Effect Of Tibia-First Gap-Balancing Technique On Gap Width Changes And Component Positioning In Robotic-Arm Assisted Total Knee Arthroplasty

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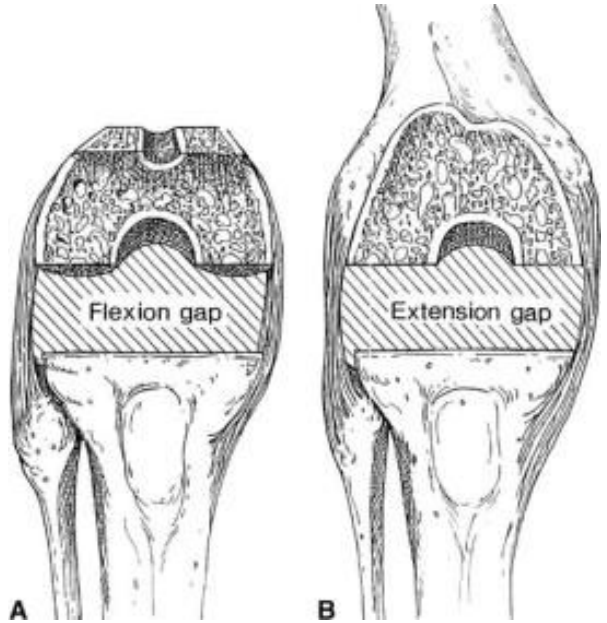
Basic Principle in Total Knee Arthroplasty

❖**it is important to revisit the basic principle, as surgeons compare techniques of alignment to optimize TKA outcomes**

- Concept of **balanced knee**: Fundamental to successful TKA
- The goal has remained unchanged, despite a various techniques



Whiteside LA et al., Springer, St Louise, p 6

Purpose

❖Purpose

- Quantitatively assess the predictability of post-resection gap dimensions and attainment of balanced gaps using robotic arm-assisted TKA
- Suggest a preventive approach to address potential discrepancies between predicted and actual post-resection gaps

Patients

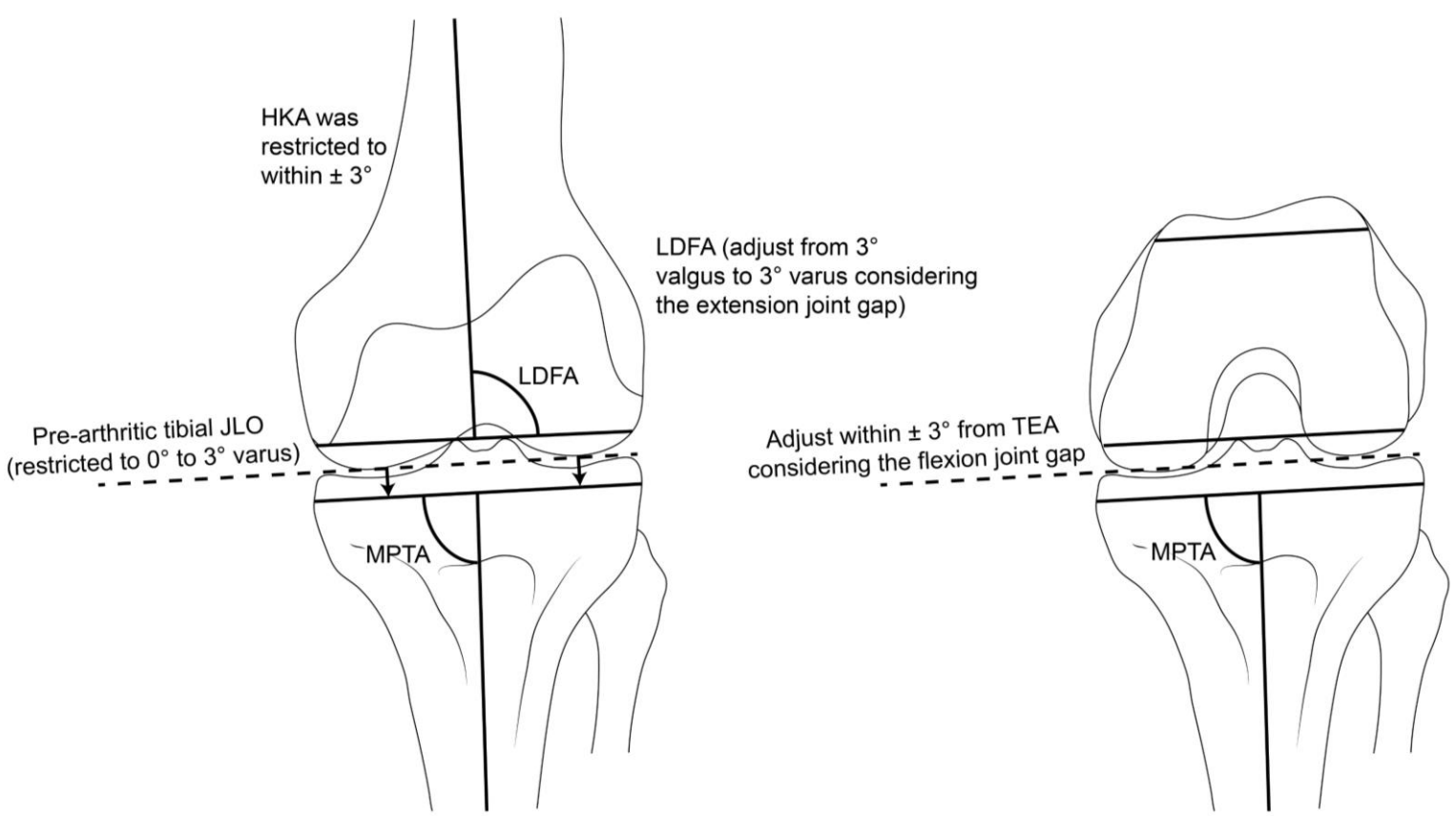
❖**A total of 100 patients undergoing robotic arm-assisted TKA using a PS prosthesis (Stryker) for end-stage knee varus arthritis in 2023**

