Evaluating joint laxity in UKR using NavioPFS

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Introduction: NavioPFS unicompartmental knee replacement (UKR) system combines CT-free planning and navigation with the robotically assisted bone preparation [1]. In the CT-free planning procedure, all relevant anatomic information is collected under navigation either directly with the point probe or by kinematic manipulation. In addition to key anatomic landmarks and the maps of the articulating surfaces of the femur and tibia, kinematic assessment of the joint laxity is performed. Relative positions of femur and tibia are collected through the flexion/extension range of the knee, with the pressure applied to fully stretch the collateral ligament on the operative side.

The planning procedure involves three stages: (1) the implant sizing and initial placement,(2) balancing of the gap on the operative side and (3) evaluating the contact points for the recorded flexion data and the planned placement of implants. In the gap balancing stage, the implants are repositioned until they allow for a positive gap, preferably uniform, throughout the entire range of flexion.

Materials and Methods: UKR was planned and prepared on six cadaver knees with the help of NavioPFS system for UKR. All knees were normal without any signs of osteoarthritis. Two surgeons have performed the medial UKR procedures (4+2), using a commercial off-the-shelf implant. The bones were prepared using the NavioPFS handheld robotic tool. The trial implants were placed in the prepared places and the knee was tested for range of motion.

Postoperatively, we have re-used the data collected during the planning procedure to compare the kinematic (gap balancing) performance of the used implant with two other commercial implant designs (Figure). All implants were placed in the orientation recommended by the respective manufacturer, sized to best fit the original bone geometry, and repositioned optimally balance the gap curve through the entire flexion range, without any negative gaps (overlaps). Since these were nonarthritic cadaver knees, the intent was to restore the original preoperative varus/valgus in neutral (zero) flexion.

Results: The three implant designs demonstrated variable degree of capability to uniformly balance the knee gap over the entire range of flexion. The first implant (A) required a gap larger than 2 mm in one case out of six, the second (B) was capable of producing the positive gap curve under 2mm of gap in all six cases, and the third (C) required a gap larger than 2 mm in 3 (50%) of cases. All three designs exhibit the reduced gap space in mid flexion, approximately between 30 and 90 degrees of flexion.

Conclusions: Despite the best attempts to replicate the original articulating surfaces, the artificial implants do not fully replicate the healthy knee kinematics. This is manifested by increased tightness in the mid flexion. To avoid the joint locking the gap has to be positive throughout the range of motion. In order to balance the gap in mid flexion, additional laxity has to be allowed in full flexion, extension, or both. NavioPFS allows for patient specific planning that takes into account the information only available intraoperatively. This kind of evaluation on a patient specific basis is a very important planning tool and it allows the insight on the implant performance in mid flexion, typically not available using conventional planning techniques. It can also help in improving kinematic performance of future implant designs.
Typical gap curve for the three tested implants (A, B, C)

References