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Robotic use improves post-resection bone cuts during total knee arthroplasty

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Abstract

The purposes of this study were to assess 1) number of bone recuts with manual TKA (MTKA) vs RATKA and 2) influence of robotics on surgeon's posture and workload during recutting.

Two surgeons each performed three MTKAs and three RATKAs. Occurrence, time and type of post-resection recuts were recorded. Movement sensors were placed on surgeons to measure lower back, shoulder, and cervical movements. Data was analyzed for average angle, percent of time in high-risk range of motion (ROM), number of times in high-risk sustained positions, and repetitions per minute. Surgeons were surveyed to assess physical and mental effort on a 1-10 scale (1 as lowest effort).

Six TKAs required recuts, five MTKA and one RATKA. 5 were on tibia and 1 (MTKA) was on femur. Compared to RATKA, MTKA had: increased time to perform recut (4.8-minutes vs. 3.7-minutes), increased occiput and T3 (38.9 vs 17.0° and 16.0 vs 3.0°) average angles, increased lower back ROM, sustained positions, and repetitions (14 vs 0%, 1 vs 0, and 1.9 vs 0), increased non-dominant shoulder ROM and repetitions (22 vs 0% and 2 vs 1), reduced dominant shoulder ROM (56 vs 19%), increased mental (4.2 vs 2.8) efforts and increased physical (3.3 vs 1.7) efforts.

Results indicate RATKA may reduce incidence of post-resection bone recuts. Increased time and required efforts for MTKA may be due to setting up surgical cutting instruments. Whereas, for RATKA, recut changes are made on the robotic surgical screen and the robotic-arm is used to help perform the recut.

1 Introduction

During total knee arthroplasty (TKA) knee balance is typically assessed during trialing. A surgeon may perform either soft tissue releases or bone re-cuts to achieve balance. Robotic assisted TKA (RATKA) allows the surgeon to dynamically assess knee balance in flexion and extension prior to performing any bone cuts, which may reduce post-trialing bone re-cuts. To the best of the authors' knowledge, there are no studies on how robotics may influence the occurrence and ease of post-resection bone cuts. The purposes of this study were to assess 1) the number of bone re-cuts required with manual TKA compared to RATKA and 2) understand how robotics may influence surgeon's posture and workload during re-cutting.

2 Materials and Methods

Two surgeons, each performed 3 MTKAs and 3 RATKAs by alternating knees on 6 cadaveric specimens. The surgeons performed TKA according to their standard procedure with the goal of achieving a balanced knee. The occurrence, time to re-cut, and type of post resection re-cuts were recorded for both MTKA and RATKA procedures. To assess surgeon ergonomics during re-cutting, kinematic and EMG sensors were placed on the surgeons to measure lower back, shoulder, and cervical movements, as well as lower back and shoulder muscle activities. High-risk range of movements were defined as above 40° flexion and above 10° flexion for the lower back, above 10° lateral flexion or extension for the lower back, and above 60° of elevation for the shoulder. Raw data was analyzed to determine percent of time in high risk range of motion (ROM), number of times each body region sustained a high-risk position for greater than 30 seconds, numbers of repetitions per minute in the high-risk position, and average angle during the re-cutting process. Following each surgery, the surgeons were asked a series of questions to assess physical and mental effort on a 1-10scale where a higher score correlated to increased effort. This series of questions was based on a validated SURG-TLX workload questionnaire [1]. Occurrence of re-cuts, as well as the surgeons' ergonomic and questionnaire data were analyzed to compare MTKA vs. RATKA.

3 Results

Five of six MTKAs required post-resection recuts and one of six RATKA required a recut. One MTKA recut was on the femur while all other recuts were for the tibia. On average, the MTKA recut process took longer than the RATKA recut (4.8 minutes compared to 3.7 minutes, respectively). When performing recuts for MTKA and RATKA, the lateral flexion of the surgeons' lower back had increased percent time in high-risk ROM, number of sustained positions, and number of repetitions at high-risk angles during MTKA compared to RATKA (14 vs 0%, 1 vs 0, and 1.9 vs 0, respectively). For both surgical procedures, flexion and extension of the lower back did not enter a high-risk position. For the non-dominant shoulder, MTKA had increased percent of time in high risk ROM and number of repetitions (22 vs 0% and 2 vs 1, respectively) when compared to RATKA. For the dominant shoulder, MTKA had reduced percent of time in high risk ROM (56 vs 19%, respectively) compared to the RATKA group. However, for the dominant shoulder, neither group had sustained positions and MTKA had an increased number of repetitions (0.5 vs 2.5, respectively). MTKA also had increased occiput and T3 (38.9 vs 17.0° and 16.0 vs 3.0°, respectively) average angles when compared to RATKA. According to the surgeon questionnaire, MTKA had increased mental (4.2 vs 2.8) and physical (3.3 vs 1.7) efforts compared to RATKA.

4 Discussion and Conclusion

Results from this study indicate that RATKA may be able to reduce the incidence of post-resection bone recuts. In the event that a recut is needed for RATKA, the reduced physical and mental demands on surgeons may be due to the fact that when performing a recut with MTKA, surgical cutting instruments must be placed back onto the bone prior to making any cuts. For RATKA, the changes for the recut are made on the robotic surgical screen and the robotic-arm is used to help perform the recut. It was noticed for RATKA, the dominant shoulder had increased ROM due to sustaining the initial position of the surgical saw while reviewing plans. When cutting, the surgeon's shoulder angle dropped approximately 45°, emphasizing the importance of being conscious of surgical posture during portions of the case not involving use of the saw. Aside from surgeon safety, the accuracy and safety of the recuts should be studied to understand potential patient benefit.

References

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