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Reliability of Laxity Acquisitions During Navigated Total Knee Arthroplasty – Comparison of Two Techniques

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Abstract

Recent developments have focused on the intra-operative management of soft-tissue balancing in total knee arthroplasty (TKA) using a computer-assisted orthopaedic surgery (CAOS) system. The aim of this study was to determine and compare the reliability of acquiring the knee joint laxities during navigated TKA with a conventional method versus a newly developed instrumented technique that uses an intra-articular quasi-constant force distractor integrated with a CAOS system. A total of 96 laxity acquisitions throughout the arc of motion were performed for the conventional and instrumented procedures. For the instrumented technique, the inter- and intraobserver reliabilities were significantly higher than the conventional manual varus/valgus stress test technique, regardless of surgeon variability and experience. Soft-tissue balance, while being a key determinant in improving outcomes in TKA, is difficult to objectively assess at the time of the surgery. This study established that the acquisition of the knee joint laxities using an instrumented technique was consistently associated with a significantly higher reliability than the conventional technique.

1 Introduction

Total knee arthroplasty (TKA) continues to be one of the most successful surgical interventions in medicine. While patient-reported outcomes after TKA are shown to improve dramatically with respect to pain, function, and quality of life; there are still approximatively 20% of patients that report dissatisfaction (Noble, et al., 2005) (Bourne, et al., 2010). Most contemporary developments have been based on bony references with the goal of restoring a neutral knee alignment (Jeffery, et al., 1991) (Ritter, et al., 1994). As an attempt to improve the patient's satisfaction, more recent developments have

focused on the intra-operative management of soft-tissue balancing surrounding the knee joint throughout the full arc of motion when using a computer-assisted orthopaedic surgery (CAOS) system. In order to acquire the laxities, conventional (unaided) technique relates to applying consecutive manual valgus and varus stress tests to the knee in extension and while flexing the limb to acquire the medial and the lateral laxities, respectively. An alternative is the placement of an intra-articular distractor intended to apply a quasi-constant stabilizing force to the knee joint during the manipulation of the limb in neutral alignment to simultaneously acquire both the medial and the lateral laxities. The aim of this study was to determine and compare the inter- and intraobserver reliabilities of acquiring the knee joint laxities during navigated TKA according to each technique.

2 Methods

We performed bilateral TKAs using a CAOS system (ExactechGPS, Blue-Ortho, Meylan, FR) on a fresh-frozen human cadaveric specimen (age 79 years, female). After the incision and using a medial parapatellar arthrotomy, the anatomical landmarks of interest were acquired by inducing motion (hip center) and probing (other landmarks) to generate a patient-specific coordinate system for both the tibia and the femur. Because a posterior stabilized type of implant was selected, the lead surgeon resected both the anterior and the posterior cruciate ligaments as well as menisci and removed all osteophytes.

At this stage (i.e., prior to any bone cuts), the joint laxities were acquired by the CAOS system according to the conventional technique, by applying a varus stress test to the knee joint while flexing the limb to acquire the lateral laxities, and then, a valgus stress test to consecutively acquire the medial laxities.

Once completed, the proximal tibial cut was performed neutral to the mechanical axis and then an intra-articular tibial distractor (Newton, Exactech, Gainesville, FL, USA) was introduced into the joint space between the tibial resection and the native femur. The distractor features 2 independent mechanically actuated compartments intended to apply a quasi-constant distraction force (nominally set-up at 20 lbs per compartment) regardless of the joint gap. Then, the joint laxities were acquired by the CAOS system according to the proposed instrumented technique, by manually manipulating the limb through a full arc of motion with the knee joint being stabilized due to the distraction force of the intra-articular tibial distractor.

For each technique, the manipulations were successively performed by a total of 4 surgeons (2 senior and 2 junior surgeons) on 6 occasions on both knees across both medial and lateral compartments. The inter- and intraobserver reliabilities were assessed using intraclass correlation coefficients (ICCs) and 95% confidence intervals (CIs) (Koo & Li, 2016).

