The Journal of Arthroplasty xxx (2017) 1–6

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Original Article

Is the Use of Spreaders an Accurate Method for Ligament Balancing?

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ARTICLE INFO

Article history:
Received 30 November 2016
Received in revised form
27 January 2017
Accepted 30 January 2017
Available online xxx

Keywords:
knee
arthroplasty
subvastus
soft tissue balance
gap balance
tension

ABSTRACT

Background: To analyze 2 methods of manual spreader gap assessment accuracy, visual vs blinded, compared with a controlled tensioner in total knee arthroplasty.
Methods: Twenty-two fresh frozen cadaver knees were used to perform total knee arthroplasty by 22 surgeons. Extension and flexion gaps were measured with empirical manual force application with spreaders in 2 different manners: (1) surgeons were blinded to gap geometry formation—blind method group (BM) and (2) surgeons viewed them—viewing method group (VM). A tensioner was used to measure the corresponding ligament tension applied during spreader measurements and to measure the extension and flexion gaps with standard force of 100 and 80 N (tensioner method [TM]) in each femorotibial compartment.
Results: All measurements with spreaders (VM and BM) presented extension and flexion gaps oversized and asymmetric ($P < .0001$), when compared with the same gaps measured with the tensioner. Approximately 63% ($P = <0.001$) and 77.3% ($P = .161$) of the VM group and 68.2% ($P = .018$) and 77.3% ($P = .161$) of the BM group demonstrated asymmetry for extension and flexion gaps up to 3 mm to the TM. Gaps measured in the VM group presented results with slightly less oversizing and asymmetries than the measurements in the BM group compared with TM, although significantly different ($P < .0001$).
Conclusion: The assessment of extension and flexion gaps with empirical manual applied force spreaders produced oversized and asymmetric gaps compared with the use of tensioner. No visual influence was observed during the spreader applied empirical manual force compared with the blinded assessment.
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One of the most important factors for total knee arthroplasty (TKA) success is ligament balancing [1-4]. The benefits of symmetrical gaps are stability and equal stress distribution in TKA components [1-5] minimizing premature wear, loosening, and need for revision [6-8]. Digital devices capable of intraoperative soft tissue tension evaluation were created to improve ligament balancing. However, these devices are not available worldwide [9]. Some surgeons still perform gap assessment using subjective criteria during TKA to determine ligament balancing [10]. To aid the surgeon in this matter, spreaders [2,11-13] and spacers blocks [14] are commonly used. However, they do not allow precision or control of the force applied [11], in opposition to tensioners which have contributed to an increased accuracy of this procedure [15-17].

Some conditions may interfere with the results during gap measurement such as surgical approach [15], patellar height and position [18,19]. One question still unanswered is whether the empirical manual force applied by the surgeon during gap assessment with spreaders is influenced, consciously or not, by the visualization of the gaps geometry, which would imply a potential method error.

The purpose of this study was to analyze 2 methods of manual spreader gap assessment accuracy, visual vs blinded, compared with a controlled tensioner. The 3 hypotheses tested were:

1. Empirical visual vs blinded extension and flexion gap assessment using manual spreaders does not properly estimate gap tension.

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2017.01.055.

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http://dx.doi.org/10.1016/j.arth.2017.01.055
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2. Empirical visual vs blinded extension and flexion gap assessment using manual spreaders does not balance medial and lateral extension and flexion gaps as well as tensioner.
3. Visual empirical spreader testing is more accurate than blinded empirical assessment.

Materials and Methods

Material

Twenty-two experienced knee surgeons performed a TKA with Genesis II (Smith & Nephew, Memphis, TN) in 22 fresh frozen cadaver knees. The knees were stored at −20°C and thawed overnight at room temperature before testing. There were no previous surgical manipulations or clinical angular deformities in the lower limbs. Each surgeon operated on one knee. The Ethics Committee of our Institution approved this study.

Surgical Technique

All TKAs were performed with the subvastus access and resection of the posterior cruciate ligament. The tibial rotation axis was determined by the third of the anterior tuberosity and the insertion of the posterior cruciate ligament. The femoral rotation axis was determined by the Whiteside line and posterior condylar axis. The cuts were made with 6 degrees of valgus in the distal femur and within extramedullary guide in the proximal tibia perpendicular to the tibial mechanical axis [1,11,16].

