EPiC Series in Health Sciences
Volume 7, 2024, Pages 31–35
Proceedings of The 24th Annual Meeting of the International Society for Computer Assisted Orthopaedic Surgery

Navigated Instrumentation Improves Reproducibility of Laxity Acquisition During a Total Knee Arthroplasty

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Abstract

Measuring the knee laxities when performing total knee arthroplasty (TKA) is part of the regular workflow and can be used as input for intra-operative planning. Gaps are traditionally measured by varus-valgus tests, but new instrumented methods have recently been proposed. This cadaveric study showed that the instrumented method is more reproducible than the manual one.

1 Introduction

When performing total knee arthroplasty (TKA), laxity assessment is essential to balance the joint and to plan the bones' cuts [9, 4, 10, 11]. Laxities can be assessed applying manual varus and valgus stress tests to the knee, starting in extension and flexing the limb to acquire the lateral and the medial gaps, respectively. However, this technique has shown a high degree of operator-related variability [3, 2, 5], leading to different gap assessments [7]. An alternative is the placement of a ligament tensioning device to distract the knee while recording the gaps using a computer assisted orthopaedic system (CAOS). The aim of this experimental study was to compare the reproducibility of laxity measurements while using the same CAOS system, between the conventional (manual varus and valgus stress tests) and instrumented (using a quasi-constant force intra-articular distractor) techniques. We hypothesized that the instrumented technique would provide more reproducible laxity measurements.

2 Material and Methods

Five operators, 3 senior surgeons (named S1, S2, S3) and 2 juniors (named J1, J2) performed laxity measurements during navigated TKA using a posterostabilized prosthesis. This study included 8 knees (4 cadaveric specimens). Each operator acquired the knee joint laxities throughout the full arc of flexion, using the conventional method prior to any bone cutting by sequentially manipulating the limb in varus and then in valgus, and then using an instrumented method with a distractor inserted between the tibial cut and the native femur. By independently distracting the two compartments of the knee, the instrumented technique enables the simultaneous acquisition of both the medial and lateral gaps. Each of the measure was repeated 6 times. Reproducibility of measurements was assessed by inter-operator and intra-operator intra-class correlation coefficients (ICC), depending on the method used and the experience of the operators.

2.1 Statistical analyses

Statistical analyses were performed using a statistical software (R software version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria[8]) with a significance level of $p < 0.05$. Superiority in continuous variables were analyzed using 1-sided t-test. Reproducibility of measurements was assessed by calculating inter-operator and intra-operator intra-class correlation coefficients (ICC) and 95% confidence intervals (CIs), following the guideline [6].

3 Results

The four specimens were women aged between 79 and 96 (mean 90±7.9). A total of 960 gaps acquisitions throughout the arc of motion were recorded with the CAOS system to evaluate the two techniques.

For a given knee and gap side, it was possible to compare the mean acquisitions done by all operators per technique (see Figure 1) in order to compute the inter-operator ICC. It was also possible to compute the intra-operator ICC, comparing the 6 acquisitions done by a given operator per technique.

Table 1 presents the results. The instrumented method had a significantly greater inter-operator ICC than the conventional method for the lateral laxity (0.92 versus 0.25; p¡0.0001) and the medial laxity (0.87 versus 0.60; p=0.02). For the conventional method, the lateral laxity acquired under varus stress was less reproducible than the medial laxity acquired under valgus stress (0.25 versus 0.60; p=0.01), while the instrumented method showed no difference (0.92 versus 0.87; p=0.8) between the two compartments. For both manual and with the distractor, the seniors had better inter-operator ICCs than the juniors, although this was not significant (manually 0.55 versus 0.39; p=0.1, with the distractor 0.92 versus 0.90, p=0.3).

The intra-operator ICC was significantly higher with the instrumented method than with the conventional method for laxity assessment in all tests (0.78 versus 0.51; p¡0.0001) and for the lateral compartment (0.84 versus 0.40; p¡0.0001), but not for the medial compartment (0.71 versus 0.63; p=0.07).