3 Results

A total of 96 laxity acquisitions throughout the arc of motion were performed for each evaluated technique. Regardless of the considered compartment (i.e., medial or lateral), the instrumented technique was associated with a higher reliability than the conventional technique for the laxity acquisitions ($p=0.017$) (see Figure 1). For the instrumented technique, the interobserver reliability ranged from moderate to good (Mean ICC=0.72), while for the conventional technique, the interobserver reliability ranged from poor to moderate (Mean ICC=0.35) (see table 1). Similarly, the intraobserver reliability was consistently higher for the instrumented technique (Mean ICC=0.66) than the conventional technique (Mean ICC=0.41) (see table 1). Regardless of the considered technique, there was no significant difference in the reliability associated with the acquisition of the laxities

between the medial compartment and the lateral compartment (p=0.453). Similarly, the experience level of the user had no statistically significant impact on the reliability of the acquisitions (p>0.05).

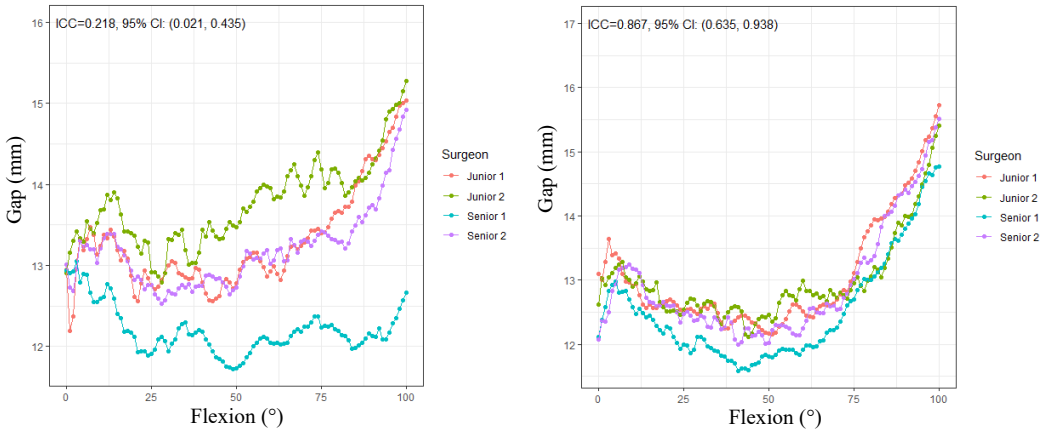

Figure 1: Examples of laxity acquisitions throughout the arc of flexion for the conventional technique (Left) and the instrumented technique (Right)

		Interobserver	Intraobserver			
			Junior #1	Junior #2	Senior #1	Senior #2
Conventional technique	Mean ICC	0.35	0.59	0.34	0.31	0.39
	95% CI	(0.04, 0.67)	(0.36, 0.82)	(0, 0.77)	(0, 0.68)	(0, 0.84)
Instrumented technique	Mean ICC	0.72	0.63	0.62	0.71	0.69
	95% CI	(0.43, 1)	(0.2, 1)	(0.37, 0.86)	(0.26, 1)	(0.46, 0.93)

Table 1: interobserver and intraobserver reliability for the conventional and instrumented techniques

4 Discussion

It has been previously established that soft-tissue balance, while being a key determinant in improving outcomes in TKA, is difficult to objectively assess at the time of the surgery (Dai, et al., 2020) (MacDessi, et al., 2019). In this regard, the acquisition of the laxities using a CAOS system has the potential to provide valuable quantitative information to ultimately guide the definition of the femoral planning parameters in terms of size, alignment, as well as soft-tissue considerations. This being said, the reliability and predictability of the acquisition technique is key to provide proper input data.

This study established that the acquisition of the knee joint laxities using an instrumented technique was consistently associated with a significantly higher reliability than the conventional manual varus/valgus stress test technique. One aspect relates to the application of a distraction force to the knee joint, which tends to greatly stabilize the joint during the manipulation of the limb. Another consideration relates to the manipulation of the limb in neutral alignment for the instrumented technique, which is easier to consistently apply relative to manual application of valgus or varus stress. Additionally, the instrumented technique yielded consistent reliability across all four surgeons regardless of experience level. Finally, while not relevant to the purpose of this study, the instrumented technique allows the acquisition of both the medial and lateral laxities during the same manipulation, a

gain of time compared to the need for consecutive manipulation with the conventional varus and valgus stress technique.

This evaluation has a few limitations worth being mentioned. This study was performed on a single cadaveric specimen with a low body mass index (BMI) (i.e., 20kg/m^2) compared to standard TKA patients (mean BMI of 31kg/m^2) (Craik & Rickman, 2016). Finally, there are still open discussions regarding the amount of distraction force to be applied to the knee joint during the acquisitions. In this regard, future developments include the possibility of fluctuating the input load according to patient-specific parameters.

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