not statistically different* between the FMA, TMA, and HKA phenotypes.**

- ***OKS*** **was *not statistically different* between the TMA and HKA phenotypes.**

- ***The most varus FMA phenotypes*** **was associated with a greater *OKS* than other FMA Phenotypes.**

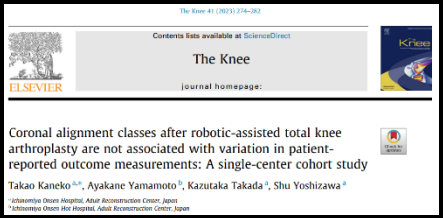
at a mean follow-up 4 years

Weakness of this study and Conclusion

- The number of patients was small
- No comparison group
- Postoperative PROMs reflect short-term results
- 3DCT were taken in the supine position

→ A larger prospective study with a larger number of cases and with medium- and long-term results is needed to further substantiate the present results.

∗ Conclusion: *Coronal alignment classes after robotic-assisted TKA are not associated with variation in PROMs*



Kaneko T et al. *Knee* 2023; 41: 274-284