Innovative Multi-Modal Physical Therapy Reduces Incidence of Manipulation Under Anesthesia (MUA) in Non-Obese Primary Total Knee Arthroplasty

TANNER MCGINN, BS
RESEARCH ASSISTANT
RUBIN INSTITUTE FOR ADVANCED ORTHOPEDICS
CENTER FOR JOINT PRESERVATION AND REPLACEMENT
SINAI HOSPITAL OF BALTIMORE
BALTIMORE, MARYLAND

MORAD CHUGHTAI, MD
RESEARCH FELLOW
DEPARTMENT OF ORTHOPAEDIC SURGERY
CLEVELAND CLINIC
CLEVELAND, OHIO

ANIL BHAVE, PT
PHYSICAL THERAPIST
RUBIN INSTITUTE FOR ADVANCED ORTHOPEDICS
CENTER FOR JOINT PRESERVATION AND REPLACEMENT
SINAI HOSPITAL OF BALTIMORE
BALTIMORE, MARYLAND

OSTMAN ALI, MD
RESEARCH ASSISTANT
RUBIN INSTITUTE FOR ADVANCED ORTHOPEDICS
CENTER FOR JOINT PRESERVATION AND REPLACEMENT
SINAI HOSPITAL OF BALTIMORE
BALTIMORE, MARYLAND

PRATHIK MUDALIAR, MD
RESEARCH ASSISTANT
RUBIN INSTITUTE FOR ADVANCED ORTHOPEDICS
CENTER FOR JOINT PRESERVATION AND REPLACEMENT
SINAI HOSPITAL OF BALTIMORE
BALTIMORE, MARYLAND

ANTON KHLOPAS, MD
RESEARCH FELLOW
DEPARTMENT OF ORTHOPAEDIC SURGERY
CLEVELAND CLINIC
CLEVELAND, OHIO

STEVEN F. HARWIN, MD
CHIEF
ADULT RECONSTRUCTION AND TOTAL JOINT REPLACEMENT
DEPARTMENT OF ORTHOPAEDIC SURGERY
BETH ISRAEL MEDICAL CENTER
NEW YORK, NEW YORK

MICHAEL A. MONT, MD
CHAIRMAN
DEPARTMENT OF ORTHOPAEDIC SURGERY
CLEVELAND CLINIC
CLEVELAND, OHIO

ABSTRACT

Introduction: Patients may experience knee stiffness following total knee arthroplasty (TKA). Non-operative measures, such as more physical therapy and special splints are warranted in such cases. In the event of failure of these measures to restore knee range of motion, more invasive procedures with higher risks, such as manipulation under anesthesia (MUA) or repeat surgery, can be utilized. Thus, it becomes essential to optimize their non-operative measures in order to avoid more invasive, riskier options. Therefore, the
Knee stiffness is a relatively frequent complication after total knee arthroplasty (TKA) and has been reported in up to 25% in some series. It can impair one’s ability to perform activities of daily living, such as going up and down stairs as well as standing up from the seated position. In addition, range of motion (ROM) in post-TKA patients is one of the most important factors for quality of life and satisfaction following TKA. 

Physical therapy after TKA plays a major role in helping patients achieve optimal range of motion. Typically, if physical therapy fails to improve ROM (to > 90 degrees flexion or < 15 degrees extension) beyond the six to eight week period postoperatively, a manipulation under anesthesia (MUA) may be considered as an option. Manipulation under anesthesia can improve knee stiffness and maintain range of motion for up to one year in patients who experience knee flexion deficit following TKA. However, complications following MUA include hemarthrosis, supracondylar fracture, patellar or quadriceps tendon avulsion, component loosening, and possible increased risk for revision. In addition, if an MUA fails, it may subject the patient to a repeat MUA or a revision surgery. Therefore, it becomes essential to optimize conservative measures in order to avoid riskier options. 

The goal of outpatient physical therapy following a TKA is to return the patient to functional, everyday activity. Typically, the outpatient regimen begins within six weeks of the surgical date of a TKA. The standard of care uses exercise modalities including biking and climbing stairs in combination with manual therapy protocols. The innovative multimodal physical therapy (IMMPT) approach at our facility uses these approaches while incorporating newer modalities to improve range of motion (bracing and Astym® therapy, Performance Dynamics, Inc. Muncie, Indiana) and muscle strength (NMES and bracing).

