Manipulation Under Anesthesia Rates in Technology-Assisted versus Conventional-Instrumentation Total Knee Arthroplasty

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Although conventional total knee arthroplasty (TKA) has proven to be highly safe and effective, a substantial percentage of patients are unsatisfied with their results and still experience various postoperative complications. Notably, some studies report that 20% or more of patients are not fully satisfied with their surgical results. Given these findings, a number of recent technological advancements have been developed in attempts to improve TKA outcomes, including the implementation of robotic assistance. Recent literature has suggested that patients who underwent robotic-assisted TKA (RATKA) reported superior three-month, six-month, and one-year postoperative outcomes compared to patients operated on with conventional methods. Yet, while these earlier reports have supported these operating room technologies, longer-term follow up is still necessary.

Knee stiffness following TKA is an additionally challenging complication and has been found to occur in up to 13.5% of patients. This adverse outcome is a result of decreased range of motion (ROM), and it has been implicated as the leading cause of 90-day readmissions following TKA. These readmissions only further drive increasing healthcare costs, putting the patient at increased postoperative complication risks and can lower patient satisfaction. If postoperative
rehabilitation is unsuccessful, patients can be treated by manipulations under anesthesia (MUA), a procedure in which the adhesions causing stiffness are manually broken. Additionally, multiple studies have associated MUA rates as a marker of knee stiffness following TKA.20–22

Various technological advancements, specifically robotic-assistance, have been implemented for TKAs to improve patient outcomes and decrease complication rates. However, currently, there is a lack of information regarding the impact that these new technologies have on MUA rates following TKA. Therefore, the purpose of this study was to evaluate rates of MUAs between a consecutive series of patients who underwent robotic-assisted surgery compared to patients who underwent TKA with conventional instrumentation to assess if this new technology might lead to postoperative improvements.

**MATERIALS AND METHODS**

**Patient selection**

A total of 188 consecutive total knee arthroplasties were performed by five fellowship-trained, high-volume surgeons at various academic and community institutions. These patients were paired to a consecutive equal number of control patients by the specific surgeon for comparison. All patients followed similar postoperative rehabilitation protocols starting on postoperative day one. Institutional Review Board approval was achieved at all sites prior to the initiation of this study.

**Mako Robotic Arm System**

All RATKAs were performed utilizing the Mako Robotic-Arm Interactive Orthopaedic System (Mako Surgical Corp., Stryker Orthopaedics, Fort Lauderdale, Florida). This extensively-implemented system uses computed tomography data to generate a patient-specific surgical plan (Fig. 1).23 Similarly, after adjusting this plan intraoperatively, the robotic arm helps the surgeon keep the cutting tools within the operative field, while real-time dynamic feedback provides information regarding patient alignment intraoperatively (Fig. 2).24,25 The Triathlon® Total Knee (Stryker Orthopaedics, Mahwah, New Jersey) components were utilized in all cases.
Table I

RATES OF MUA AFTER ROBOTIC-ASSISTED TKR VERSUS MANUAL TKR

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number of MUA (Completed Procedure)</th>
<th>MUA Rate (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotic-Assisted TKA (n=188)</td>
<td>2 (1.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual TKA (n=188)</td>
<td>9 (4.79)</td>
<td></td>
<td>0.032</td>
</tr>
</tbody>
</table>

Abbreviations: TKA=total knee arthroplasty, MUA=manipulation under anesthesia.

Outcome measures and data analysis

Rates of MUs were evaluated within and between cohorts. Additionally, the percent difference of rates was calculated to compare cohorts. All patients were evaluated with a minimum of two years follow-up time from the index procedure. Chi-square analyses were utilized to compare the MUA rates between the cohorts. A p-value <0.05 was set for statistical significance.

RESULTS

Among the included surgeons, rates of manipulation under anesthesia in the study cohort ranged from 0 to 3%, while in the control cohort, they ranged from 7 to 11%. The overall manipulation under anesthesia rate for the study cohort was 1.06% (2/188 patients), while it was 4.79% in the control cohort (9/188) (p=0.032).

A 127.5% difference in manipulation under anesthesia rate was found between the two cohorts. These findings were consistent across the five surgeons with none of the surgeons having more manipulations under anesthesia in the study cohort (Table I).

