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The Effect of a Rapid Rehabilitation Program on Patients Undergoing Unilateral Total Knee Arthroplasty

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BACKGROUND: Few studies have looked at longer term functional outcomes of rapid rehabilitation (physical therapy in the postanesthesia care unit on the day of surgery) for patients undergoing total knee arthroplasty.

PURPOSE: The purpose of this interdisciplinary study (physical therapy and nursing) was to assess the effect of a rapid rehabilitation program on inpatient length of stay (LOS) and functional recovery.

METHODS: Functional outcomes were measured by the Knee Injury Osteoarthritis Outcome Score presurgically and at 4 and 12 weeks postoperatively and by progression along a physical therapy rehabilitation pathway.

RESULTS: Experimental group LOS was significantly shorter than the control group ($p = .0261$). Multilevel regression modeling showed that KOOS and physical therapy clinical pathway score trajectories did not differ significantly between groups. Patients receiving rapid rehabilitation were 2.5 (95% CI [0.958, 6.53]) times more likely to have a positive physical therapy rehabilitation trajectory than patients in the control group.

CONCLUSION: Findings validated earlier study results in terms of LOS; however, further research is needed to assess the effect of rapid rehabilitation on longer term functional outcomes.

Introduction and Background

Total knee arthroplasty (TKA) is a high-volume, high-cost surgical procedure performed in many hospitals to relieve the pain of osteoarthritis. Over the past two decades, various clinical initiatives have been designed to streamline care delivery, improve outcomes, and reduce costs for patients undergoing total knee arthroplasty.

Quick return to function after a TKA or unicondylar knee arthroplasty (UKA) is a desirable outcome for patients, their family members, and their caregivers. Delayed recovery may prevent a timely return to work and normal activity and increase healthcare costs. Following TKA or UKA, rapid rehabilitation (RR) or the initiation of the first physical therapy (PT) visit in the postanesthesia care unit (PACU) on the day of surgery has been shown to decrease the hospital length of stay (LOS) (Isaac et al., 2005; Larsen, Hvass, Hansen, Thomsen, & Soballe, 2008). More empirical data are needed to confidently confirm the value of RR. To this end, this study was designed to assess the effect of an RR program on inpatient LOS, inpatient PT clinical pathway progress, and functional recovery for patients undergoing a unilateral TKA in an urban orthopaedic specialty hospital.

Rapid rehabilitation, the independent variable, is defined as PT in the PACU on the day of surgery (designated as postoperative day [POD] 0). This PT visit consists of treatments related to bed mobility (rolling to either side, scooting up and down, moving from supine to sitting), with the appropriate amount of assistance (maximum, moderate, minimum supervision assist), transferring (sit to stand, stand to sit) with the appropriate amount of assistance (maximum, moderate, minimum supervision assist) with the principal goal of ambulation of 10 feet with appropriate amount of assistance (maximum, moderate, minimum, supervision assist) with a rolling walker. Non-RR patients are not ambulated in the PACU and do not begin PT until POD 1, where they share the same goals on that day as the RR patients. These goals are bed mobility with the appropriate amount of assistance (maximum, moderate, minimum, supervision assist), transferring (with moderate or minimal assist), and ambulation of 40–80 feet with moderate assist with a rolling walker. The dependent variables were (1) inpatient LOS in days, (2) inpatient

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progress along the clinical pathway established for postsurgical PT, and (3) outpatient functional recovery based on the Knee Injury and Osteoarthritis Outcome Score (KOOS) survey at 4 and 12 weeks postsurgery.

The study was an interdisciplinary effort by PT and nursing personnel. Nurses were involved in clearing candidates for RR and a nurse researcher was available as a resource. Physical therapists were interested in examining the outcomes of this relatively new program. A physical therapist administrator contacted the nursing research coordinator, which led to the interdisciplinary collaboration to design and implement the study.

Review of the Literature

Studies have consistently demonstrated a reduction in LOS for TKA and UKA patients undergoing RR (Ibrahim, Alaazzawi, Nizam, & Haddad, 2013; Isaac et al., 2005; Larsen et al., 2008; van den Beelt, van Essen, Heesterbeek, & Defoort, 2015). All of these studies referred to RR as a mobilization intervention by physical therapists on the day of surgery POD 0. Only Isaac and colleagues (2005) specifically described their intervention as mobilization with the use of a walker frame and straight leg raises performed 4 hours postoperatively. Ibrahim et al. (2013) conducted an evidence-based review, describing several studies in which the implementation of PT on the day of surgery was compared to PT beginning on POD 1. Specific PT protocols were not described in the review.

