Short-term clinical outcome of functionally aligned robotic-assisted BCS TKA is better than that of mechanically aligned navigation-assisted BCS TKA

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COI disclosure

- Smith & Nephew：Lecture and advisor fee

Background

- Traditionally, a postoperative neutral mechanical alignment was the gold standard in total knee arthroplasty (TKA) and mechanically aligned TKA has achieved good long-term survival.

Jeffery RS, et al. JBJS Br (1991), Ritter MA, et al. CORR(1994)

- However, recent study demonstrated the variety of coronal alignment in non-arthritic population and raises a question whether post-operative neutral alignment is not a target for all patients.

Bellemans J, et al. CORR (2012)

- To resolve this issue, a couple of personalized alignment such as kinematic alignment, restricted kinematic alignment, inverse kinematic alignment, and functional alignment has been proposed.

Almaawi MA, J Arrhroplasty (2017), Mac Dessi SJ, et al. Bone Joint J (2020), Winnock de Grave P, et al. KSSTA (2022), Kayani B, et al. Trials (2020)

Objective

- Recently introduced robotic technologies accelerate the surgery based on the personalized alignment in TKA.

- The purpose of this study is to compare the clinical outcome of mechanically aligned navigation-assisted TKA and functionally aligned robotic-assisted TKA.

Patients

- A total of 132 bicruciate-stabilized (BCS) TKA was included in this study.
- Fifty-nine knees were navigation-assisted TKA and 73 knees were robotic-assisted TKA.
- Fixed valgus deformity, previous osteotomy, extra-articular deformity cases were excluded.
- This study was approved by the institutional review board.

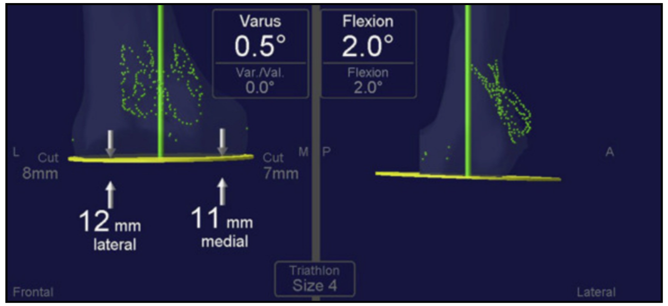
	Navigation	Robotics	
Number of cases	59	73	
Age	73.0 ± 8.1	72.8 ± 8.9	n.s.
Male / Female	11 / 48	24 / 49	n.s.
BMI	27.3 ± 4.3	26.5 ± 3.8	n.s.
OA / RA / ON	54 / 4 / 1	64 / 7 / 2	n.s.

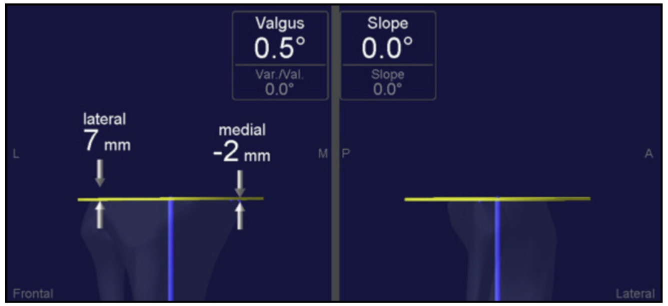
Implant

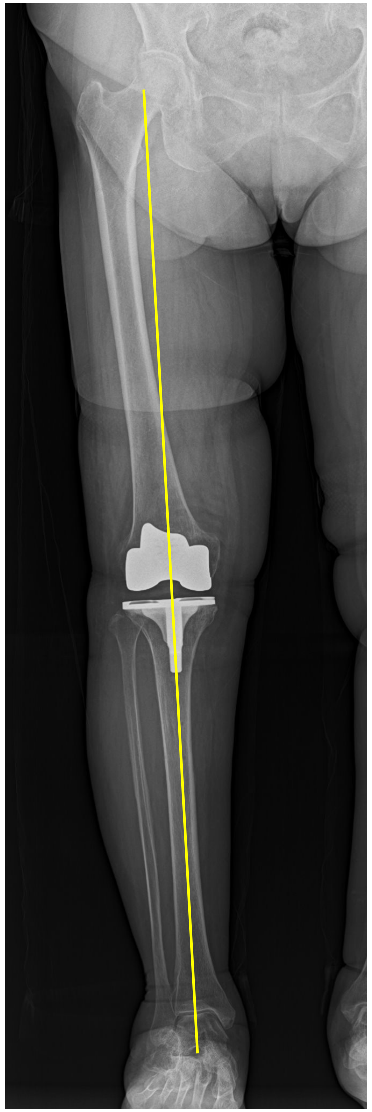
- Journey2 BCS (Smith & Nephew)
- Characterized by dual post-cam mechanism and asymmetric tibial surface