DISCUSSION

As providers continually strive to decrease complications and increase patient satisfaction following TKA, the advent of various technologies, such as robotic-assisted surgery, have potentially been utilized as promising solutions. However, despite RATKA previously shown benefits, there is a lack of information regarding its effect on MUA rates. Our study found that patients undergoing robotic-assisted TKA experienced a 4.5-fold decrease in rates of manipulation under anesthesia. Given that MUs can be utilized as a surrogate marker for knee stiffness following total knee arthroplasty, this lower rate indicates that study cohort patients had less knee stiffness and, therefore, greater initial postoperative range of motion than the control cohort.

Our study has some limitations. We did not account for various patient characteristics, such as age, comorbidity burden, body mass index (BMI), or number of prior procedures. While these variables may have been confounding factors influencing MUA rates, given that we reported on a large cohort across multiple surgeons and multiple hospitals, our results may be generalizable. Additionally, since this is the first study comparing MUA rates between RATKA and manual TKA, it provides the basis for future, larger efforts.

Other studies have previously reported on various benefits provided by robotically-assisted TKA. When comparing RATKA patients to those that underwent traditional manual TKA, increased physical function scores, higher patient satisfaction (p<0.05), and lower postoperative pain (p<0.05) were found for those undergoing robotic-assistance at 6-month follow-up. Similarly, RATKA yielded higher total and physical function scores when compared to manual controls at one-year (p-values <0.05). Similarly, Sultan et al. found that robotic-assistance yielded smaller mean differences between pre- and postoperative posterior or condylar offset ratio (PCOR) (0.03 vs. 0.004; p=0.01) compared to traditionally-performed TKA patients. Additionally, a smaller number of patients in the robotically-assisted cohort (4 vs. 12%) had Insall-Salvati Index scores outside of the normal range. Both of these findings indicate that RATKA yields greater improvements in postoperative ROM. Furthermore, Cool et al. found that compared to manual TKA (n=2595), RATKA patients (n=519) had 90-day episode-of-care costs that were $2,391.00 less (p<0.0001).

The results from this study further highlight the potential of these new operative technologies for total knee arthroplasty. We found that robotic-assistance decreased rates of MUA, indicating a decreased incidence of stiffness initially following the index procedure. Therefore, based on these data, assistive technologies may have a further advantageous role contributing to enhanced patient outcomes.

AUTHORS' DISCLOSURES

Dr. Mont is a consultant for, or has received institutional or research support from, the following companies: CyMedica Orthopedics, Inc., Performance Dynamics, Inc., Kolon Pharmaceuticals, Inc., PeerWell, Inc., Sage Products LLC, TissueGene, Inc., OnGoing Care Solutions Inc., DJO Global, MicroPort Orthopedics, Inc., OrthoSensor, Inc., National Institutes of Health (NIAMS and NICHD), Stryker, Johnson & Johnson, Pacira Pharmaceuticals, Inc., and US Medical Innovations. Dr. Mont is on the editorial/governing board of the American Journal of Orthopedics, the Journal of Arthroplasty, the Journal of Knee Surgery, and Surgical Technology International. He is a board or committee member of AAOS.

Dr. Malkani receives grants and personal fees from Stryker. He also on the medical/orthopaedic publications editorial/governing board for the Journal of Arthroplasty and is a board member of AAOS.

Dr. Roche is the chief marketing officer for OrthoSensor Inc. He also receives grants and personal fees from Stryker, OrthoSensor Inc., and Smith & Nephew plc.

Dr. Kolisek receives grants and personal fees from Stryker. He is also on the medical/orthopaedic publications editorial/governing board for OrthoTech Review Orthopaedic Knowledge...
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Dr. Gustke receives grants, personal fees, and stock or stock options from OrthoSensor Inc., Stryker, and Zimmer Biomet. He is on the medical/orthopaedic publications editorial/governing board for the Journal of Arthroplasty.

Dr. Hozack receives grants, personal fees, and stock or stock options from Stryker. He is also on the medical/orthopaedic publications editorial/governing board for the Journal of Arthroplasty.

All other authors have no conflicts of interest to disclose.

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