There has been minimal evidence of longer term effects on return to functionality. In a study comparing a group of postoperative TKA patients receiving accelerated rehabilitation with those who did not, there were no adverse effects during the hospital stay for either group, while the LOS declined from 6.6 days in the control group to 3.6 days in the RR group. A small subset of the RR group was followed postdischarge and at 6 weeks showed a significant improvement in function as measured by the American Knee Society score and by the Oxford functional ratio score (the control group was not followed) (Isaac et al., 2005).

Few studies have compared groups postdischarge to determine the effect of an RR program on return of function. Larsen, Hansen, Thomsen, Christiansen, and Soballe (2009) followed two small patient groups: 17 knee arthroplasty patients who received RR and 14 who did not. Both groups completed health-related quality-of-life questionnaires at baseline and weekly through 12 weeks postoperation and then again at 39 and 52 weeks. There was no significant statistical or clinical difference found between groups; the authors ascribed the lack of a difference to an imbalance in the baseline quality-of-life scores between the two groups that placed the RR group at a disadvantage from the start.

Jorgenson and Kehlet (2013) performed a prospective multicenter study of 3,020 patients for LOS, readmission rate, and the feasibility of including elderly patients with comorbidities who may have used mobility aides preoperatively in an RR study. The study demonstrated that it is feasible to include elderly patients with comorbidities in RR programs, but that this may result in increased LOS in those older than 80 years. They also reiterated that RR programs do not increase the readmission rate, and do in fact decrease LOS (Jorgenson & Kehlet, 2013).

Renkawitz et al. (2010) compared two accelerated multimodal clinical pathways, standard and optimized, to see if it was feasible for patients to adhere to the more accelerated one. All 143 patients in both groups were able to complete the pathways, with initial benefits in function for the RR pathway group on day 5, which evened out by day 8.

The majority of the literature has focused on the benefits of RR in regard to a decrease in LOS and

Table 1. Rapid Rehabilitation TKA Clinical Pathway Tracking Form

	Activity	POD 0 _____ Date		POD 1 _____ Date		POD 2 _____ Date		POD 3 _____ Date	
		Achieved	PT	Achieved	PT	Achieved	PT	Achieved	PT
TKA (AM)	Ambulation				40-80 ft Min A w/RW		>100 ft S w/AD		150 ft Ind w/AD
	Stairs						4 steps ↑↓ Min A		6 steps ↑↓ Ind
	Fctnl Goals Achieved			/3		/4		/4	
	PROM(flexion)								
TKA (PM)	Bed Mobility		Max/Mod A		Mod/Min A		CGA/S		Ind
	Transfers		Max/Mod A		Mod/Min A		CGA/S		Ind
	Ambulation		10 ft Mod A w/RW		40-80 ft Min A w/RW		>100 ft S w/AD		150 ft Ind w/AD
	Stairs						4 steps ↑↓ Min A		6 steps ↑↓ Ind
	Fctnl Goals Achieved	/3		/3		/4		/4	
	PROM(flexion)								

Note. A = Assist; AD = Appropriate Assistive Device; CGA = Contact Guard Assist; Ind = Independent; RW = Rolling Walker; S = Supervision.

cost-effectiveness; however, there continues to be a lack of literature on the achievement of PT clinical pathway goals and patient functional outcomes postdischarge.

Purpose and Hypotheses

The purpose of this study was to assess the effect of an RR program on inpatient LOS, inpatient PT clinical pathway progress, and functional recovery for patients undergoing a unilateral TKA in an urban orthopaedic specialty hospital.

The hypotheses for this study were as follows: (1) subjects participating in an RR program will have a decreased inpatient LOS as compared with those not participating in an RR program and (2) subjects participating in an RR program will demonstrate better functional outcomes on the inpatient PT clinical pathway during hospitalization and on the KOOS at 4 weeks and at 12 weeks postoperatively, compared with those not participating in an RR program. Other variables considered were age, gender, body mass index (BMI), comorbidities, day of week of surgery, and type of surgery. These were to be evaluated for any differences between groups and potential impact on the outcome variables.

Methods

Setting

The setting was a 190-bed urban orthopaedic teaching hospital that is part of a major academic medical center. Specialties include orthopaedic surgery, rheumatology, rehabilitation, and neurology.

Measures

Length of stay was measured in days and was obtained from the electronic medical record. For study eligibility, the surgery had to occur on the day of admission.

