

Intraoperative Varus-Valgus Joint Laxity Pattern was Associated with Postoperative Knee Flexion Angle and Patient-Reported Outcome Measures in Bicruciate-Stabilized Total Knee Arthroplasty

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Disclosure of Conflicts of Interest

The authors have no financial conflicts of interest to disclose concerning the presentation.



Background & Purpose

- In total knee arthroplasty (TKA), appropriate soft tissue balance is essential for good clinical outcomes^{1,2)}.
- In conventional TKA procedures, mediolateral (ML) soft tissue balance has generally been assessed by gap measurements in knee extension and flexion. On the other hand, in recent-introduced robot-assisted TKA procedures³⁾, laxity under varus-valgus (VV) stress in the entire knee range of motion (ROM) is assessed to evaluate ML soft tissue balance.
- Although it has been reported that ML laxity under VV stress correlates well with gap measurements⁴⁾, there is still insufficient evidence regarding the relationship between intraoperative ML laxity throughout the entire knee ROM and postoperative outcomes.
- The purpose of this study was...

to clarify the relationship between postoperative clinical outcomes and intraoperative ML laxity patterns throughout the entire knee ROM after implant placement in TKA.



Materials & Methods

• One hundred and sixty-seven mechanically aligned BCS TKAs



Age (year)	Gender (Male : Female)	BMI (kg/m²)	Pre-op Extension (degree)	Pre-op Flexion (degree)	Pre-op HKA (degree)
71.6 ± 8.8	28:106	24.7 ± 7.5	-8.7 ± 7.1	120.2 ± 10.8	171.1 ± 6.1

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Materials & Methods

• Knee laxity data obtained using navigation system⁵)



- ✓ We defined the amount of change in varus and valgus angles from the unstressed mechanical axis at each knee flexion angle as <u>the</u> <u>lateral and medial joint</u> <u>laxity under a varusvalgus force (JLVV)</u>
- \checkmark Medial and lateral JLVVs were calculated at a knee flexion of 10°, 30°, 60°, 90°, and 120° .
- ✓ Then, the patients were categorized into three groups based on the post-implantation medial and lateral JLVV at a knee flexion of 10°, 30°, 60°, 90°, and 120° using hierarchical cluster analysis [Pattern (P) 1−3].

Primary Endpoints

- Among the three clusters of JLVV patterns,
 - 1 Knee flexion angles
 - ② Patient-reported outcome measures (PROMs)
 - ✓ Knee injury and Osteoarthritis Outcome Score (KOOS)
 - ✓ The patient-satisfaction score in the 2011 Knee Society Score (2011 KSS)

were compared at postoperative one year.

Statistical analysis

- ✓ To compare the patients' characteristics, knee flexion angles, and pre- and postoperative KOOS among the three clusters, oneway analysis of variance (ANOVA) was used for continuous data and Fisher's exact tests was used for categorical data.
- Two-way repeated measures ANOVA was used to analyze the effects of post-implantation JLVV patterns (P1-3) and knee flexion angles (10°, 30°, 60°, 90°, and 120° of flexion) on each of the medial and lateral JLVV values. Subsequently, post-hoc pairwise multiple comparisons of the JLVV values within each JLVV pattern group were performed using Bonferroni's correction.
- ✓ The level of statistical significance was set at P < 0.05.
- \checkmark All data are expressed as means ± standard deviations.
- A power analysis was performed with G*Power using an α error of 0.05, a 1 β error of 0.80 (the rate of type II error should be no more than 20%), and an effect size of 0.40, and the results indicated that a required sample size to detect differences were 66 knees for one-way ANOVA, and 51 knees for two-way repeated measures ANOVA.



Results: the Three JLVV Patterns



(dearees)

Patients' background	P1 (n=47)	P2 (n=55)	P3 (n=32)	P value
Age (year)	73.3 ± 8.1	69.8 ± 9.8	72.1 ± 7.5	0.115
Gender (Male : Female)	7:40	13:42	8:24	0.466
BMI (kg/m²)	25.5 ± 3.6	26.8 ± 4.3	26.6 ± 4.8	0.272
Pre-op knee extension (degree)	-8.4 ± 6.5	-10.3 ± 7.1	-6.5 ± 7.5	0.054
Pre-op knee felxion (degree)	120.3 ± 12.5	118.8 ± 9.7	122.3 ± 9.8	0.332
Pre-op HKA (degree)	170.8 ± 5.8	172.0 ± 6.1	170.1 ± 6.4	0.327
KOOS Pain	46.8 ± 15.5	40.6 ± 16.9	44.4 ± 20.7	0.210
KOOS Symptom	53.2 ± 18.3	46.7 ± 20.3	47.7 ± 24.2	0.259
KOOS ADL	60.5 ± 15.7	55.5 ± 16.4	54.0 ± 18.8	0.188
KOOS Sports	21.7 ± 18.0	19.3 ± 19.4	16.4 ± 20.2	0.480
KOOS QOL	26.7 ± 17.6	25.1 ± 16.3	20.3 ± 14.3	0.230
2011KSS Satisfaction	13.0 ± 6.5	10.7 ± 5.6	10.1 ± 7.0	0.088

 \checkmark There were no significant differences in patient background and preoperative knee range of motion and PROMs among the three clusters.

