Use of a New Tensor to Assess the Accuracy of the Soft-Tissue Balance in Total Knee Arthroplasty

Introduction
Obtaining proper intraoperative soft tissue balance at the time of total knee arthroplasty is thought to be one of important factors to achieve stable postoperative outcomes. It is ideal to fulfill a rectangular flexion and extension gap, although the difficulties are well recognized. Therefore, various ways, such as surgeon’s experiences, spacers, and tensors, have been reported to assess soft-tissue balance. We have used a new tensor which enables us to measure soft tissue balance with a patella in the physiologic normal position. The purpose of this study was to investigate (i) whether the new tensor enabled us to evaluate intraoperative soft-tissue balance properly and (ii) whether the intraoperative soft-tissue balance influenced postoperative outcomes, such as range of motion and valgus/varus instability.

Materials and Methods
Patients:
A total of 40 primary TKAs in 24 patients were performed by the same senior author between January 2008 and December 2008. There were 5 male and 19 female patients ranging in age from 63 to 83 years (mean, 74.5 years old). The diagnosis was osteoarthritis in 18 cases, osteonecrosis in 1 case, and rheumatoid arthritis in 5 cases. The patients underwent TKA using a posterior-stabilized design (Scorpio NRG, CR and PS Primary Knee System, Stryker or Scorpio Plus, Mobile Bearing Knee System, Stryker), with resurfacing of the patella.

Tensor Device:
At surgery, we use the tensor (Joint Dependent Kinematics: JDK-mini II, Stryker, Tokyo, Japan) shown in figure 1. The tensor consists of 2 metallic plates that are located on the surfaces of the tibia and the femur. These plates are connected to main body which has a gap scale and a tilting scale with torque wrench. The joint distraction force was set at 30lb (13.6kg). The upper plate is set on the femoral side, and is free to tilt medially or laterally. So, the tensor indicates the distance of distraction between the 2 metal plates and the medial/lateral angular deviation between the plates under the influence of the relative tensions in the soft tissues. Additionally, it has the offset arm which allows us to investigate soft tissue balance with the patella in the normal position.

Surgery:
A midline surgical incision with a midvastus approach was used. After osteophytes were removed, the anterior cruciate ligament and posterior cruciate ligament were sacrificed. At our institution, we use the modified gap technique to balance the knee at the time of TKA. Briefly, the distal femoral osteotomy was set at 7° valgus angle to the femoral axis and the proximal tibial osteotomy was perpendicular to the tibial axis in the coronal plane. After the initial bone cuts, the soft-tissue balances between the distal femur and the proximal tibia or between the posterior femur and the proximal tibia were measured in 0° flexion and 90° flexion. The soft-tissue release was performed until the tensor showed angulation ±4° in both flexion and extension. In case of a failure to obtain a proper soft-tissue balance notwithstanding three times trials, to accomplish the accurate soft-tissue balance was gave up. In reference to the gap differences between flexion and extension, we decided the amount of the femoral posterior resection. After all bony resections and soft tissue releases, the tensor was used again to measure the soft-tissue balances between the femoral trial prosthesis and the proximal tibia at 0° extension and 90° flexion.

Results
The average extension gap (0 degree) between the femoral trial prosthesis and the proximal tibia was 11.1 ± 2.4 mm and the average flexion gap (90 degree) was 15.7 ± 3.4 mm (Figure 2A). Similarly, the average medial angular deviation was 0.7 ± 1.1 at 0° extension and 0.7 ± 2.7 at 90° flexion. The medial/lateral angular deviation was ±4° in all cases at 0 degree, although two cases (5.0%) showed outliers at 90 degree (Figure 2B, 2C). Intraoperative gap differences and extension/flexion gap were not related to the postoperative flexion angle. Likewise, the medial/lateral angular deviation and the extension gap were not related to the postoperative valgus/varus instability (Data not shown).

Discussion
It is recommended to perform the intraoperative soft tissue balance measurements with a reduced patella rather than an inverted patella to reduce the risk for joint gap and ligament imbalances(1). In the study, we could evaluate the balance with a patella in the normal position by using the new tensor, which would be expected to indicate more accurate intraoperative/postoperative outcomes.

Some authors have described that perfect soft-tissue balance is to achieve a rectangular flexion and extension gap and equality in the size of the flexion and extension gaps under equal tension. However, deeper knee flexion might be expected, if we make the flexion gap larger than the extension gap. From this standpoint, it is desirable to clarify the proper gap differences between flexion and extension for achieving the deep flexion angle, although we could not find any relationships between the intraoperative gap difference and the postoperative flexion angle in the study. There was no correlation between the intraoperative soft-tissue balance and postoperative outcomes. The small deviations among these cases might keep from indicating these correlations. Other possibility is that a variety of factors influence the postoperative outcomes, such as preoperative/intraoperative instability, contracture, or deformity. Therefore, it may be difficult to predict the postoperative outcomes from intraoperative assessment of only soft-tissue balance. For example, use of a tensor in conjunction with a computer-assisted navigation system, which improve the accuracy of the alignment and implantations, may help us to resolve our inquiry.

References:

Figure 1 Tensor Device: The tensor has the offset arm which enables us to measure soft-tissue balance without inverting a patella.

Figure 2 The joint gap at 0 degree and at 90 degree (A). The medial/lateral angular deviation at 0 degree (B) and 90 degree (C).