Gap measurement was carried out with the patella and the extensor mechanism laterally displaced without eversion. No ligament release was allowed until all measurements were performed. After performing all the femoral and tibial cuts, the measurements of the extension and flexion gaps were performed by 2 different instruments: 2 spreaders and 1 tensioner. The spreaders were graduated in 2 mm. The Force Controlled Ligament Tensioner (Smith & Nephew, Switzerland) was graduated in 20 N (0-140 N) and in 1 mm. The instruments were positioned at the midpoint of condylar width in the femorotibial compartment.

Flexion and extension gap measurements were carried out in 5 different procedures.

- Procedure 1: Measurement without direct gap geometry formation vision, blind method group (BM), *during application of manual force with spreaders in extension and flexion.*

Vision of the knee gap was blocked with a surgical dressing during the application of empirical manual force with spreaders in each tibiofemoral compartment (Fig. 1A). Values were recorded in millimeters.

- Procedure 2: Measurement with direct gap geometry formation vision, viewing method group (VM), *during application of manual force with spreaders in extension and flexion.*

Gaps were measured in the same manner as described in the first step. However, gap geometric formation direct vision was allowed during empirical manual force application (Fig. 1B). The values were recorded in millimeters.

- Procedure 3: Tensioner definition of the empirical manual forces applied at procedure 1 (BM).

The values, in millimeters, of each compartment of the knee during measurements with spreaders in the first procedure were reproduced using the tensioner to obtain the corresponding force applied in Newtons (N). The average values were recorded when the force in tensioner remained between the exact graduations (Fig. 1C and D).

- Procedure 4: Tensioner definition of the empirical manual forces applied at procedure 2 (VM).

It was conducted the same way as procedure 3; however, the VM was evaluated.

- Procedure 5: Tensioner measurement of the extension gap with 100 N and flexion gap with 80 N.

We used the standard forces described by Himstedt et al [17,20] to measure the extension (100 N) and flexion (80 N) gaps in each femorotibial compartment.

Statistical Analysis

The results of empirical manual forces applied in spreaders in both methods, VM and BM, were analyzed and compared with the standard force assessment with tensioner [17,20]. The mean, median, and standard deviation were analyzed and the significance level was set at 0.05.

Gap comparisons were made individually for the lateral and medial compartments at flexion and extension. In addition, total flexion gap and total extension gap measurements were analyzed to evaluate gap asymmetry between the individual femorotibial compartments and also compared with full gap formation, representing the medial and lateral relationship according to the position of the knee.

To evaluate if there were differences in the sizes of the gaps in the 2 spreader measurement VM and BM, the results obtained were submitted to a Student *t* test for dependent samples (paired *t* test). Measurements with spreader empirical manual force and the standard force tensioner were compared with the *Sign test*. The mean and median of extension and flexion gap asymmetry, in both methods, were compared using the *nonparametric Wilcoxon signed ranks*.

The comparison of accuracy of the measurements with spreaders in relation to the tensioner for asymmetries of 2, 3, and 4 mm were calculated by the test of 1 ratio. It was used the 90% percentile to support a satisfactory accuracy.

SAS software version 9 (SAS Institute Inc, Cary, NC), and Minitab version 16 (Minitab, Inc, State College, PA) were used for all statistical analysis.

Results

Empirical Manual Force Applied in Spreaders During the Measurement of Gaps with (VM) and without (BM) Visualization of the Geometry Formation

Assessment of the lateral extension gaps by VM and BM demonstrated that 81.8% and 77.1%, respectively, applied greater than 100 N empirical manuals forces. For the lateral flexion gaps (LFGs), VM and BM demonstrated that 81.8% and 95.3%, respectively, applied forces higher than 80 N.

Assessment of the medial extension gaps by VM and BM, demonstrated that 63.6% and 59.1%, respectively, applied forces greater than 100 N. For medial flexion gaps (MFGs), VM and BM, demonstrated that 68.2% and 63.6%, respectively, applied forces greater than 80 N.

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