Component Size Prediction for Total Knee Arthroplasty Using Two- and Three-dimensional planning

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Introduction

- Preoperative planning should be reliable and reproducible in total knee arthroplasty (TKA)
- Conventionally, preoperative planning in TKA has been performed on standard radiographs with acetate overlays of the implants
- Previous studies reported that low accuracy [1-3] and low intra- and inter-observer reproducibility [2] in the acetate templating
- With the prevalence of digital radiography, opportunities exist for improvement in preoperative planning

Aim of this study

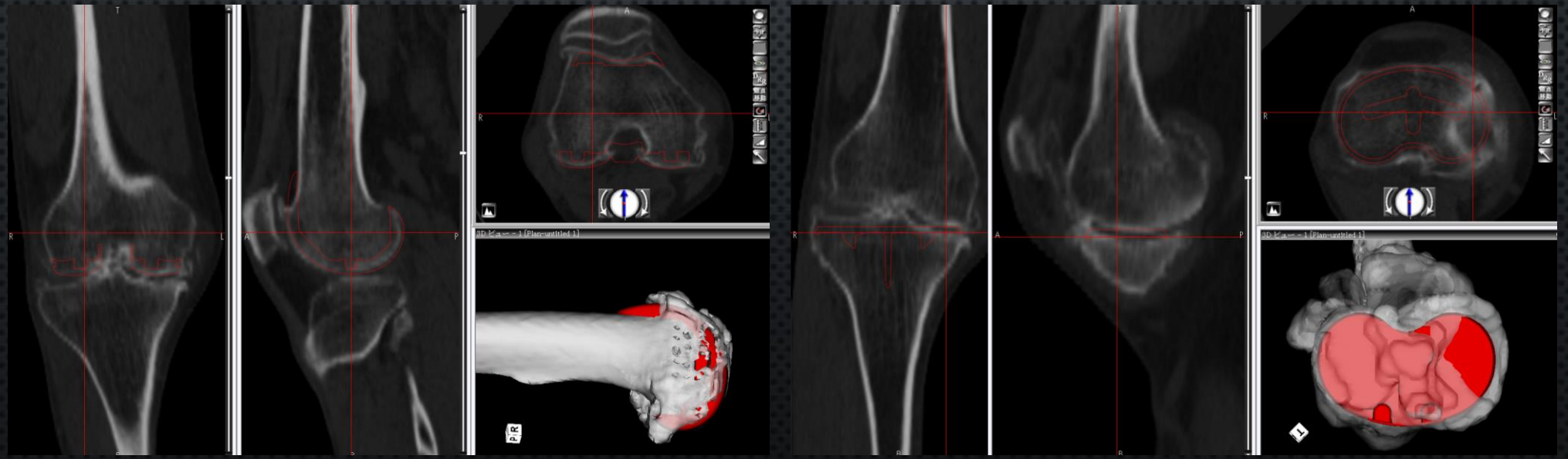
Evaluating the accuracy and reproducibility of preoperative component size prediction for TKA using conventional two-dimensional (2D) templating and computed tomography (CT)-based three-dimensional (3D) planning

Methods

- Eighty-one consecutive patients (62 females and 19 males) with a mean age of 74.8 years who underwent primary unilateral TKA were enrolled in this study
- All patients had the same posterior stabilized knee component implanted (Vanguard® Complete Knee System; Zimmer Biomet, Warsaw, IN) using the same modified balanced gap technique.

Preoperative 2D and 3D planning

- Preoperatively, both the 2D acetate templating and CT-based 3D planning were carried out for all patients.
- In the 2D templating, radiographs used were anteroposterior view of the standing knee and 30° knee flexed lateral view with the patient supine. Plain radiographs were templated against acetate templates supplied by the manufacturer.
- In the 3D planning, CT scan of the whole lower extremity was used. The size and setting position of the femoral and tibial components were simulated with the 3D planning software (Zed Knee; LEXI, Tokyo, Japan).



Analysis

【Accuracy】

- The accuracy was calculated by comparing the predicted size in the 2D templating and 3D planning with that used at surgery.
- The chi-square test was used to compare the accuracy of the two procedures. Statistical significance was set at $p < 0.05$.

【Reproducibility】

- The intra- and inter-observer reproducibility of the 2D templating and 3D planning was assessed using the linear weighted kappa (κ) coefficient.
- The intra-observer reproducibility was determined by measuring 10 randomly selected patients by the same researcher twice after an interval of 3 weeks.
- The inter-observer reproducibility was determined by measuring 10 randomly selected patients by the two researchers.

Results 1

【Accuracy in 2D】

The size of the femoral and tibial component was predicted within ±1 size in 98% (52% exactly) and 100% (62% exactly) of the cases, respectively.

【Accuracy in 3D】

The component size was predicted within ±1 size in 98% (57% exactly) for the femur and 100% (54% exactly) for the tibia.

→ No statistical difference in accuracy between 2D and 3D planning

Error from the actual implant size

Error (size)	Femur		Tibia	
	2D templating	3D planning	2D templating	3D planning
-2	2 (2%)	0	0	0
-1	32 (40%)	23 (29%)	20 (25%)	24 (30%)
0	42 (52%)	46 (57%)	50 (62%)	44 (54%)
+1	5 (6%)	10 (12%)	11 (13%)	13 (16%)
+2	0	2 (2%)	0	0
Within ±1	79 (98%)	79 (98%)	81 (100%)	81 (100%)
Out ±1	2 (2%)	2 (2%)	0	0

Results 2

【Reproducibility in 2D】

- The intra-observer reproducibility for the femoral and tibial component were good (κ = 0.70) and excellent (κ = 0.84), respectively.
- The inter-observer reproducibility for the femoral and tibial component were moderate (κ = 0.42) and good (κ = 0.68) in the 2D templating.

【Reproducibility in 3D】

- The intra-observer reproducibility for the femoral and tibial component were excellent (κ = 0.84) and good (κ = 0.65), respectively.
- However, the inter-observer reproducibility for the femoral and tibial component were fair (κ = 0.37 for femur, κ = 0.36 for tibia) in the 3D planning.

Weighted κ intra- and inter-observer coefficients

κ	Femur		Tibia	
	2D templating	3D planning	2D templating	3D planning
intra-observer	0.70	0.84	0.84	0.65
inter-observer	0.42	0.37	0.68	0.36

Discussion 1

- The accuracy of the acetate templating of femoral and tibial components was reportedly **8% to 55%** [1-3]

  In our study **52%** for femur and **62%** for tibia in 2D templating
  57% for femur and **54%** for tibia in 3D planning

- The component sizing accuracy within ±1 size of the actual components implanted was reportedly **64% to 96%** with the acetate templating [1-3]

  In our study **98%** for femur and **100%** for tibia in 2D and 3D planning

The accuracy of the 2D and 3D planning in our study was at least as accurate as that in the previous studies

However,

The 3D planning did not allow an improvement in the accuracy of the component size prediction, compared to the 2D templating

Discussion 2

In our study,

The intra-observer reproducibility of the 3D planning was as good as that of the 2D templating

However,

The inter-observer reproducibility of the 3D planning was lower than that of the 2D templating

With this degree of the accuracy and reproducibility, the superiority of the 3D planning over the 2D templating in predicting implant size was not supported in TKA using the modified balanced gap technique.

Conclusion

Regarding preoperative component size prediction in TKA using the modified balanced gap technique, the CT-based 3D preoperative planning may not be superior to the conventional 2D acetate templating

References

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