METHOD TO EVALUATE THE EFFECT OF LEG POSITION ON THE INTRAOPERATIVE MEASUREMENT OF PLANNED RESECTION DURING COMPUTER-ASSISTED TOTAL KNEE ARTHROPLASTY

Yifei Dai PhD[1*], Laurent D Angibaud BS[1], Barton Harris MD [2]

[1*] Exactech Inc, Gainesville, FL, 32653, USA, Yifei.Dai@exac.com

[2] OrthoVirginia, Henrico, VA, 23229, USA

INTRODUCTION

Proper alignment and positioning of the knee prosthesis is critical for the long-term clinical success of the total knee arthroplasty (TKA) [1]. Computer-assisted orthopaedic surgery (CAOS) provides great value in ensuring accurate, reliable and reproducible TKA outcomes [2-3]. Depending on surgeon preferences or patient factors (e.g. BMI, ligament condition, and individual joint anatomy), resection planning (guided adjustment of cutting blocks) is performed with different knee flexion, abduction/adduction (ABD/ADD) and internal/external (I/E) rotation angles, potentially leading to measurement errors in the planned resections due to a modified tracker/localizer spatial relationship. This study developed a method to assess the variation in the intraoperative measurement of the planned resection due to leg manipulation during TKA. A preliminary study using this method was performed on a specific CAOS system, and the leg position variables (flexion, ABD/ADD, and I/E rotation) that contribute to the variability were identified for the system studied.

MATERIALS AND METHODS

Computer-assisted TKA (ExactechGPS®, Blue-Ortho, Grenoble, FR) was performed on a neutral whole leg assembly (MITA knee insert and trainer leg, Medial Models, Bristol, UK) by a board-certified orthopaedic surgeon (BH), with one tracker rigidly fixed on the proximal tibia and the distal femur, respectively. After acquisition of the landmarks following the CAOS surgical flow, a cutting block was adjusted and fixed to the proximal tibia, targeting the resection parameters listed in Table 1A. The surgeon then manipulate the leg to his preferred leg flexion, ABD/ADD, and I/E rotation angles, which were representative of his normal practice assuming no limitation in leg manipulation existed caused by patient factors. An instrumented resection checker with a guide tracker was then attached to the cutting block to measure the planned resection at the preferred leg position (baseline). Next, the surgeon moved the leg to 9 sampled positions, representing typical leg position/orientation during TKA (based on a survey from the surgeon prior to the study, Table 1B). The output of the guide tracker (planned resection) was recorded by the CAOS system at each leg position.

Tibial resection parameters at each sampled position were compared to the baseline. Regression was performed to identify the variables (flexion, ABD/ADD, I/E rotation) that significantly contribute to the measured variation ($p<0.05$).

RESULTS

The resection parameters at the baseline leg position are presented in Table 1A. Clinically negligible variations were found across the 9 positions (Table 1B), with mean errors equal of less than 0.1mm in resection depths and equal or less than 0.2° in alignment parameters. For this particular system analyzed, leg flexion strongly correlated with the measurement errors

in medial resection depths ($p \leq 0.01$, $R^2=0.76$), lateral resection depth ($p=0.01$, $R^2=0.61$) and posterior slope ($p<0.01$, $R^2=0.92$) (Fig. 1). The system studied tended to measure less in resection depths and posterior slope with an increased leg flexion (Fig. 1). No other statistical significance was found (N.S.).

DISCUSSION

The study demonstrated a method to assess the impact of leg position on the accuracy of resection planning during TKA. The results here showed that ExactechGPS can provide robust measurements of the planned resection parameters during TKA, independent of the ABD/ADD and I/E rotation of the knee. Although for the system studied, measurement errors strongly correlated with leg flexion, the magnitude of the errors was clinically negligible (within ±0.5 mm/° at a confidence level of 95%, Table 1B).

Although CAOS systems have been evaluated for accuracy in the spatial distance measurement and clinical alignment outcomes [4,5], the impact of leg position has been often overlooked during the evaluation, even though the assessment is clinically relevant and the change of leg position intraoperatively is prevalent. The method can be applied to various CAOS systems to improve the understanding of system-specific clinical variability on the measurement of planned TKA resection.

REFERENCES

1. Sharkey PF, Hozack WJ, Rothman RH, Shastri S, Jacoby SM, Insall Award paper. Why are total knee arthroplasties failing today? Clin Orthop Relat Res, 404, pp: 7-13, 2002.
2. Jenny JY, Clemens U, Kohler S, Kiefer H, Konermann W, Miehlke RK, Consistency of implantation of a total knee arthroplasty with a non-image-based navigation system: a case-control study of 235 cases compared with 235 conventionally implanted prostheses, J Arthroplasty, 20(7), pp: 832-839, 2005.
3. Rosenberger RE, Hoser C, Quirbach S, Attal R, Hennerbichler A, Fink C, Improved accuracy of component alignment with the implementation of image-free navigation in total knee arthroplasty, Knee Surg Sports Traumatol Arthrosc, 16(3), pp: 249-257, 2008.
4. Wiles AD, Thompson DG, Frantz DD, Accuracy assessment and interpretation for optical tracking systems, Proc SPIE, 5367, pp: 421-432, 2004.
5. Rosenberger RE, Hoser C, Quirbach S, Attal R, Hennerbichler A, Fink C, Improved accuracy of component alignment with the implementation of image-free navigation in total knee arthroplasty, Knee Surg Sports Traumatol Arthrosc, 16(3), pp: 249-257, 2008.

