ISAKOS CONGRESS 2023 | Boston Massachusetts June 18–June 21 | SHOWA University | SUks Showa University knee surgery

Accuracy of the Component Alignment and Sizing in Total Knee Arthroplasty: Preoperative Templating and Postoperative Evaluation Using CT-Based 3D Pre-Operative Planning Software

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Background

Accurate component placement and optimal soft tissue balance are essential for successful total knee arthroplasty (TKA). The conventional mainstream of preoperative templating and postoperative evaluation techniques in TKA was mainly performed based on 2-D X-ray images. However, 3-D templating and evaluation using CT or MRI data have recently become more popular, which enables them to be more accurate. Hence, this study evaluated the accuracy of the component alignment and size matching rates by comparing preoperative templating to postoperative data collected using CT-based 3D preoperative planning software (ZedKnee; LEXI, Tokyo, Japan).

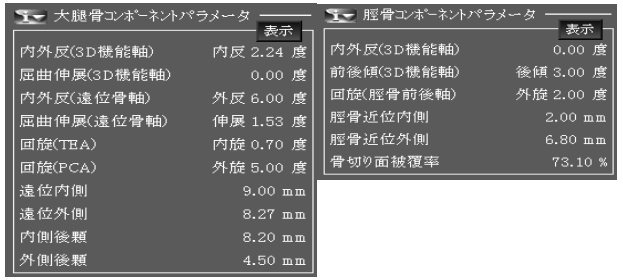
Methods

We retrospectively included 150 patients, 219 knees (115 females, 35 males; 75.1±7.5 y.o.), who had undergone primary at our institute from July 2015 to December 2020.

Preoperative 3D-CT Templating

Remodeling of 3D bone model
by importing CT data in DICOM format into a database application

Positioning of Implants
Implants can be placed at optimal positions on 3D model and MPR images



Calculate Parameters

Our Preoperative Planning

Implants; PS Fixed Bearing of ATTUNE (Depuy Synthes, Warsaw, IN, USA)

Aimed Alignment: Mechanical Alignment

Femoral Component: 6° of valgus for distal femoral axis[1], Rotation; 3° externally for PCA (posterior-condylar axis)[1]

Tibial component: Varus/Valgus; 0° for tibial axis, Posterior slope; 3°, Rotation; following Akagi's line. [2]

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Methods

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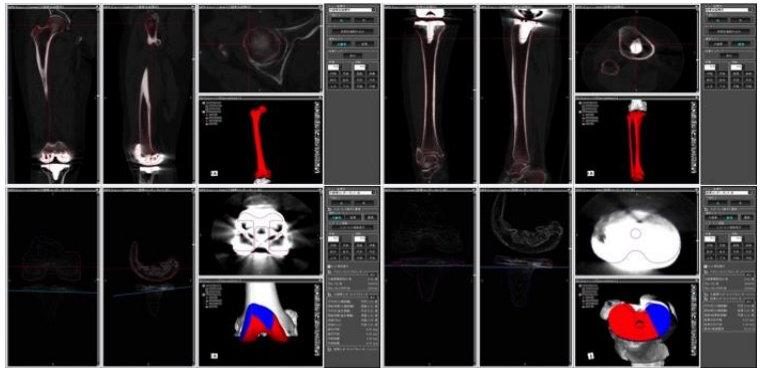
Postoperative 3D-CT Evaluation

(CTs were routinely taken on the 3rd postoperative day for assessing PE-DVT.)



"Compare and assess how implant placement parameters have been changed and placed against the reference plane or reference axis as well as how much the alignment has changed after the operation as compared with preoperative plans." (http://www.lexi.co.jp/en/products/zedview/zedknee)

We evaluated

- Pre and postoperative component size matching rates
- Accuracy of the component's installation.