❖**Exclusion criteria**

- Varus deformity of more than 20°
- Flexion contracture greater than 15°
- Inflammatory arthritis or posttraumatic arthritis
- Inadequately documented intraoperative gap measurements

Surgical Technique

❖Tibia-first, gap-balancing technique within predefined boundaries (restricted FA)



Tibia	
Coronal	Parallel to the native tibial joint line
	Boundary: 0° to 3° varus
Axial	PCL – med 1/3 − lat 2/3 TT
Sagittal	Set to 0°–3° of the posterior slope in the sagittal plane
Femur	
Coronal	Parallel to the tibial resection, with soft tissue envelope tensioned in extension
	Equal gaps lateral and medial in extension
	Boundary: 3° valgus to 3° varus
Axial	Parallel to the tibial resection, with the soft tissue envelope tensioned in 90° flexion
	Equal medial gaps in extension and flexion, with slight lateral laxity acceptable
	Boundary: sTEA ± 3°
Sagittal	0°–5° to optimise sizing
Overall	*Boundary: 0° to 3° varus*

Outcome Measures

❖**Primary outcome:** proportion of balanced knee (gap differential ≤2.0 mm)

- **Extension balance**: Difference between medial and lateral gaps at 10° flexion
- **Flexion balance**: Difference between medial and lateral gaps at 90° flexion
- **Medial balance**: Difference between medial laxities in extension and flexion
- **Lateral balance**: Difference between lateral laxities in extension and flexion

