ISAKOS CONGRESS 2023 | Boston Massachusetts June 18–June 21

Reliability of Preoperative Planning Method That Considers Latent Medial Joint Laxity in Medial Open-Wedge high Tibial Osteotomy

Dong Jin Ryu,* MD, PhD, Sung-Sahn Lee,† MD, PhD, Eui Yub Jung,‡ MD, MS, Joon Ho Wang,§ MD, PhD

*Department of Orthopaedic Surgery, Inha University Hospital, Incheon, Republic of Korea.
†Department of Orthopaedic Surgery, Ilsan Paik Hospital, Inje University School of Medicine, Goyang-si, Republic of Korea.
‡Department of Orthopaedic Surgery, National Medical Center, Seoul, Republic of Korea.
§Department of Orthopaedic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea.

ISAKOS CONGRESS 2023

Boston
Massachusetts
June 18–June 21

Conflict of interest

The authors declare that they have no conflict of interest.

Introduction

- Medial open-wedge High tibial osteotomy ***(MOWHTO)***

  : established procedure for early medial OA in relatively active patients.

- Although several techniques for preoperative correction planning to obtain accurate alignment, **unexpected correction errors** remain **unresolved**.

- *The factors associated with coronal correction* errors in MOWHTO are *still unclear*.

- ***Soft tissue laxity*** recognized as a ***crucial factor*** affecting correction error.

- ***Medial joint laxity***

  : represents the changes in ***joint line convergence angle (JLCA),*** affects soft tissue correction.

Purpose

- (1) ***Quantify medial laxity*** and develop a preoperative planning method that considers medial laxity
- (2) ***Develop an equation*** to reduce coronal correction error in terms of preoperative **medial soft tissue laxity**.

*** Hypothesis**

: conventional ***Miniaci preoperative planning*** method *has a risk of overcorrection* for MOWHTO as *compared with* a method for *medial soft tissue laxity reduction planning*.

Methods

**** Study design / Subject***

- 117 patients (139 knees)

- Conventional Miniachi (47 knees), Latent medial laxity reduction (92 knees)

**** Surgical procedure***

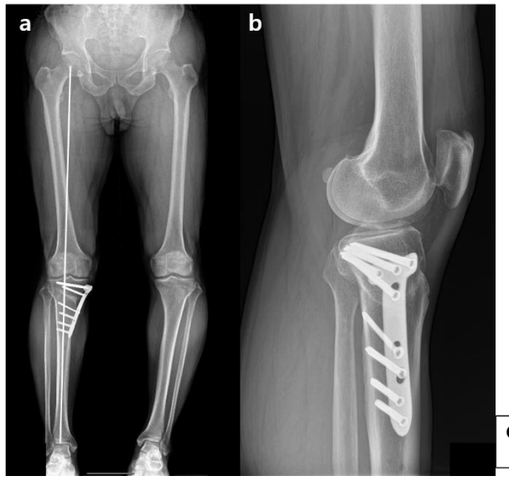
- Targeted postoperative mechanical axis (MA) was 3° valgus