Methods: Surgical procedure (Navigation)

- An image-free navigation system (Precision N; Stryker) was used.
- The distal femur and proximal tibia were cut perpendicular to the mechanical axis in the coronal plane using cutting blocks and a saw blade.
- Femoral flexion and tibial posterior slope were set 3-5° and 3° respectively.
- The extension and flexion gap was then evaluated using an implant-specific space block.
- To control the flexion gap, the rotational alignment and AP position of the femoral component was decided based on the gap measurement.

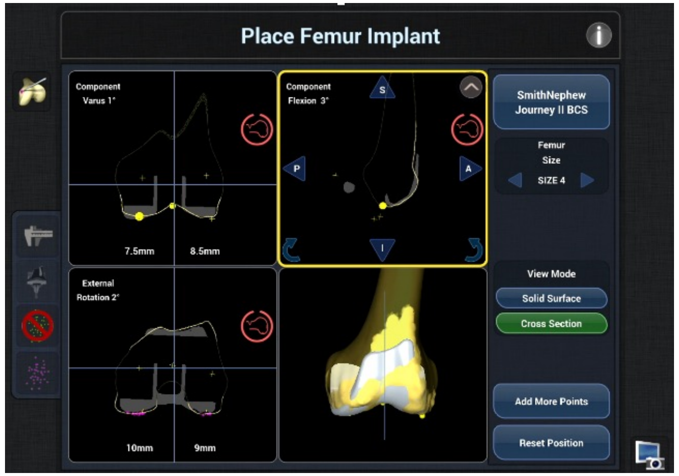


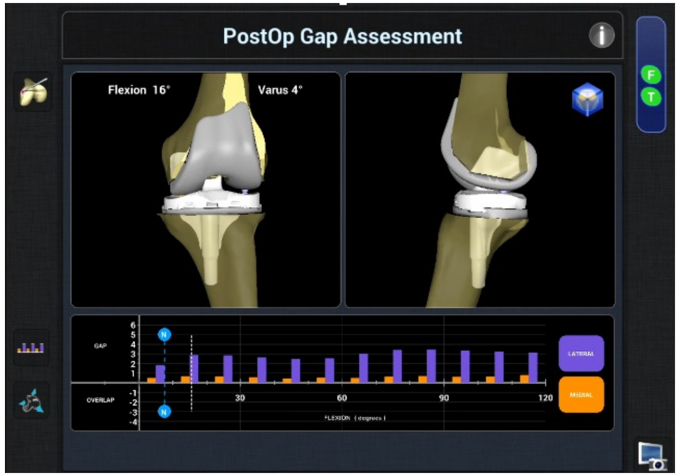




Methods: Surgical procedure (Robotics)

- An image-free handheld robotics (NAVIO; Smith & Nephew) was used.
- This system creates a realistic virtual three-dimensional model of the knee and proposes the initial implant size and position.
- The initial intraoperative plan started from neutral mechanical alignment.
- After gap evaluation using robotics, the was manipulated to minimize the soft tissue imbalance while limb alignment must fall within ± 3 degrees of neutral in coronal plane.
- After approval of the plan, femur and tibia were cut using robotically controlled handheld bur.