There is a paucity of literature describing the effects of rehab modalities on rates of MUA following primary TKA. Therefore, we conducted a
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Table I
Demographic characteristics

<table>
<thead>
<tr>
<th></th>
<th>IMMPT</th>
<th>Standard</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>47</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Age (SD)</td>
<td>69 (50 to 88)</td>
<td>67 (42 to 85)</td>
<td>0.248</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Men(%)</td>
<td>13 (28)</td>
<td>28 (35)</td>
<td>0.393</td>
</tr>
<tr>
<td>- Women(%)</td>
<td>34 (72)</td>
<td>52 (65)</td>
<td></td>
</tr>
<tr>
<td>BMI (SD)</td>
<td>26 (20 to 30)</td>
<td>27 (18 to 30)</td>
<td>0.112</td>
</tr>
</tbody>
</table>

Table II
Study flow table

<table>
<thead>
<tr>
<th>Total Cohort</th>
<th>127 subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outpatient physical therapy groups</td>
<td>IMMPT</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
</tr>
<tr>
<td>Number of follow up ROM</td>
<td>43</td>
</tr>
<tr>
<td>Lost to follow up</td>
<td>4</td>
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</tbody>
</table>

Table III
Rate of manipulation under anesthesia and range-of-motion measurements

<table>
<thead>
<tr>
<th></th>
<th>IMMPT</th>
<th>Standard</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>47</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>MUA(%)</td>
<td>1 (2)</td>
<td>10 (13)</td>
<td>0.045</td>
</tr>
<tr>
<td>Optimal ROM (%)</td>
<td>35 (81)</td>
<td>63 (82)</td>
<td>0.9</td>
</tr>
<tr>
<td>Flexion (Mean/SD)</td>
<td>115 (90 to 130)</td>
<td>115 (90 to 140)</td>
<td>0.7</td>
</tr>
<tr>
<td>Extension (Mean/SD)</td>
<td>0.81 (0 to 10)</td>
<td>0.83 (0 to 20)</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Materials and Methods

Patients and database variables

We performed a review of consecutive patients who underwent TKA performed by three fellowship-trained adult reconstructive surgeons over a two-year period from January 2013 to December 2014. We collected a total of 453 TKAs during that time. Only patients who were non-obese (BMI < 30 kg/m²) and did not undergo a revision TKA (primary TKAs only) were included in this study. This yielded 127 patients. This cohort had a mean of 67 years (range, 42 to 88 years). These patients were stratified into two separate cohorts, depending on the type of physical therapy they received after their surgery. The two cohorts were: the IMMPT cohort, who all received their therapy at our institution (N = 47), and the standard therapy cohort, who received their physical therapy at outside facilities (N = 80). There were no significant differences in demographic characteristics of the cohorts (Table I).

We were able to collect ROM data on 120 knees (IMMPT = 43, standard = 77). Range of motion was considered “optimal ROM” if flexion was greater than or equal to 110 degrees and extension was less than or equal to 5 degrees. The mean follow-up time was 12 months (standard deviation, 6 months). Table II demonstrates the study flow diagram.

A manipulation under anesthesia was suggested for patients who failed to reach flexion of at least 90 degrees or 15 degrees of extension by the first post-op visit at six weeks. During the course of the study, there were 11 MUs which occurred within three months (Table III).

Standard-of-care physical therapy protocol

A typical postoperative course following a primary total knee replacement is broken into either three or four different phases, but the time guidelines are as follows: 1) Acute inpatient physical therapy typically between one to three days; 2) one to six weeks of outpatient physical therapy focusing on increasing quadriceps strength, passive ROM, and ambulation without assistive devices; and 3) Four to eight weeks returning to typical everyday functionality.10 Some of the modalities used include stationary bikes, climbing stairs, standing isometric ROM exercises, balance training, and sit to stand exercises.12 In addition to these modalities, manual therapy protocols are also included. Typically, standard therapy consists of activating quadriceps during passive knee extension, active dorsiflexion during knee extension, and hamstring activation with knee flexion mobilization. During both extension and flexion, the patient’s patella should be mobilized. If the patients hip ROM becomes tight or limited, then hip abductor stretching is used (Appendix 1).