DISCLOSURES

Yifei Dai and Laurent Angibaud are current employees of Exactech Inc.

Barton Harris is a paid consultant of Exactech Inc.

A

	Medial Resection Depth (mm)	Lateral Resection Depth (mm)	Var/Val Alignment (°)	Posterior Slope (°)
Targeted	-	10.0	0.0	3.0
Planned (Baseline)†	8.3	9.6	0.0	3.3

† Measured after adjustment of the cutting block at the surgeon's preferred leg position.

B

	Flexion (°)	ABD/ADD (°)*	I/E Rotation (°)*	Medial Resection Depth (mm)**	Lateral Resection Depth (mm)**	Var/Val Alignment (°)**	Posterior Slope (°)**
Leg Position							
1	0	0	0	0.3	0.1	0.2	0.5
2	0	12.5††	0	0.6	0.6	0.0	0.5
3	45	0	0	0.0	-0.1	0.1	0.3
4	45	12.5††	0	0.0	-0.2	0.2	0.2
5	90	0	0	-0.1	-0.3	0.2	0.1
6	90	12.5††	0	0.1	0.1	0.0	0.2
7	155††	0	0	-0.2	-0.5	0.4	0.0
8	155††	12.5††	0	-0.2	-0.6	0.4	-0.1
9	155††	0	50††	-0.3	-0.2	0.0	-0.2
Error (Mean ± SD)				0.0 ± 0.3	-0.1 ± 0.4	0.2 ± 0.2	0.2 ± 0.2
95% Confidence Interval				[-0.2, 0.2]	[-0.4, 0.2]	[0.1, 0.3]	[0.1, 0.3]

†† Measured maximum angles from surgeon's trial run

* Positive values indicate adduction and external rotation in the leg position

** Positive values indicate increased resection depth, more varus, and higher posterior slope in the measured planned resection at the sampled leg position (compared to the surgeon's preferred leg position).

Table 1. A) Targeted resection parameters and planned resection measured at the surgeon's preferred leg position. B) Nine leg positions sampled, with errors in the measurement of the planned resection at each leg position indicated.

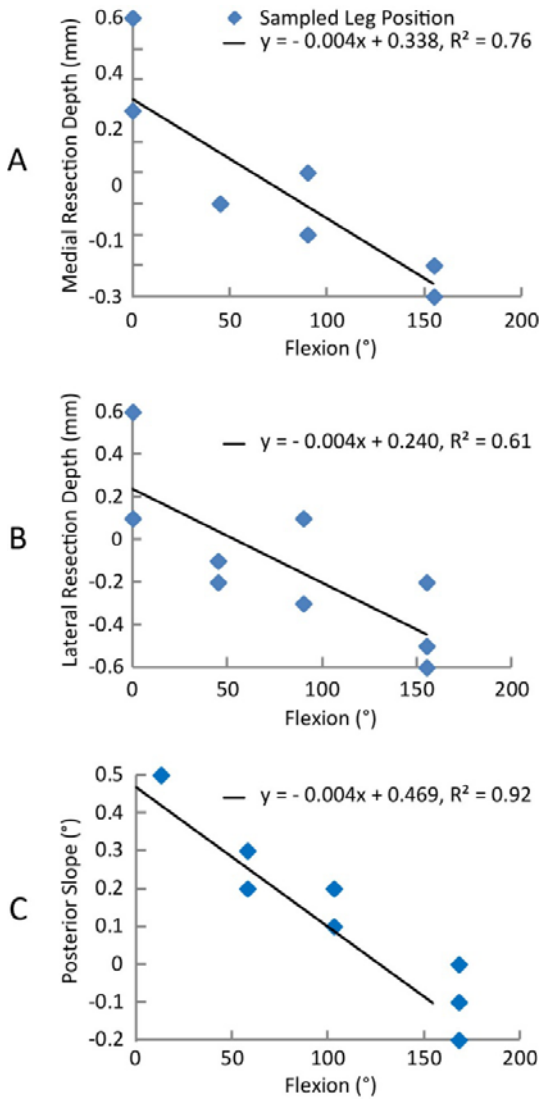

Figure 1. Correlation between leg flexion and the measurement errors in A) medial resection depth, B) lateral resection depth, and C) posterior slope.