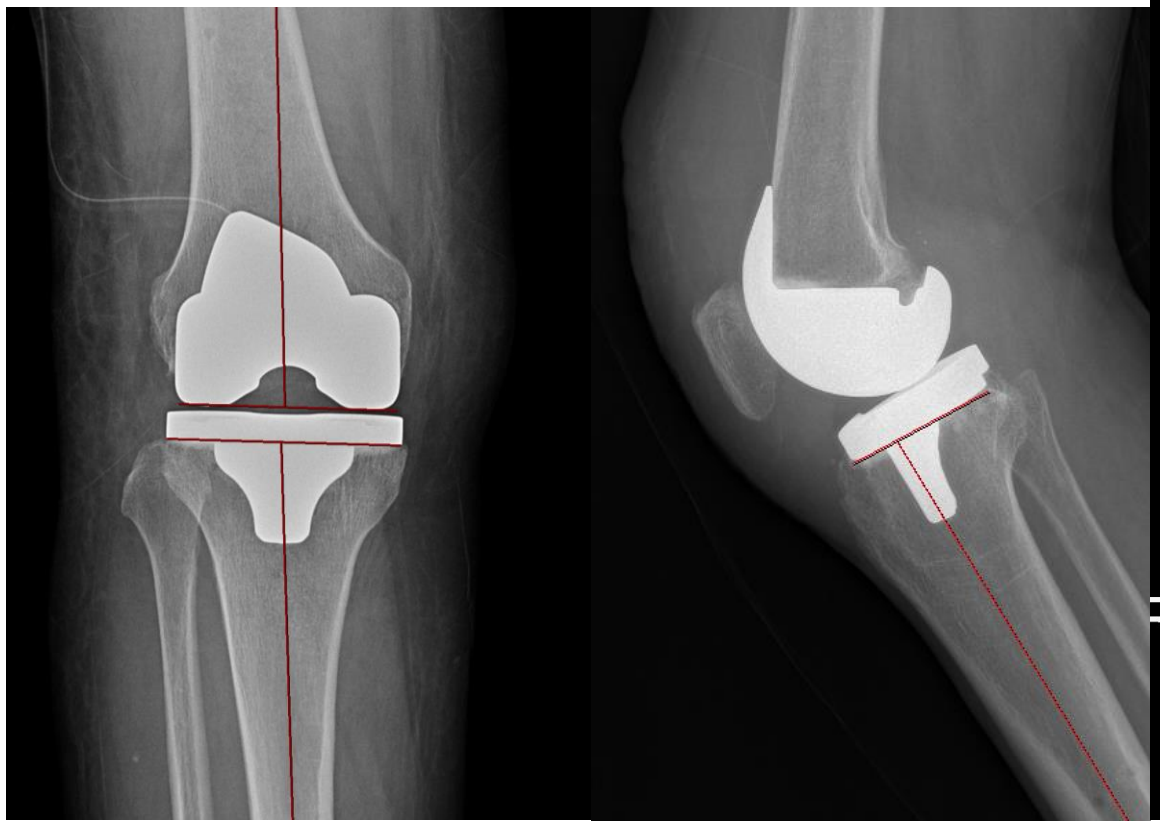
❖**Secondary outcome**

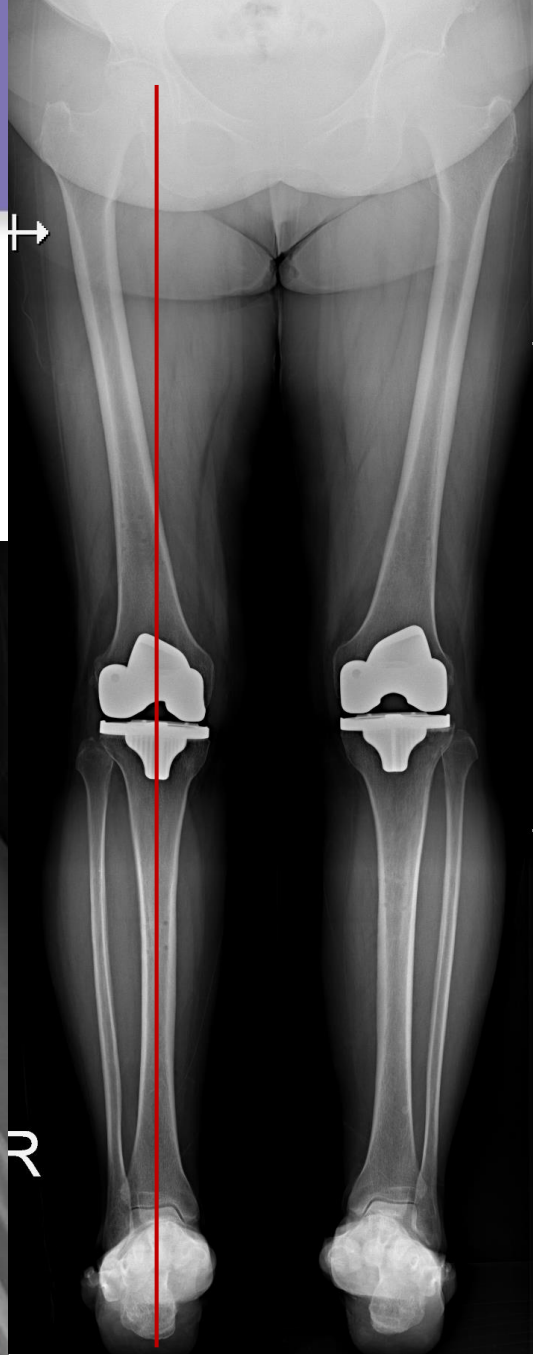
- Patient reported outcome measures (PROMs) and ROM
- Bone resection depth from robotic systems, implant alignment