4 Discussion and conclusion

This study established that the instrumented technique, using an intra-articular distractor, offers better reproducibility than conventional one when measuring the knee laxities, confirming previous work [1]. Indeed, if we assess the level of reliability using the [6] classification, inter-operator ICC has globally been shown passing from poor to excellent when moving from conventional to instrumented technique. It is the same when focusing on lateral gaps and it passes from moderate to good for the medial gaps measures. This study also emphasizes that inter-operator reliability to measure lateral gaps with the conventional method is poor, while

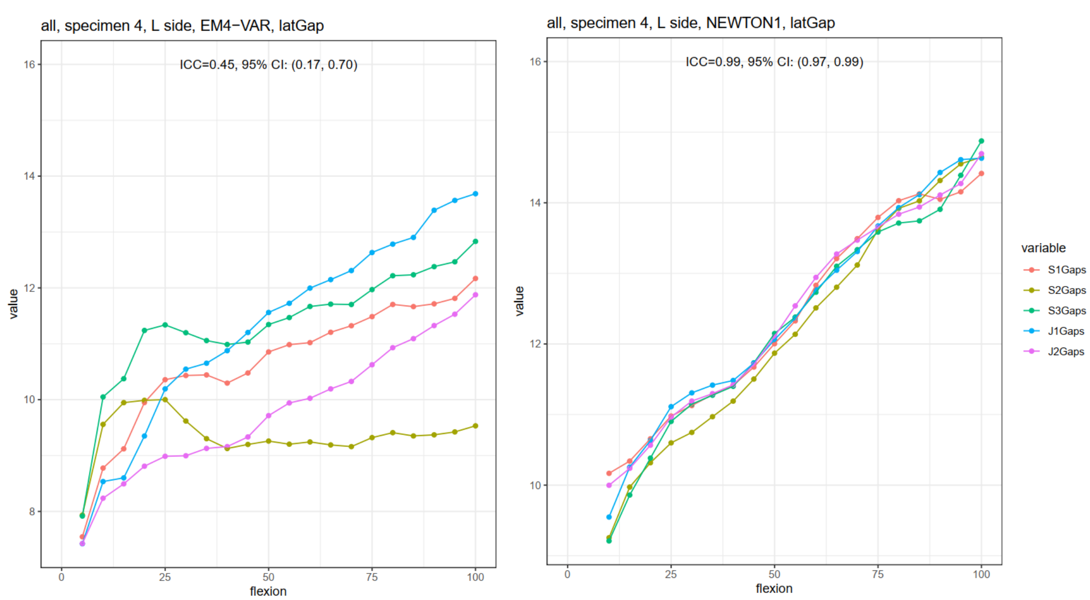

Figure 1: Lateral compartment gaps measured by the conventional (left) and instrumented (right) methods for specimen 4, left knee.

	Conventional Technique	**Instrumented Technique**	
	mean ICC (95% CI)		1-sided t-test
	Inter-operator		
All tests	0.43 (0.23, 0.60)	0.90 (0.76, 0.96)	p<.0001
Varus tests (lat. gaps)	0.25 (0.09, 0.43)	0.92 (0.81, 0.97)	p<.0001
Valgus tests (med. gaps)	0.60 (0.37, 0.76)	0.87 (0.71, 0.95)	p=.002
	Intra-operator		
All tests	0.51 (0.33, 0.70)	0.78 (0.64, 0.88)	p<.0001
Varus tests (lat. gaps)	0.40 (0.22, 0.60)	0.84 (0.71, 0.92)	p<.0001
Valgus tests (med. gaps)	0.63 (0.44, 0.80)	0.71 (0.57, 0.84)	p=.07

Table 1: Inter-operator and Intra-operator Intraclass Correlation Coefficient (ICC) per Technique of Laxity Measurements for All Tests, Varus Tests and Valgus Tests.

it is moderate for medial gaps. Using the instrumented technique this difference is not significant between lateral and medial gaps measurements. In other words, with the conventional technique varus tests are shown harder to reproduce between operators than valgus ones. The instrumented technique eliminates this inter-operator difference.

Concerning intra-operator reproducibility, this study showed that the ICC passed from moderate to good when moving from conventional to instrumented technique and even from poor to good when focusing on lateral gaps measurements. Intra-operator reliability to measure lateral gaps with the conventional method is poor, when it is moderate for medial gaps. On the contrary, using the instrumented technique this intra-operator reliability is good to measure lateral gaps and moderate for the medial ones.

The instrumented method enabled better reproducibility of the knee laxity acquisitions, limiting the influence of experience and the acquisition difficulty inherent in maintaining a varus force throughout flexion with the manual method. The application of a force controlled by the distractor, as well as its ease of use in the neutral position, may play a role in the reproducibility of gaps acquisitions.

The use of a distraction device coupled with navigation experimentally improved the reproducibility of knee laxity measurements compared with conventional manual varus/valgus acquisitions.

Acknowledgements

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. These donors and their families deserve our highest gratitude.

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