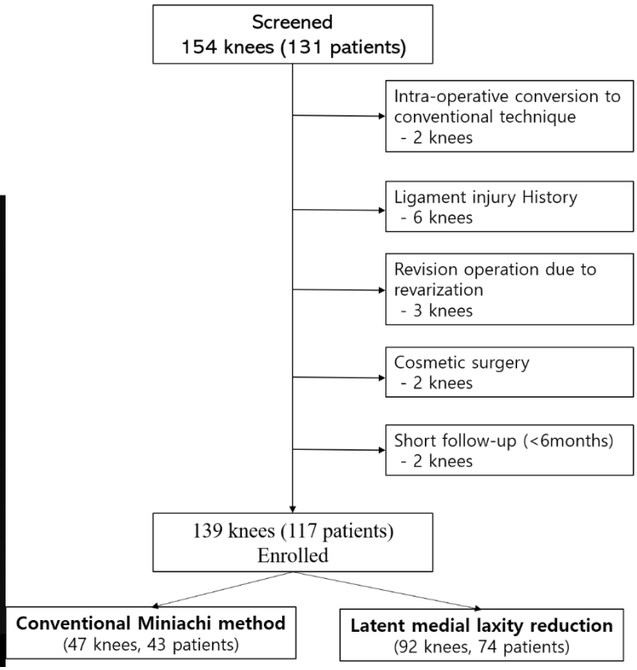
- Biplane MOWHTO was done

- *acceptable correction : valgus range of 1.5 to 4.5°*

- overcorrection: > valgus 4.5°

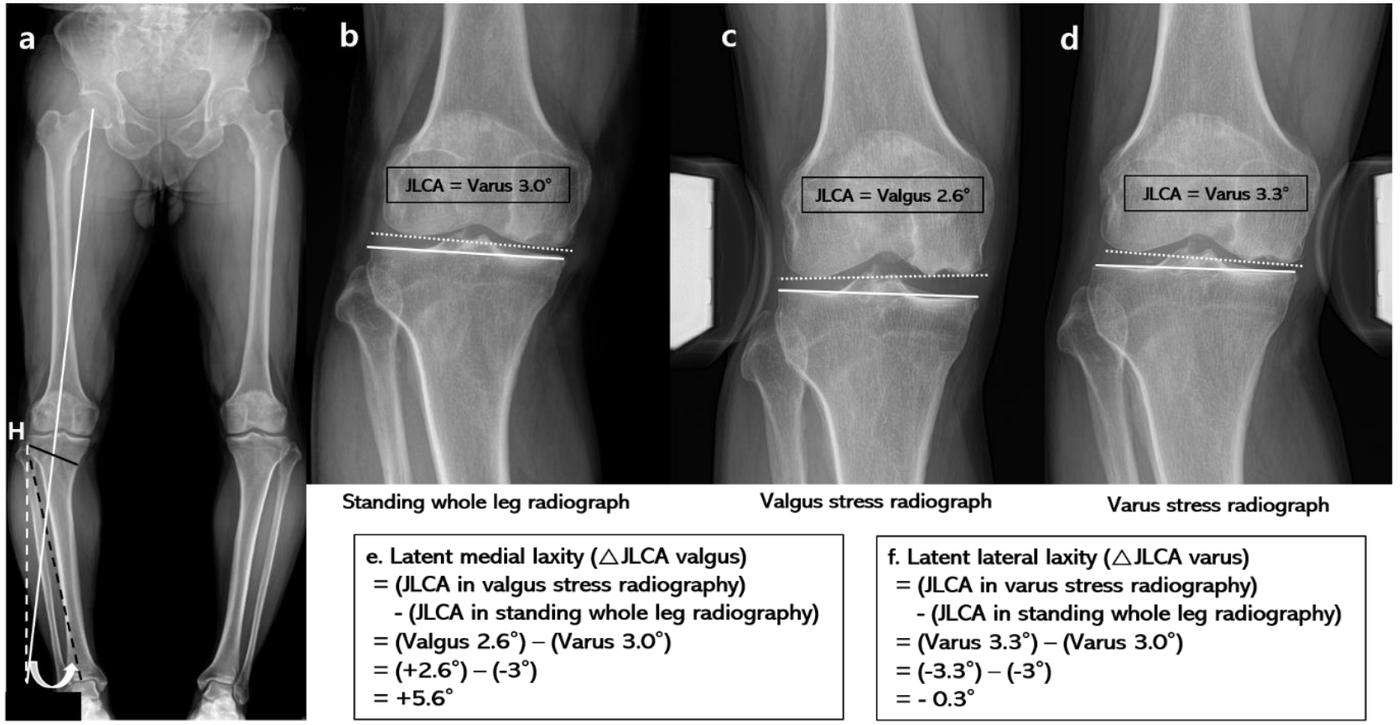
- undercorrection: < valgus 1.5°





Methods

**** Preoperative planning (Miniachi & Latent medial laxity reduction (LMLR) method)***



Standing whole leg radiograph | Valgus stress radiograph | Varus stress radiograph

e. Latent medial laxity (△JLCA valgus)
= (JLCA in valgus stress radiography)
- (JLCA in standing whole leg radiography)
= (Valgus 2.6°) – (Varus 3.0°)
= (+2.6°) – (-3°)
= +5.6°