IMMPT physical therapy protocol

This protocol was originally developed because of inconsistencies in the success of commonly utilized rehabilitation
modalities. The initial part of the IMMPT regimen utilized neuromuscular electrical stimulation, bracing with customized knee devices and joint active systems, in 30 minute sessions of one-on-one time with a physical therapist. This approach has been previously proven to be successful in treatment of functional problems (flexion contractions, quadriceps weakness, and flexion deficit) following total knee arthroplasty. In the event patients did not receive satisfactory results from the initial treatment, they received application of Astym therapy, a relatively new, non-invasive, therapeutic approach that addresses soft tissue dysfunction by relying, in part, on the use of cellular mediators and growth factors to assist in resorbing scar tissue, stimulating tissue turnover, and regenerating soft tissues. Clinical studies demonstrate the effectiveness of Astym therapy in the treatment of various soft tissue dysfunctions. Astym therapy has shown noteworthy results in patients suffering from persistent knee stiffness following TKA. In a large study of patients who had failed other interventions for persistent knee stiffness, patients who underwent Astym therapy reported significant mean improvements in both Knee Society objective (80 vs. 57 points; \( p < 0.0001 \)) and functional scores (80 vs. 54 points; \( p = 0.0003 \)). The treatment can be generally categorized into 1) range of motion and 2) muscle strength enhancement strategies.

### Range of motion strategies

The three unique modalities used for range of motion in the IMMPT protocol (Table IV) were Astym therapy, customized knee device braces, and joint active system braces. Astym therapy utilizes handheld instrumentation, applied topically, to locate underlying dysfunctional soft tissue and then transfer particular pressures and shear forces to the dysfunctional tissue through specific protocols and patterns developed from scientific and clinical study. The Astym instrumentation is designed to assess the presence of dysfunctional tissue by amplifying the tactile sensation of the underlying texture of the soft tissues in order to provide the treating clinician with indications where rough or improperly organized tissue is located. Once an area of potential dysfunctional tissue is located, the clinician applies appropriate pressures and shear forces to that tissue to initiate a reparative cellular response in dysfunctional tissue. Astym therapy was used to treat the medial and lateral patellar retinaculum, the patellar tendon, the proximal rectus femoris muscle insertion, the hamstring muscles, the gastrocnemius-soleus muscle complex, the distal ilio-tibial band, the quadriceps muscle—including the quadriceps tendon—and the achilles tendon.

<table>
<thead>
<tr>
<th>Clinical Problem</th>
<th>Modality</th>
<th>Timing</th>
<th>Duration and use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Quadriceps lag &gt;15 degrees in straight leg raise, at intake for outpatient PT</td>
<td>NMES treatment in clinic</td>
<td>Day one of PT</td>
<td>Until quad lag less than 5 degrees in SLR, 20 minutes every time in PT</td>
</tr>
<tr>
<td>2) Quadriceps Lag &gt; 15 and poor quad activation in quad setting</td>
<td>Home NMES unit</td>
<td>Day One of PT</td>
<td>Until quad lag less than 5 degrees in SLR, 20 minutes BID daily</td>
</tr>
<tr>
<td>3) Quadriceps lag and difficulty, in walking and stairs</td>
<td>OCSI Sport brace, extension assist orthosis</td>
<td>4 to 6 weeks of PT</td>
<td>up to 3 months or until safely ambulating and able to go up and down one flight daily use for minimum 3 hours per day when up and about</td>
</tr>
<tr>
<td>4) Knee flexion contracture &gt;15 degrees</td>
<td>CKD fitting, customized knee device</td>
<td>2 to 3 weeks of PT</td>
<td>Until knee flexion contracture less than 5 degrees. thirty minutes 2 to 3 times daily</td>
</tr>
<tr>
<td>5) Knee flexion ROM less than 90 degrees</td>
<td>Astym therapy</td>
<td>4 weeks from initiation of PT</td>
<td>8 to 12 session from start date or until AROM greater than 120 degrees</td>
</tr>
<tr>
<td>6) Knee flexion ROM less than 90 degrees</td>
<td>Joint active system knee flexion device</td>
<td>Less than 90 degrees of after</td>
<td>AROM greater than 120 degrees</td>
</tr>
</tbody>
</table>
patients were taught the correct use of the devices and used them for 30 minutes, three times a day.

**Muscle strength enhancement strategies**

Four unique modalities were used for muscle strength enhancement as part of the IMMPT (Table IV), and those were SAFTE (slide and flex and tighten and extend) exercises, neuro-muscular electrical stimulation (NMES), OCSI bracing, and Astym® therapy. SAFTE exercises were generally performed in sets of 10 repetitions, three to four times a day, in the early post-surgical phase as outlined in a previous study. Patients who had quadriceps lag during a straight leg raise test or poor contraction in the long leg position received a NMES unit to be used at home for 20 minutes, two times a day. In the late recovery phase, we employed high flexion knee activities such as squats and kneeling to address quadriceps strength through the entire arc of flexion range of motion. In addition, an OCSI sports brace was used to improve quadriceps and hamstring strength in patients who continued to have difficulty with quadriceps activation (deficit in functional activities such as walking, stair climbing, etc.).