Methods: summary of alignment philosophy

		Navigation	Robotics
Target alignment		Mechanical alignment (MA)	Functional alignment(MA $\pm 3°$)
Femoral component	Coronal plane	Perpendicular to MA	MA $\pm 2°$
	Sagittal plane	Flexion 3-5°	Flexion 3-5°
	Axial plane	Parallel to SEA	SEA $\pm 2°$
Tibial component	Coronal plane	Perpendicular to MA	MA $\pm 2°$
	Sagittal plane	Posterior slope 3°	Posterior slope 3°
	Axial plane	Akagi's line	Akagi's line and ROM
Soft tissue balance evaluation		Implant-specific pacer block	Robotics and implant-specific spacer block
Extension balance control		Minor soft tissue release	Manipulation of implant position under robotic control
Flexion balance control		AP position of femoral component	Manipulation of implant position under robotic control

Evaluation items

- Range of motion (ROM)
- Hip-knee-ankle angle (HKA)
- 2011 Knee society score (KSS)
  - Objective knee indicators
  - Current knee symptoms
  - Patient satisfaction
  - Patient expectation
  - Functional activities

Statisitical analysis

- Unpaired t-test was used to evaluate differences between navigation and robotics.
- The level of significance was set at $p < 0.05$ for all tests.

Results

- Preoperative ROM, HKA and 2011 KSS scores

	Navigation	Robotics	
Preoperative extension	-10.3 ± 7.9	-12.7 ± 7.7	n.s.
Preoperative flexion	118.5 ± 12.7	116.0 ± 14.0	n.s.
Preoperative HKA	169.8 ± 6.2	170.6 ± 6.7	n.s.
2011 KSS Objective knee indicators	28.8 ± 14.4	24.3 ± 19.6	n.s.
2011 KSS Symptoms	6.6 ± 4.4	6.5 ± 5.2	n.s.
2011 KSS Patient Satisfaction	15.3 ± 4.8	14.1 ± 6.8	n.s.
2011 KSS Patient Expectation	12.8 ± 1.7	13.6 ± 1.7	$P < 0.05$
2011 KSS Functional Activities	29.6 ± 17.3	32.6 ± 17.1	n.s.

Results

- Postoperative ROM, HKA and 2011 KSS scores

	Navigation	Robotics	
Preoperative extension	-1.8 ± 4.4	-0.8 ± 2.2	n.s.
Preoperative flexion	123.7 ± 11.4	126.4 ± 9.5	n.s.
Preoperative HKA	179.4 ± 2.2	178.5 ± 2.7	n.s.
2011 KSS Objective knee indicators	72.8 ± 5.5	74.6 ± 2.8	P < 0.05
2011 KSS Symptoms	18.8 ± 5.2	20.6 ± 4.2	P < 0.05
2011 KSS Patient Satisfaction	26.5 ± 8.5	29.3 ± 7.4	P = 0.08
2011 KSS Patient Expectation	10.2 ± 2.3	9.9 ± 2.5	n.s.
2011 KSS Functional Activities	59.49 ± 22.9	68.4 ± 15.5	P < 0.01

Discussion

- The most important finding of this study is that clinical outcome of functionally aligned robotic-assisted BCS TKA is better than mechanically aligned navigation-assisted BCS TKA.

- Functional activities showed most significant difference between groups.

- This result is similar to the previous study that compared the outcome of mechanically aligned TKA and kinematically aligned TKA.

Matsumoto T, et al. BJJ (2017), Niki Y, et al. J Arthroplasty (2018)

Discussion

- Kinematically aligned TKA is reported to obtain ligament balance easily and to achieve better clinical without concerned problems like alignment-related failure.

Laende EK, et al. BJJ (2019), Shelton TJ, et al. BJJ (2017)

- 80% of Japanese patients fall out of the safety range even in the restricted kinematically-aligned TKA

Suda Y, et al. Knee (2022)

- Functional alignment that respects soft tissue envelope while achieving mechanically-sound prosthetic alignment is a promising way to improve the clinical outcome

Oussedik S, et al. BJJ (2020)

Conclusion

- Functionally aligned robotic-assisted BCS TKA showed better postoperative 2011 KSS items of objective knee indicators, symptoms and functional activities compared to that of mechanically aligned navigation-assisted BCS TKA.

- Personalized alignment using robotics potentially provides better clinical outcome than uniform mechanical alignment for all cases.

- Differences between navigation and robotics such as limb alignment, soft tissue balance, bone resection volume, joint line obliquity may affect the results.

- Further study to investigate which factor affect this result is necessary.