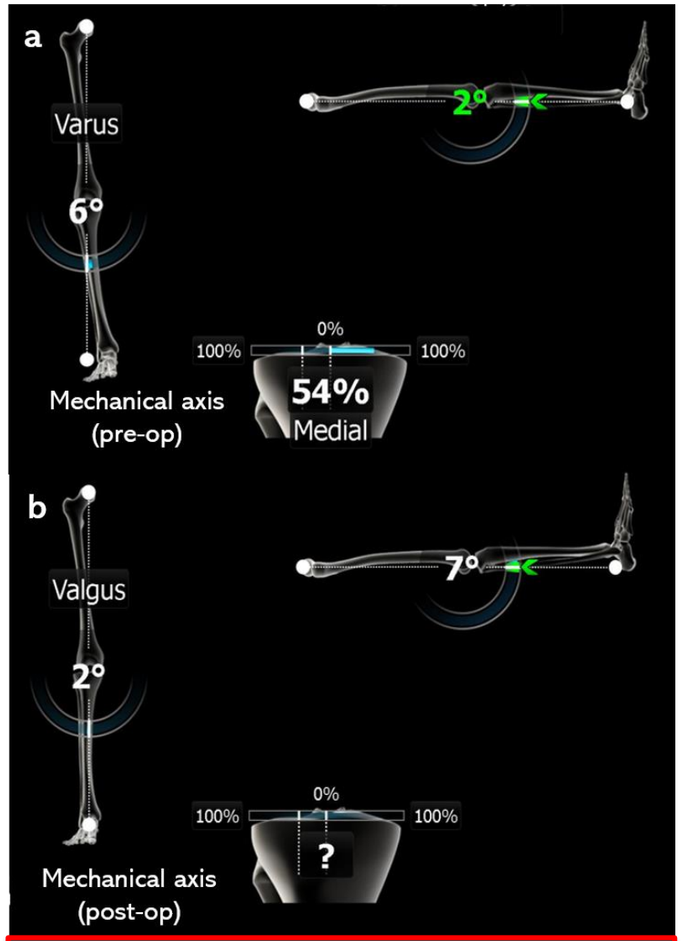
f. Latent lateral laxity (△JLCA varus)
= (JLCA in varus stress radiography)
- (JLCA in standing whole leg radiography)
= (Varus 3.3°) – (Varus 3.0°)
= (-3.3°) – (-3°)
= - 0.3°

LMLR method

$$Planned\ coronal\ correction\ angle = TCA - \tfrac{1}{2}\Delta JLCA_{valgus}$$

or

$$TCA - \tfrac{1}{3}\Delta JLCA_{valgus},$$



c Real correction angle in navigation :
Valgus 2°(+2) – Varus 6° (-6) = Valgus 8° (+8)

Results

* Demographics & post OP mechanical axis

Characteristics and Radiographic Parameters[a]

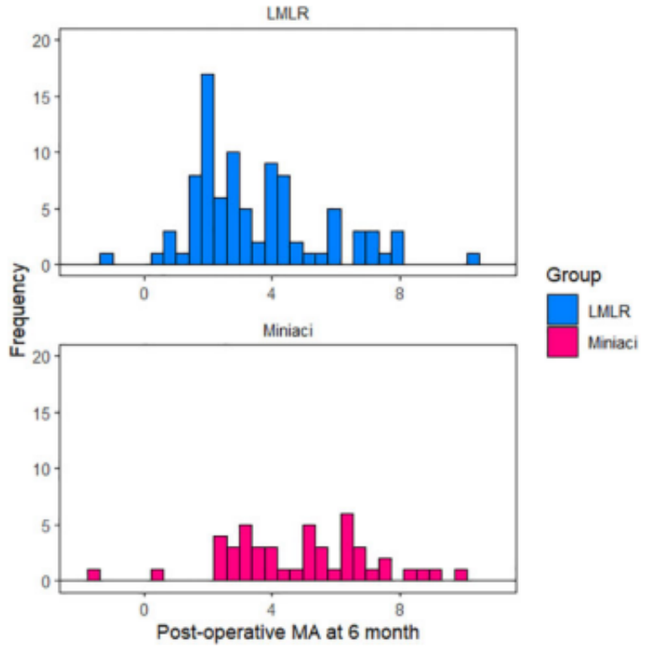
	Knees, Mean (Range)			
	Total (N = 139)	Miniaci Method (n = 47)	LMLR Method (n = 92)	*P* Value
Age, y	54.4 (33 to 65)	53.66 (33 to 64)	54.78 (36 to 65)	.378
Male:female[b]	48:91	13:34	35:57	.223
MA on standing XR, deg[c]				
Preoperative	–8.46 (–5.0 to –18.8)	–7.83 (–5.1 to –12.7)	–8.78 (–5.0 to –18.8)	.071
6-mo postoperative	3.97 (–1.5 to 10.4)	4.87 (–1.5 to 9.8)	3.51 (–1.1 to 10.4)	**.001**
JLCA, deg[c]				
On standing-leg XR	–3.52 (–12.8 to 1.1)	–3.24 (–8.4 to –0.2)	–3.67 (–12.8 to 1.1)	.255
On valgus stress XR	1.13 (–2.2 to 7.6)	1.19 (–1.5 to 5.7)	1.10 (–2.2 to 7.6)	.768
On varus stress XR	–5.18 (–12.1 to –0.9)	–4.88 (–8.7 to –0.9)	–5.34 (–12.1 to –1.0)	.162
$\Delta JLCA_{valgus}$, deg[c]	4.66 (0.8 to 16.8)	4.44 (0.8 to 10.1)	4.78 (1.2 to 16.8)	.428
$\Delta JLCA_{varus}$, deg[c]	–1.67 (–4.4 to 0.7)	–1.63 (–3.3 to –0.3)	–1.68 (–4.4 to 0.7)	.809
RCA, deg	9.94 (6.0 to 20.0)	10.23 (6.0 to 16.0)	9.79 (6.0 to 20.0)	.338
TCA, deg	11.46 (8.0 to 21.80)	10.83 (8.1 to 15.7)	11.78 (8.0 to 21.8)	.071

