Intra-Operative Assessment of the Soft Tissue Envelope is Integral to the Planning of UKA Components

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INTRODUCTION

Recent advances in 3D printing enable the use of custom patient-specific instruments to place drill guides and cutting slots for knee replacement surgery[1]. However, such techniques limit the ability to intra-operatively adjust an implant plan based on soft-tissue tension and/or joint pathology observed in the operating room, e.g. cruciate/lateral ligament integrity[2]. It is hypothesized that given the opportunity, a skilled surgeon will make intra-operative adjustments based on intra-operative information not captured by the hard tissue anatomy reconstructed from a pre-operative CT scan or standing x-ray. This study investigates the frequency and magnitude of intra-operative adjustments from a single orthopedic surgeon during 38 unicondylar knee arthroplasty (UKA) cases performed using robotic assisted surgical technique[3].

METHODS

For each patient, a pre-operative plan was created based on the 3D bony anatomy, analogous to a plan created with patient-specific cutting blocks or customized implants. With robotic technology that utilizes pre-operative imaging, intra-operative navigation and robotic execution, this “anatomic” plan can be fine-tuned and adjusted based on the soft tissue envelope measured intra-operatively. The planned position, orientation and size of the components can be adjusted to achieve an optimal dynamic ligament balance prior to any bony cuts. This is the plan that is then executed under robotic guidance. Intra-operative adjustments are defined as any size, position or orientation changes occurring intra-operatively to the pre-operative anatomic plan and include changes to implant pose and size, femoral and tibial implant translations and rotations and implant gaps as measured intraoperatively.

RESULTS

The surgeon adjusted the pre-operative implant plan in 33 out of 38 procedures or 86.8% of cases, leading to combined RMS changes of 2.0 mm and 2.1 degrees to the femoral implant, and 0.9 mm and 1.4 degrees to the tibial implant. The RMS femoral implant translations and rotations were 1.0, 1.5, 0.9 mm and 1.0, 1.0, 1.7 degrees in the medial, anterior, and superior directions, respectively. The RMS tibial implant translations and rotations were 0.2, 0.4, 0.8 mm and 1.3, 0.4, 0.6 degrees in the medial, anterior, and superior directions, respectively. Implant sizes were adjusted in 14 out of 38 procedures or 36.8% of cases, with all changes occurring to the femoral implant, and 13 out of those 14 cases showing a reduction in the femoral implant

size. Before any intra-operative adjustments, the mean and standard deviation of all implant gaps measured across all surgeries were -0.9 and 1.9 mm, respectively. After intra-operative adjustments, the mean and standard deviation of all implant gaps measured across all surgeries were 0.0 and 1.6 mm, respectively. From the same set of data, the mean of each surgery's mean implant gaps before and after intra-operative adjustments were -0.9 and 0.0 mm, respectively. The standard deviation of each surgery's mean implant gaps before and after intra-operative adjustments were 1.2 and 0.3 mm, respectively. Lastly, the mean of each surgery's standard deviation of implant gaps before and after intra-operative adjustments were 1.5 and 1.7 mm, respectively. The standard deviation of each surgery's standard deviation of implant gaps before and after intra-operative adjustments were 0.6 and 0.6 mm, respectively.

CONCLUSIONS

The large majority of surgical cases showed some degree of intra-operative implant adjustments. These data support the hypothesis that surgical planning of UKA components based on accurate 3D dimensional reconstructions of anatomy alone is not adequate to create optimal implant gap spacing throughout flexion. Gap balancing results may provide clues to soft-tissue tensions in the patients knees which may influence surgeon's placement of the implant and may also affect the patients outcomes[4,5]. Measurement and knowledge of the patient's soft tissue envelope allows for significant changes to the implant plan prior to any bony cuts.

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DISCLOSURES

Martin Roche is a consultant of Stryker Corp.

Michael Conditt and Sharon Branch are employees of Stryker Corp.