The KOOS is a subject-completed 5-point Likert-type scale consisting of 42 self-report items designed to measure patients' opinions about their knee pain, administered preoperatively and at 4 and 12 weeks, postoperatively. The four domains addressed in the KOOS are symptoms, pain, performance of activities of daily living, and quality of life relevant to knee function. The scale items, now translated into more than 30 languages, were created on the basis of literature and expert panel review and pilot testing. The scale yielded high test-retest reliability after a 9-day interval with a range of correlations between .75 and .93 for the individual domains. Convergent validity was evaluated by correlating KOOS scores with related subscales of the SF-36 physical function questionnaire, yielding correlation coefficients ranging between .46 and .57 (p values not published). Predictive validity was tested by repeated administrations of the tool preoperatively and at 3 and 6 months following knee surgery, with high effect sizes indicating responsiveness of the scale (Peer & Lane, 2013; Roos, Roos, Lohmander, Ekdahl, & Beynonn, 1998).

The Physical Therapy Clinical Pathway (see Table 1) consisted of treatment sessions, each with a set of goals for the initial postoperative course. A score of 1 was assigned to each goal. Quantitative assessment of pathway success was then based on the actual goals achieved versus the expected goals for each session. Each postoperative day had a potential pathway score associated with it: goals observed versus goals expected, expressed as a fraction. If a subject achieved all goals, the ratio of observed to expected goals would equal 1. Daily goals included progressions from POD 0 to POD 3 in bed mobility and transfers (from maximum assist to independent), ambulation (from 10 feet moderate assist with a rolling walker to 150 feet with an assistive device), and beginning on POD 2, stairs (four steps up and down with minimal assist to six steps up and down independently on POD 3).

Subjects

The convenience sample used for this study was composed of patients between the ages of 18 and 80 years who were undergoing total or unicondylar knee arthroplasty and having a principal diagnosis of osteoarthritis of the lower leg. Subjects were excluded if they were not fluent in English, did not have surgery on the day of admission, were unable or unwilling to initiate the inpatient PT clinical pathway, or were discharged to a location other than home. In addition, if a hospital readmission or an outpatient procedure related to the affected knee occurred within 30 days of discharge, the case was excluded. A power analysis was done to estimate the sample size needed to show a 25% decline in KOOS scores at 4 weeks and at 12 weeks between the experimental and control groups. The recommended sample size for α of .05 and 80% power was 60 for each group. The initial plan was to enroll 75 in each group to compensate for some expected attrition during the 12-week study. The sample of patients undergoing TKA or UKA at the hospital was obtained from April 2011 through September 2012. Human subjects' protection approval was obtained through the institutional review board of the Medical Center.

Recruitment

Potential participants were approached by nurses during their preadmission testing appointments and informed consent was obtained. At the time of the study, RR was being phased in as the default protocol for all TKA and UKA patients unless the physician deemed the patient a poor candidate. Based on the time of day of surgery, participants fell into two naturally occurring groups. During the study period, because of lower numbers of PT staff in the evening, it was often not possible for therapists to visit the PACU to provide RR for patients whose surgeries took place later in the day. In order not to deprive subjects of RR treatment solely for the sake of the study, the experimental group was composed of patients whose surgery occurred early in the day, in time to receive RR PT in the PACU on the day of surgery. The control group was made up of patients whose surgeries were scheduled later in the day, when physical therapists were not available to visit the PACU. These patients began PT on POD 1 based on the PT clinical pathway for that day.

As a standard of care, any patient receiving RR was first screened for eligibility by the nurse practitioner, who assesses stability of vital signs, level of pain control, and the ability to have the head of the bed elevated and legs dangled. All consented patients received standard nursing and PT care while in the hospital.

Participants were asked to complete a baseline KOOS questionnaire during the preadmission testing visit and were given two additional KOOS surveys with stamped return envelopes for the 4- and 12-week responses. Subjects were also given the option to supply their e-mail addresses for later completion of an online version of the KOOS survey.

Data Collection

There were three areas of focus for inpatient data collection: (1) factors related to the surgical experience, collected by PACU nurses; (2) factors related to pain management, collected by the pain management team of nurses and nurse practitioners; and (3) factors related to compliance with the PT clinical pathway, collected by physical therapists. Data forms for each clinical area were completed on the basis of the medical record for each consenting participant following discharge to home. PACU nurses collected data related to the presence of comorbidities, postoperative complications, the need for transfusion, the American Society of Anesthesiologists (ASA) classification and the type of anesthesia used. The pain management nurses categorized the pain protocol used for the patient following surgery: epidural patient-controlled analgesia (PCA), intravenous PCA (IVPCA), perineural infusion (PNI) with other drugs, or oral analgesics only. Details about discontinuance of the pain management protocols were also collected. Patient data about compliance with the PT protocol were detailed. Each day from POD 0 until POD 3 or discharge day, whichever came first, physical therapists recorded the functional goals achieved in each session.