[a]Bold *P* value indicates statistically significant difference between methods ($P < .05$). JLCA, joint-line convergence angle; ΔJLCA, difference in JLCA between standing and valgus stress radiograph; LMLR, latent medial laxity reduction; MA, mechanical axis; RCA, real correction angle; TCA target correction angle; XR, radiograph.
[b]No. of knees.
[c]Positive values denote valgus alignment, and negative values denote varus alignment.

Postoperative Mechanical Axis Outcomes After Each Planning Method[a]

	Total	Miniaci Method	LMLR Method	*P* Value
Acceptable[b]	84	19	65	**.0006**
Overcorrection	47	26	21	
Undercorrection	8	2	6	

[a]Bold *P* value indicates statistically significant difference between methods ($P < .05$). LMLR, latent medial laxity reduction.
[b]Defined as mechanical axis within a valgus range of 1.5° to 4.5°.



- The Miniaci method showed a higher incidence of overcorrection than the LMLR method at postoperative 6 months (P = .0006)

Results

Subgroup Analysis According to $\Delta JLCA_{valgus}$[a]

$\Delta JLCA_{valgus}$	Method, n (%)		
	Miniaci	LMLR	*P* Value
>5.5°			**.0008**
Acceptable correction	3 (21.4)	25 (73.5)	
Overcorrection	11 (78.6)	9 (26.5)	
<5.5°			**.017**
Acceptable correction	16 (51.6)	40 (76.9)	
Overcorrection	15 (48.4)	12 (23.1)	

[a]Bold *P* values indicate statistically significant difference between methods ($P < .05$). JLCA, joint-line convergence angle; ΔJLCA, difference in JLCA between standing-leg and valgus stress radiographs; LMLR, latent medial laxity reduction.

Multiple Linear Regression Analysis of the Real Correction Angle[a]

DV: Explicative Variable	Unstandardized Coefficients		Standardized Coefficients	
	B	SE (*B*)	ß	*P* Value
RCA				
Constant	0.596	0.376		.117
TCA	0.891	0.036	1.005	**<.0001**
$\Delta JLCA_{valgus}$	–0.255	0.046	–0.221	**<.0001**

[a]$R = 0.942$, $R^2 = 0.888$, adjusted $R^2 = 0.885$; $P < .05$. Bold *P* values indicate statistical significance ($P < .05$). DV, dependent variable; JLCA, joint-line convergence angle; ΔJLCA, difference in JLCA between standing-leg and valgus stress radiographs; RCA, real correction angle; TCA, target correction angle.

Intermethod ICC Values of Each Simplified Formula Versus Ideal Correction Angle Method[a]

DV: Explicative Variable	Intermethod ICC (95% CI)[b]
Regression value	
Miniaci	0.881 (0.822-0.921)
TCA – $\Delta JLCA_{valgus}$	0.819 (0.733-0.879)
TCA – ½$\Delta JLCA_{valgus}$	0.976 (0.964-0.985)
TCA – ⅓$\Delta JLCA_{valgus}$	0.992 (0.988-0.995)

[a]DV, dependent variable; ICC, intraclass correlation coefficient; JLCA, joint-line convergence angle; $\Delta JLCA_{valgus}$ difference in JLCA between standing-leg and valgus stress radiographs; TCA, target correction angle.
[b]Each ICC value, $P < .0001$.