Implant Alignment

❖**Radiographic evaluation using weight-bearing radiographs**

- Mechanical HKA angle
- MPTA
- LDFA
- Posterior tibial slope





Statistical Analysis

- For normally distributed variables, paired and independent t-tests, and ANOVA test were employed to compare differences among continuous variables

- For non-normally distributed variables, Wilcoxon signed-rank tests were performed to evaluate differences. Furthermore, the Mann–Whitney U test with Bonferroni correction was applied for post hoc comparisons.

- Chi-square test or Fisher’s exact test for categorical variables

Demographics

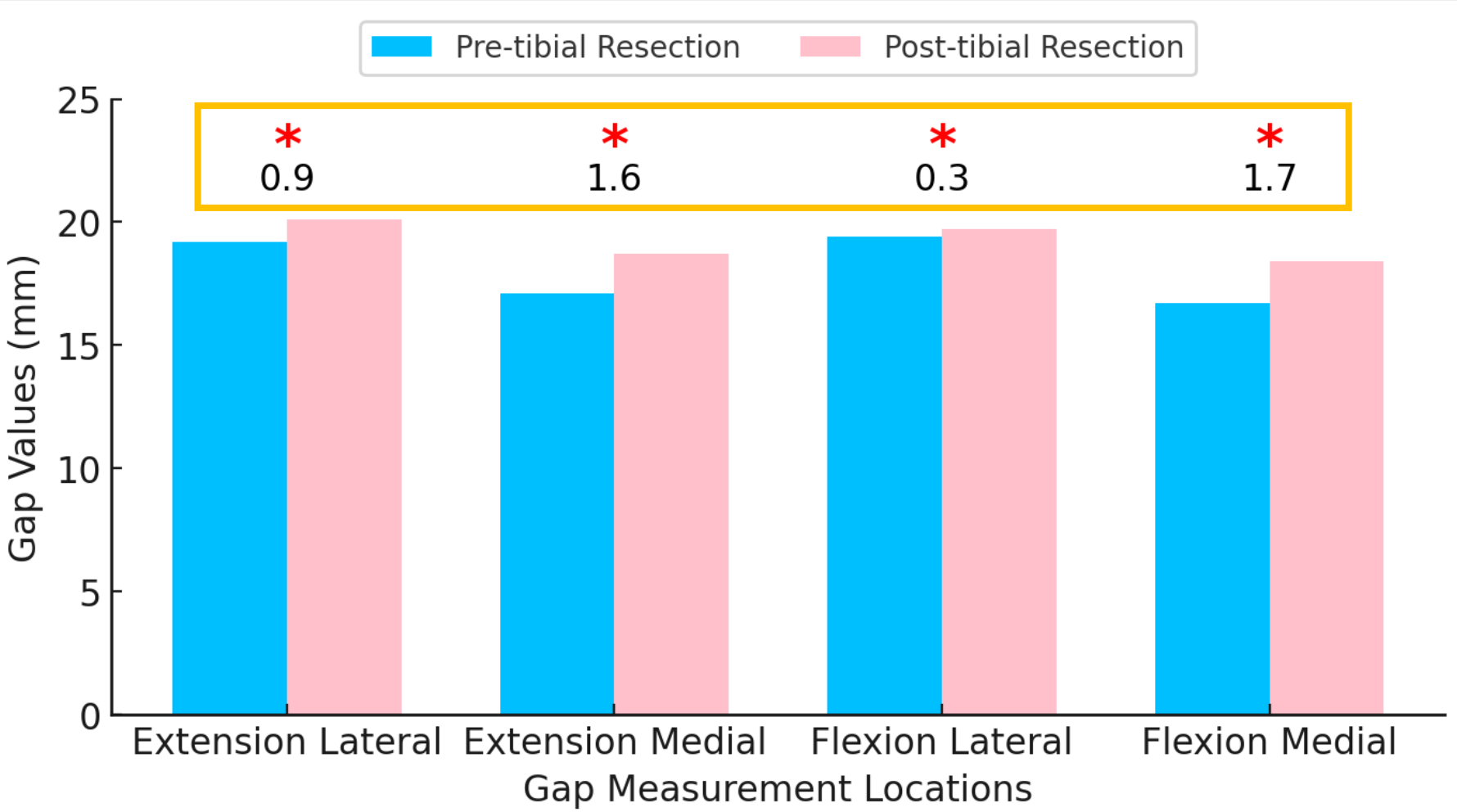
	Value
Age *(yr)*	72.1 ± 9.1
Female sex *(no. of patients)*	82 (82.0)
Body mass index *(kg/m²)*	26.1 ± 3.9
ASA grade *(no. of patients)*	
II / III	60 (60.0)
Side of operation *(no. of patients)*	40 (40.0)
Right	
Left	52 (52.0)
Preoperative radiographic parameters *(deg)*	48 (48.0)
mHKA	
MPTA	9.0 ± 4.9
LDFA	84.9 ± 2.6
aHKA	89.2 ± 2.3
JLO	−4.3 ± 3.7