At the two postsurgical time intervals, attempts were made to communicate with the patients by telephone to ascertain their progress and remind them to complete and return the KOOS forms that they had been given preoperatively. If they could not locate the survey, or if they preferred, the KOOS was then administered over the phone.

Data Analysis

Descriptive statistics were used to summarize demographics, PACU, PT, and pain management data. Student's *t* tests were used to compare LOS between groups. To accommodate hierarchical or naturally nested data, typical in patient care settings, multilevel modeling (MLM) was used (Gelman & Hill, 2006). Multilevel modeling is a type of regression that allows for inclusion of predictors at different levels in the model such as at treatment and patient levels (Raudenbush & Bryk, 2002). Patient KOOS functional outcomes and PT rehabilitation trajectories, or courses, can be analyzed as a type of hierarchical model where patient times of observations are nested within each patient, and patients can be nested within different types of rehabilitation treatments they receive. The trajectories vary within the individual as a function of time (Level 1) while interpatient differences can be a function of treatment protocols such as RR (Level 2).

Intrapatient Level

Patients begin their postoperative trajectories at different levels of functioning, also known as intercepts, and the variance in the patterns of patient rehabilitative functioning is captured in the MLM model as slopes. Growth modeling of an individual's trajectory is a type of MLM also known as hierarchical model or mixed-effect model and random coefficient model (Eckardt, 2012; Raudenbush & Bryk, 2002). The robustness of the MLM model of patient rehabilitative data is that it allows the researcher to identify and analyze different patient phenotypes based on these varying intercepts and slopes, and more importantly, to plan interventions that are patient-centered. The patients' repeated functional outcome and rehabilitation measures over time provided the intrapatient data points for phenotyping of subpopulations of patients according to their rehabilitative course.

Interpatient Level

Samuels and Eckardt (2013) used growth curve modeling to demonstrate that postoperative pain can be described in terms of its trajectory, or pain resolution over time, with pain reassessment as the predictor of pain resolution. Those researchers extracted data from postsurgical patients' ratings of pain, while controlling for nurse reassessment of patients after pain control interventions. Patients were grouped according to frequency of pain reassessment. From those data points, researchers constructed a line representing the pain trajectory, and identified an intercept, or the initial measure of pain, and a slope, or the degree of pain resolution for each patient. Researchers also compared average intercepts and slopes for pain measures between groups. A similar approach is being used for this analysis of two outcome variables of interest: the KOOS scores as a measure of functional outcome scores, and PT clinical pathway scores that specifically measure physical mobility milestones achieved. For the primary variable of interest in this study, postoperative rehabilitative functioning, longitudinal KOOS scores from three time points were analyzed: preoperative, postoperative week 4, and postoperative week 12. For the secondary variable of PT clinical pathway goal attainment, this study examined patient trajectories of physical rehabilitation after knee surgery over a postoperative period of 4 days. Within-patient rehabilitative functioning was examined as a function of time using both variables of interest. Between-patient groups, differences in intercepts of average rehabilitative functioning, and differences of average rehabilitative trajectories over postoperative period were also examined.

Results

Data were analyzed in SPSS 20 and STATA 11. Initial descriptive statistics of patient sample groups were conducted. After initial exploration in differences between

groups on demographics and LOS, difference in rehabilitative functioning between the two groups was estimated controlling for initial postoperative functioning with a postoperative time zero measure. An MLM was then developed examining intrapatient trajectories over time of postoperative rehabilitation and interpatient group postoperative rehabilitation trajectories. Patient intercepts of rehabilitation measures were included in the models of both within- and between-group analyses.

During the enrollment period, 188 patients consented to participate in the study and had surgery for knee replacement as planned. Of the 188 consenting subjects, 95 were not discharged home and were excluded from the study. The remaining 93 subjects, discharged home and initially followed in the study, represented an enrollment rate into the study of 49.5%. There were 18 further exclusions for subjects who did not meet the inclusion criteria, leaving 75 participants, with 45 in the control group and 30 in the experimental group (those who received RR).