- Multiple linear regression with a stepwise selection model revealed a high correlation coefficient

: Adjusted planned correction angle = 0.596 + 0.891 x Target correction angle – 0.255 x Δ $JLCA_{valgus}$

- Upon simplification equation showed the highest inter-method ICC value (0.991)

: Target correction angle – 1/3Δ$JLCA_{valgus}$

while the Miniaci method showed a relatively low ICC value of 0.87

Discussions

- ***Miniaci method*** has a tendency for *coronal overcorrection*, especially for those with high-grade latent medial laxity ($\Delta JLCA_{valgus}$ >5.5°).
- Preoperative correction planning that ***considers latent medial laxity*** should be used.

$$\begin{aligned} &Adjusted\ preoperative\ planning\ correction\ angle \\ &= 0.596 + 0.891 \times TCA - 0.255 \times \Delta JLCA_{valgus} \\ &\text{or, alternatively,} \\ &TCA - \tfrac{1}{3}\Delta JLCA_{valgus}. \end{aligned}$$

- JLCA could be changed by shifting the weight-bearing axis from medial to lateral and by stretching the medial soft tissue.

Ogawa et al. AOTS. 2016

- **large change in JLCA** from before and after MOWHTO may **suggest alignment overcorrection**.

Lee DH et al. KSSTA. 2016

Discussions

- *Preoperative valgus stress* can mimic the postoperative valgization status of the proximal tibia.

- Consensus on the effect of medial laxity and varus angular deformity on overcorrection,

  but the relevance of latent lateral laxity is still controversial. Lee DK et al. KSSTA. 2020

- Although there is no clear study on the ***quantifying effect of medial laxity***,

  - *1°* of valgus overcorrection was related to every *2.5° of JLCA.* Kim SH, Knee, 2017

  - *1.3°* is almost equal to a mean *JLCA change of 1.2°.* Park JG, KSSTA, 2020

- Considering these values, we developed a ***simple formula*** of subtracting

  one-half or one-third of the JLCA from the TCA.

Conclusions

- The conventional ***Miniaci method*** has the ***risk of coronal overcorrection*** after MOWHTO.

- An equation that ***considers medial laxity*** can facilitate a preoperative plan ***for optimal correction*** during MOWPTO.

References

- 1) Akamatsu Y, Mitsugi N, Mochida Y, et al. Navigated opening wedge high tibial osteotomy improves intraoperative correction angle com pared with conventional method. Knee Surg Sports Traumatol Arthrosc. 2012;20(3):586-593.
- 2) Kim MK, Ko BS, Park JH. The proper correction of the mechanical axis in high tibial osteotomy with concomitant cartilage procedures a retrospective comparative study. J Orthop Surg Res. 2019;14(1): 281.
- 3) Kim SH, Ro D-H, Lee Y-M, Cho Y, Lee S, Lee M-C. Factors associated with discrepancies between preoperatively planned and postoperative alignments in patients undergoing closed-wedge high tibial osteotomy. Knee. 2017;24(5):1129-1137.
- 4) Kyung BS, Kim JG, Jang K-M, et al. Are navigation systems accurate enough to predict the correction angle during high tibial osteotomy? Comparison of navigation systems with 3-dimensional computed tomography and standing radiographs. Am J Sports Med. 2013; 41(10):2368-2374.
- 5) Laprade RF, Bernhardson AS, Griffith CJ, Macalena JA, Wijdicks CA. Correlation of valgus stress radiographs with medial knee ligament injuries: an in vitro biomechanical study. Am J Sports Med. 2010; 38(2):330-338.
- 6) Lee D kyung, Wang JH, Won Y, et al. Preoperative latent medial laxity and correction angle are crucial factors for overcorrection in medial open-wedge high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc. 2020;28(5):1411-1418.
- 7) Ogawa H, Matsumoto K, Ogawa T, Takeuchi K, Akiyama H. Preoperative varus laxity correlates with overcorrection in medial opening wedge high tibial osteotomy. Arch Orthop Trauma Surg. 2016; 136(10):1337-1342.