**Statistical analysis**

We performed chi-square and Student’s t-test as appropriate to compare demographics, MUA rate, and ROM as appropriate. A p-value of less than .05 was set to determine statistical significance. Data was entered into a Microsoft Excel® spreadsheet (Microsoft Corporation, Redmond, Washington) and analyzed using SPSS (IBM Corporation, Armonk, New York).

**RESULTS**

The proportion of those who had optimal ROM was similar between the two groups (81 vs. 82%, p = 0.9). The mean flexion ROM was not significantly different between the IMMPT and standard cohorts (115 vs. 115 degrees, p = 0.6). The mean extension ROM (degrees) was not significantly different between the IMMPT and standard cohorts (0.81 vs. 0.83 degrees, p = 0.9) (Table III). A single patient had a maximum flexion of 60 degrees with good extension to zero degrees. One patient had a maximum extension ROM of 20 degrees with a maximum flexion ROM of 110. Two patients had a maximum extension ROM of 15 degrees and flexion ROM of 80 and 100 degrees.

The IMMPT cohort had a significantly lower rate of MUA as compared to the standard cohort (2 vs. 13%, p = .045) (Table III). One patient in the IMMPT cohort and no patients in the IMMP cohort had a repeat MUA.

**DISCUSSION**

Knee stiffness can be a debilitating complication of TKA that may result in patient dissatisfaction and poor quality of life. Limited ROM can affect the patient’s ability to do everyday tasks such as walking upstairs, kneeling down, standing from a seated position, and walking for long distances. If an initial course of outpatient physical therapy fails to improve ROM after six weeks, an MUA is the primary surgical option considered. However, an MUA is not without risks, which include: failure to improve ROM, prosthetic loosening, need for revision surgery, and supracondylar fractures. The effects of Astym® therapy on knee stiffness can be an effective, yet safe modality to optimize ROM after primary TKA. Additionally, there is a possibility it may be as effective as MUA in ROM restoration.

There were some limitations to this study. There were patients who were lost to follow up for the final ROM measurement; however, the vast majority of patients’ final ROM was included and, therefore, is a reasonably accurate representation of ROM. The retrospective study design does not have the benefits of a prospective study. However, due to lack of research on this particular topic, our study can serve as an impetus for further research on developing the highest quality rehab protocol following a TKA.

Previous studies have analyzed the effect of aggressive physical therapy on functional outcomes following a total knee replacement. Moffet et al. performed a single blind randomized control trial of 77 patients who underwent a primary total knee replacement. They stratified their data into those patients who received intensive physical therapy (N=38) and those who received the standard-of-care for physical therapy (N=39) following a TKA. They found a significantly longer distance walked during the six-minute walk (392 vs. 360 meters, p=.029). There have also been other studies that compare the benefits of two different physical therapy protocols following a TKA. Kumar et al. conducted a prospective, randomized control study of 46 patients who had a TKA. The data was stratified into patients who received continuous passive motion machine protocol (N=46) and patients who underwent early active flexion of the knee (N=37). They found patients who underwent the early passive flexion protocol following their TKA had a significantly decreased stay in the hospital (p=.01) as well as a lower extension following the index surgery (5 vs. 8 degrees, p=.06).

Chughtai et al. performed a pilot study on 23 patients to evaluate the effects of Astym® therapy on knee stiffness. There was a significant improvement in total arc range of motion (103 vs. 57°, p < 0.001). There was also improvement in both Knee Society functional scores (80 vs. 54 points; p=0.0003) and objective scores (80 vs. 57 points; p < 0.0001) when compared to the pre-therapy objective and functional scores. Therefore, from the present study and the above mentioned study, there is evidence to suggest that Astym® therapy may improve ROM and decrease the rate of MUA in

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patients who have knee stiffness following primary total knee arthroplasty.

CONCLUSION

The present study analyzed the effect of the IMMPT regimen on the range of motion and rate of manipulation following primary total knee arthroplasty in non-obese patients. We found that the IMMPT physical therapy approach in this study provided a similar ROM result as the standard-of-care but was able to significantly decrease the rate of manipulation under anesthesia. Therefore, the present study demonstrates that patients who have knee stiffness following TKA may benefit from the additional modalities, such as Astym® therapy, in the IMMPT regimen described.  

AUTHORS’ DISCLOSURES

Mr. Bhave is a consultant for, or has received institutional or research support from, the following companies: Bonutti Technologies, Inc., DJ Orthopedics Inc., Guardian Inc., the Journal of Society of Indian Physiotherapists, Ongoing Care Solutions Inc., OrthoSensor, Inc., and the World Journal of Orthopedics.

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REFERENCES