Despite an initial decision to exclude morbidly obese subjects with a BMI greater than 35, it was found that 35% of the control group and 33% of the experimental group fell into that category. Rather than reduce the two groups further, they were analyzed as subgroups based on BMI. A comparison of the averages for age, LOS, and BMI in the two groups and their subgroups is shown in Table 2.

An independent-sample *t* test was conducted to compare the average LOS (ALOS) in the control and experimental groups. There was a significant difference in ALOS for the control group ($M = 3.6$, $SD = 1.05$) and the experimental group ($M = 3.1$, $SD = 0.63$); $t(73) = 2.27$, $p < .05$. Similarly, an independent-sample *t* test was conducted to compare the average age in the control and experimental groups. There was a significant difference in age for the control group ($M = 61.7$, $SD = 8.0$) and the experimental group ($M = 58.1$, $SD = 6.6$); $t(73) = 2.04$, $p < .05$. The difference in average BMI between the control group ($M = 32.4$, $SD = 7.0$) and the experimental group ($M = 32.9$, $SD = 7.0$) was not found to be significantly significant.

Each group was subdivided into those with BMI ≤ 35 and those with BMI > 35. For the two subgroups with BMI > 35, an independent-sample *t* test was conducted to compare the ALOS in the control and experimental groups. There was a significant difference in ALOS for the control group ($M = 3.7$, $SD = 0.9$) and the experimental group ($M = 2.9$, $SD = 0.9$); $t(24) = 2.21$, $p < .5$. Similarly, an independent-sample *t* test was conducted to compare the average age in the control and experimental groups. There was a significant difference in age for the control group ($M = 61.6$, $SD = 5.0$) and the experimental group ($M = 56.5$, $SD = 6.2$); $t(24) = 2.31$, $p < .05$.

For the two subgroups with BMI ≤ 35, the difference in ALOS between the control group ($M = 3.6$, $SD = 1.2$) and the experimental group ($M = 3.3$, $SD = 0.4$) was not statistically significant. Also the difference in average age between the control group ($M = 61.8$, $SD = 9.3$) and the experimental group ($M = 59.0$, $SD = 5.9$) was not statistically significant.

Data regarding the ASA status classification were collected to compare general physical health between groups. ASA 1 indicates that the patient is a completely healthy fit patient, a rating of ASA 2 classifies the patient as having mild systemic disease, and a patient designated as ASA 3 has severe systemic disease that is not incapacitating. In the control group, 67% were classified as ASA 1 or 2 and 33% as ASA 3. In the experimental group, 83% were classified as ASA 1 or 2 and 17% as ASA 3. Fisher's exact test was conducted to compare the difference in ASA frequencies between the control and experimental groups and it revealed that the difference was not statistically significant (two-tailed $p > .05$). No patients were classified as ASA 4-5. The types of anesthesia used varied among the patients. In the control group, the majority (52%) received combined spinal and epidural anesthesia, 24% received spinal anesthesia, and the remaining 24% were divided about equally between general anesthesia or nerve block. In the experimental group, the most common type was combined spinal and epidural anesthesia (41%); 33% received spinal anesthesia, and the remaining 26% divided between general anesthesia or nerve block.

In the PACU, immediately postoperation, the nurses recorded very few adverse reactions (only six patients with nausea). In review of the patients' records after discharge, there were no reported postoperative complications of pneumonia, cardiac abnormalities, or infection. No patient required blood transfusion. The process for retrospective chart review also identified specific comorbidities with the potential to affect postoperative recovery. These included hypertension (47%), diabetes (19%), obesity (16%), respiratory disease (12%), sleep apnea (7%), cardiovascular disease (5%), and a category called "Other" with conditions sometimes specified and sometimes not. Also tracked were patients with an LOS >4 days and whether there was a medical hold placed by the surgeon. Of the seven patients with LOS > 4 days,

Table 2. Control Group Versus Experimental Group: Length of Stay (LOS), Age, and BMI

	Control (No RR on POD 0)			Experimental (With RR on POD 0)		
Metric	BMI ≤ 35	BMI > 35	All BMI	BMI ≤ 35	BMI > 35	All BMI
Case count	29	16	45	20	10	30
LOS: Average	3.6	3.7	3.6	3.3	2.9	3.1
Age: Average	61.8	61.6	61.7	59.0	56.5	58.1
BMI: Average	28.2	40.0	32.4	29.7	41.7	32.9
% Males	24	25	24	40	30	37

Note. BMI = body mass index; RR = rapid rehabilitation.

six were on medical hold affecting their discharge; no other data were immediately available.