Gap Measurements before/after Tibial Cut

	Quantitative effect of tibial cutting on the gaps			*P* value
	Gap in planning	Gap after cutting	Gap increase	
Extension (10°)				
Lateral gap	19.2 ± 0.9	20.1 ± 1.2	0.9 ± 1.0	**<0.001**
Medial gap	17.1 ± 1.7	18.7 ± 1.7	1.6 ± 1.2	**<0.001**
Flexion (90°)				
Lateral gap	19.4 ± 1.3	19.7 ± 1.6	0.3 ± 1.7	**<0.001**
Medial gap	16.7 ± 1.7	18.4 ± 1.5	1.7 ± 1.5	**<0.001**

Significant increase in lateral and medial gaps at extension and 90° flexion after tibial cut

Gap Measurements before/after Tibial Cut



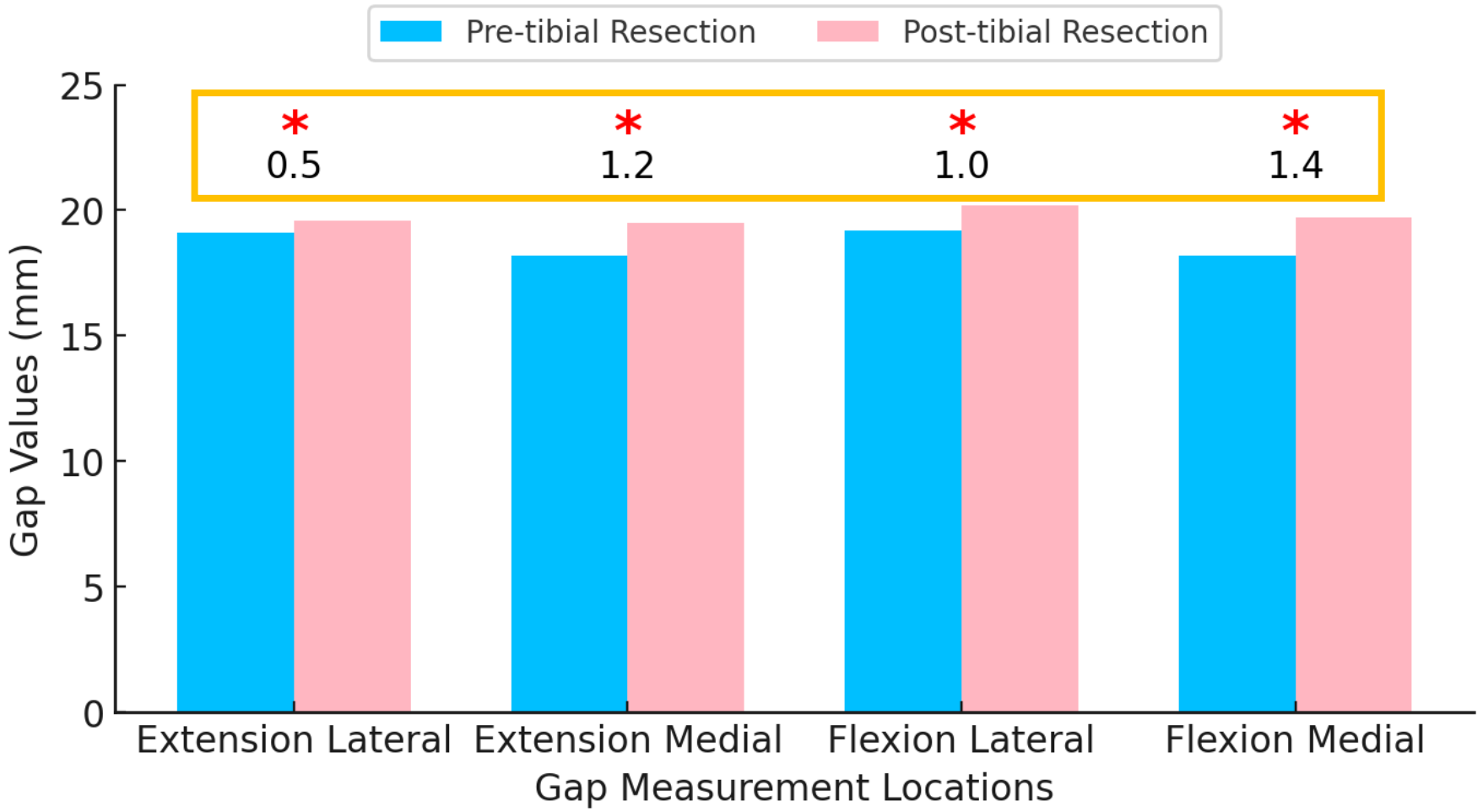
Gap increments following bone resection are unpredictable, asymmetrical gap changes

Gap Measurements before/after Femoral Cut

	Quantitative effect of femoral cutting on the gaps			*P* value
	Gap in planning	Gap after cutting	Gap increase	
Extension (10°)				
Lateral gap	19.1 ± 0.8	19.6 ± 0.7	0.5 ± 0.8	**<0.001**
Medial gap	18.2 ± 1.3	19.5 ± 0.7	1.2 ± 1.2	**<0.001**
Flexion (90°)				
Lateral gap	19.2 ± 0.8	20.2 ± 0.7	1.0 ± 0.9	**<0.001**
Medial gap	18.2 ± 1.0	19.7 ± 0.8	1.4 ± 1.2	**<0.001**

Significant increase in lateral and medial gaps at extension and 90° flexion after femur cut

Gap Measurements before/after Femoral Cut



Gap increments following bone resection are unpredictable, asymmetrical gap changes

Number of Balanced Knees (Gap Diff ≤2 mm)