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Results

Pre- and Postoperative component size matching rates

Femoral components 72.2% （114/158）, Tibial components 62.7% （99/158）

1 size down; 15 knees, 1 size up; 27 knees, 2 sizes up; 2 knees, 1 size down; 14 knees, 1 size up; 45 knees

Table 1. Alignments of Femoral Components

	Preoperative	Postoperative	（°Mean±SD）
Valgus/Varus（3D axis）	-0.1±2.1	-2.2±2.2	（+ valgus/- varus）
Valgus/Varus（Distal Femoral axis）	6.1±0.9	4.1±2.3	（+ valgus/- varus）
Extension/Flexion（3D axis）	-0.2±0.8	0.4±2.8	（+ extension/- flexion）
Extension/Flexion（Distal Femoral axis）	1.8±2.0	2.4±3.1	（+ extension/- flexion）
Rotation（Posterior Condylar Axis）	3.2±0.8	3.9±2.2	（+ external/- internal）

Table 2. Alignments of Tibial Components

	Preoperative	Postoperative	（°Mean±SD）
Valgus/Varus（3D axis）	0.0±0.3	-0.8±1.9	（+ valgus/- varus）
Posterior slope（3D axis）	3.0±0.4	4.3±2.2	
Rotation（Anteroposterior axis）	0.2±0.9	-7.0±7.1	（+ external/- internal）

Discussion 1

Component Size Matching Rates

The tibial component's pre- and postoperative size matching rates were lower than the femoral ones. Furthermore, in many cases, the actual implant sizes finally installed were one size larger than the estimated preoperatively. In such cases, it might result from prioritizing the coverage over the rotation.

Discussions 2

Alignments of Components

Table 3. Comparing to previous studies

	Femoral components		Tibial components		
	Valgus/Varus	Rotation	Valgus/Varus	Posterior slope	Rotation
This study	-2.2±2.2	3.9±2.2	-0.8±1.9	4.3±2.2	-7.0±7.1
Kodama et al.[3)]	-0.7±3.0		1.3±1.1	2.5±1.8	
Asada et al.[4)]	-0.7±2.7		-0.1±1.6		
Sato et al.[5)]	1.5±0.9	2.8±1.6	1.5±0.8	2.5±1.9	-3.8±0.8
Matziolis el al.[6)]	1.0±0.6		1.4±0.9	2.5±1.3	

※（°±SD），-; varus or internal rotation

Femoral valgus/varus was slightly varus, and tibial rotation showed a strong tendency toward internal rotation with a large variation. In addition, compared to the preoperative plan, there were 70 knees with errors of more than 7˚ of internal rotation of the tibial component and 2 knees with errors of more than 3˚ of external rotation. Among them, 42 knees with 10˚ or more errors were all placed internally rotated.

Discussions 3

Correlation with Patient's Outcomes

- Klasan et al. argue that the zone without a negative impact on PROMs (Patient Reported Outcome Measures) is rotated from 7˚ internally to 3˚ externally from the Insall's axis of the tibia[5].

- Panni AS et al. found that more than 10˚ of internal rotation of tibial components represents a significant risk factor for pain and inferior functional outcomes after TKA.[6]

Limitations

- Since ZedKnee (LEXI, Tokyo, Japan) is a software based on CT data, cartilage thickness was not taken into consideration.
- There might be variations in the bony landmark settings that provide the reference point for the 3D templating.
- Pre- and postoperative PROMs have not been examined.

Conclusions

- Using 3D planning software in the preoperative planning of TKA enabled us to place components in good position and alignment.
- However, there was a tendency for the tibial component to be placed internally rotated with a greater variation than the previous studies and the femoral component to be placed in a slightly varus.
- Therefore, the results indicated that we need to improve and refine intraoperative techniques to reflect preoperative planning to intraoperative practice more accurately.

What's next?

- Assessment of the correlation between component alignments and PROMs is required.
- We are improving intraoperative techniques to reproduce preoperative planning more accurately.
  - ✓ Using the custom-made caliper to estimate the amount of distal femoral bone resection.
  - ✓ Some tips to reproduce Akagi's line on the tibial surface after tibial resection.
  - ✓ Assessment of the validity of preoperative planning - In need of adjusting parameters individually.

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