Reduced Incidence of Mid-Flexion Instability with Force-Controlled Gap-Balancing In Total Knee Arthroplasty

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INTRODUCTION:

Instability is a common cause of early failure following total knee arthroplasty (TKA) and represents 11-26% of the revisions. Among the different types of instability, mid-flexion instability (MFI) tends to be the most debated. MFI refers to the specific clinical situation where the knee is stable in full extension and at 90° of flexion, but unstable somewhere between these 2 points, generally between 30° and 60° of flexion. While the potential causes of MFI are numerous, one leading explanation relates to altered ligament tension during the range of motion. Toward this end, a recommendation is to routinely assess the varus-valgus stability in mid-flexion range during TKA. Most advanced enabling technologies for TKA allow the possibility of planning the bone cuts based on soft-tissue balance throughout the full arc of motion, which should mitigate the risk of MFI. The objective of this study was to evaluate the incidence of MFI during TKA enhanced with force-controlled gap-balancing by processing the appearance of the final joint laxity curves obtained under distraction during the trial reduction.

METHODS:

A retrospective review was performed on a proprietary cloud-based web database that archives technical logs of cases performed using an instrumented computer-assisted surgery system during tibia first TKA. A total of 2864 cases performed by 120 individual surgeons were considered without any exclusions. At the time of the trial reduction stage, the final joint laxities were acquired by placing an intra-articular force-controlled tensioner between the proximal tibial cut and the trial femoral component while manipulating the limb from extension to flexion. Each individual joint laxity curve was processed to detect the possibility of MFI. In the absence of a discrete definition of the MFI, for the purpose of this study, it was assumed that risk of MFI may occur if the maximal joint gap measured between 30° and 60° of flexion (mid-flexion range) was larger than the maximal gaps measured between 0° and 20° of flexion (extension range) and between 85° and 95° of flexion (flexion range) by more than 2mm. In addition, the individual joint laxity curves were combined to establish the mean and percentile gap values for both the medial and lateral compartments throughout the full arc of motion.

RESULTS:

The incidence of potential MFI was 1.05% (i.e., n=30 of 2864) and 1.12% (n=32 of 2864) for the medial compartment and lateral compartment, respectively. The incidence of potential MFI reported on both the medial and the lateral compartments for the same patient was 0.2 % (i.e., n=6 of 2864). Among the cases associated with potential MFI (i.e., n=56 of 2864), the mean MFI was 2.67mm (ranging from 2.03 to 5.03mm) and 2.77mm (ranging from 2.00 to 5.52mm) for the medial compartment and lateral compartment, respectively. The appearance of the mean laxity curves revealed that the gaps tend to be rectangular in extension with slight lateral opening in flexion. Flexion gap tends to be larger than the extension gap by ~1.5 mm (see Figure 1).

DISCUSSION AND CONCLUSION:

Despite the adoption of enabling technologies such as navigation or robotic assistance, MFI remains a challenge in TKA. A recent analysis of the American Joint Replacement Registry revealed that patients who had robotic-assisted TKA had higher odds of 2-year revision for instability than patients who had TKA with conventional mechanical instrumentation. Therefore, soft-tissue balance management could be a noticeable consideration when comparing different enabling technologies. Some technologies rely on manual assessment at discrete angles of flexion (e.g., extension and 90° only) at the beginning of the surgery, which tends to lack accuracy. Other technologies allow for reliable acquisition of the laxities using force-controlled distractor throughout the entire range of motion for the set-up of the surgical plan. According to this study, despite the conservatism of the selected MFI threshold (i.e., 2mm of added laxity), such an approach translated into a reduced risk of MFI, which may explain the previously reported improved clinical outcomes using this platform.

Figure 1: Mean and percentile of the medial and lateral gaps throughout the full arc of motion.