- ✓ P1 showed medial JLVV of 3° or more at 30°, 60°, 90°, and 120° of knee flexion, all of which were larger than P 2–3 (P < 0.05). On the contrary, P2 exhibited stable JLVVs throughout the entire knee ROM, all of which were smaller than 3°. The medial JLVVs were also generally stable in P3, but the medial JLVV at 120° was smaller than those at other knee flexion angles (P < 0.05).
- In P1, lateral JLVV showed no significant change between 3-4 degrees at flexion \checkmark angles other than at 10° of knee flexion. In contrast, at P2 and P3, lateral JLVV increased with knee flexion. In P2 and P3, the lateral JLVV showed the maximum value at 90° of knee flexion (P < 0.05), and the values were 6° for P2 and 10° for P3.



Results: Knee Flexion Angle at PO 1Y

	P1 (n=47)	P2 (n=55)	P3 (n=32)	P value
Post-op knee extension (degree)	-1.3 ± 3.8	-1.5 ± 2.7	-0.9 ± 2.0	0.740
Post-op knee flexion (degree)	120.5 ± 11.4	127.8 ± 6.7	128.5 ± 5.9	<0.001*



- ✓ Regarding the knee ROM at postoperative one year, P2 and 3 had significantly better flexion angles than P1.
- ✓ In terms of improvement of knee ROM, P2 and 3 were significantly better than P1.



Results: PROMs at PO 1Y

	P1 (n=47)	P2 (n=55)	P3 (n=32)	P value
KOOS Pain	83.0 ± 10.0	87.3 ± 13.3	86.4 ± 11.67	0.176
KOOS Symptom	80.4 ± 11.4	86.0 ± 9.8	81.7 ± 11.3	0.028*
KOOS ADL	85.1 ± 12.0	85.9 ± 12.5	86.4 ± 9.3	0.883
KOOS Sports	57.7 ± 24.4	52.3 ± 27.2	50.3 ± 26.8	0.413
KOOS QOL	66.9 ± 20.8	67.7 ± 22.2	66.0 ± 20.1	0.935
2011 KSS Satisfaction Score	26.6 ± 6.5	30.1 ± 5.7	30.0 ± 5.7	0.009*



- ✓ One year after surgery, all subscales of KOOS and 2011 KSS satisfaction score showed significant improvement in all patterns of JLVV compared to preoperative conditions.
- ✓ Notably, improvements of KOOS pain and symptom scores, and 2011 KSS satisfaction score in P2 were significantly better than those of P1.



Discussions

The most important findings of this study assessing ML laxity throughout the entire knee ROM;

- In BCS TKA,
 - **Medial stability** less than 3° throughout entire knee ROM
 - Lateral laxity of approximately 6–10° at 90 degrees

 \rightarrow Better knee flexion

• Furthermore, patients with moderate lateral laxity of about 6° achieved best 1-year postoperative PROMs compared to patients with less or excessive lateral laxity.

Previous studies have showed similar results evaluating other types of TKA as follows;

- In CR TKA,
 - Medial stability in knee extension and flexion \rightarrow Better patient satisfaction⁶⁾
 - Lateral laxity in knee extension
 - Lateral laxity in knee flexion
- In PS TKA,
 - **Medial stability** in knee flexion
 - Larger lateral laxity in knee flexion \rightarrow Lower KSS⁹⁾
- Better tibial internal rotation against \rightarrow femur during knee flexion^{7,8)}



Limitations

- This is a retrospective study evaluating a single type of implant with a short time follow-up period.
- Since this study was conducted on patients with varus knee osteoarthritis, the results of this study cannot be applied to patients with valgus knee osteoarthritis.
- Intraoperative manual stress testing was not quantified, although its intra- or inter-observer coefficients were excellent in our previous study⁴⁾.
- The classification based on hierarchical cluster analysis used in this study does not cover all patterns of ML laxity.



Conclusions

- Intraoperative ML joint laxity patterns under VV stress throughout the entire knee ROM after BCS TKA, which were assessed using a navigation system, were associated with knee flexion angles and PROMs (KOOS and 2011 KSS satisfaction score) at postoperative one year.
- Patients with medial stability less than 3° throughout the entire knee ROM combined with moderate lateral laxity of approximately 6° at 90° of knee flexion achieved best PROMs in BCS TKA.



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