	Quantitative effect of tibial cutting on the gaps		Quantitative effect of femoral cutting on the gaps	
	Planning	After cutting	Planning	Trialling
Extension gap	61%	76%	90%	**98%**
Flexion gap	48%	73%	91%	**97%**
Lateral gap	98%	86%	98%	**98%**
Medial gap	89%	77%	94%	**97%**

Gap-balancing technique after tibia cut achieved balanced knees about 98% of cases

Limitations

I. Retrospective review of a relatively small number of knees with short term follow-up

II. Gap measurements were performed manually, and no interobserver reliability assessment was conducted. As a result, the absolute gap measurements may differ amongst surgeons

III. It is not certain whether these intraoperative outcomes would be correlated with improved long-term outcomes and survivorship

IV. Gap changes depend on area where the osteophytes have been removed and its size

Takeaway

❖**Initial assessment ← Inconsistent gap increments → Subsequent bone resections**

- Post hoc analysis: **MF, ME** > LE, LF
- Slightly tighter medial gap is advisable to obtain desired gaps for pre-section gap technique

❖**Tibia-first, gap balancing technique using restricted FA strategy achieved a well-balanced knee in 98% of cases**

❖**Further research is necessary to ascertain whether these promising intraoperative outcomes translate into improved long-term implant survivorship**