Nurse practitioners and nurses on the pain management team followed the subjects enrolled in the study and recorded the type of pain protocol selected for each patient. Protocol 1, prescribed for 45% of patients, included Epidural Patient-Controlled Analgesia (EPCA) on POD 0, sometimes combined with oral analgesics, and on POD 1, discontinuation of the EPCA and a conversion to oral analgesics. Forty-two percent of patients were placed on Protocol 2, which included IVPCA on POD 0, and on POD 1, discontinuation of the IVPCA, and a conversion to oral analgesics. Protocol 3 included PNI on POD 0, in combination with IVPCA or oral analgesics, and on POD 1, discontinuation of PNI and maintenance with oral analgesics was used on 12% of patients.

Follow-up of subjects postdischarge proved to be the most difficult aspect of the study. In addition to advising participants to complete their KOOS questionnaires, participants were asked whether they received PT at home, and if so for how many sessions. They were also queried about outpatient PT and if they had any postoperative complications. For the first 8 months of the study, graduate students in PT conducted the phone calls during the daytime hours once or twice a week. The timing proved to be in conflict with the lifestyle of the subjects: many of them had returned to work or were not otherwise available in the daytime. Later, in the course of the study, staff members conducted the calls later in the day and found more subjects available for conversation. Of the 45 control subjects, 20 were reached by telephone at intervals ranging from 17 days to 119 days following surgery. Of the 30 experimental subjects, 14 were reached by telephone at intervals ranging from 17 days to 111 days following surgery.

The study design called for interaction with the subjects to obtain the KOOS surveys: (1) preoperatively, usually at the time of education and consent, (2) at 4 weeks postoperatively, and (3) at 12 weeks postoperatively. The preadmission KOOS was obtained from 38 of 45 control subjects (84%) and from 24 of 30 experimental group subjects (80%). For the surveys due at 4 weeks postoperation, we accepted any surveys within 21–35 days postoperation as representative of the 4-week interval. Including all time intervals from surgery to survey date, the 4-week KOOS was obtained from 17 of 45 control subjects (38%) and from 13 of 30 RR subjects (43%). Similarly, for the surveys due at 12 weeks postoperatively, we planned to accept any surveys within 77–91 days after surgery as representative of the 12-week interval.

A comparison of final mean KOOS score using an independent-sample t test showed no significant difference between patients who received rapid rehabilitation intervention (M = 57.33; 95% CIs [29.32, 85.4]) and those who did not (M = 77.14; 95% CIs [68.54, 85.742]). When postoperative time 0 measure of KOOS scores were added as a covariate in the model, participation in RR did not have an estimated significant average main treatment effect on patients' rehabilitative functioning [$F(2, 58) = 3.25$, $p = .07$)].

The patients' individual-level KOOS trajectory data on average were not significantly different between groups. Patients' KOOS trajectories varied both within and between groups. The individual patient trajectories are represented by individual patient trend lines of KOOS scores (y-axis) moving across three time points (x-axis) (Figures 1 and 2). Patients with missing data, such as missing the second time point KOOS score, have only the two data points for their trajectory. Based on the observed patient rehabilitation trajectories, three types of patients were identified: patients with a positive slope, patients with a negative slope, and patients with a flat slope. A positive slope signifies increasing KOOS scores over the time intervals. To classify individual patient trajectories, we examined changes in KOOS scores over time—their individual trajectory slopes. A 50% confidence interval around each individual's slope was constructed, and if it included zero, patients were classified as having a flat slope. Of the remaining patients, those with KOOS scores that decreased over time were classified as having negative slope, and those that increased over time were classified as having a positive slope.

In the intervention (RR) group, none of the patients had a negative slope, 20% had a flat slope, and 80% had a positive slope. The control group had no patients with a negative slope; 18% with a flat slope; and 82% of patients with a positive KOOS score slope. Patients lacking more than one measure were excluded from the analysis, which reduced the sample to 38 participants (15 in the intervention group and 23 in the control group).

All patients were expected to participate in PT postoperatively to ensure a safe discharge and to begin the recovery process. The PT department designed a clinical pathway spanning POD 0 through POD 3 in which the goals for increased mobility were escalated each day. The patients who were able to participate in a PT session on POD 0 were in the experimental group, whereas those who did not have PT on POD 0 were in the control group. A key element in determining patient assignment to the experimental group was the timing of the surgery.

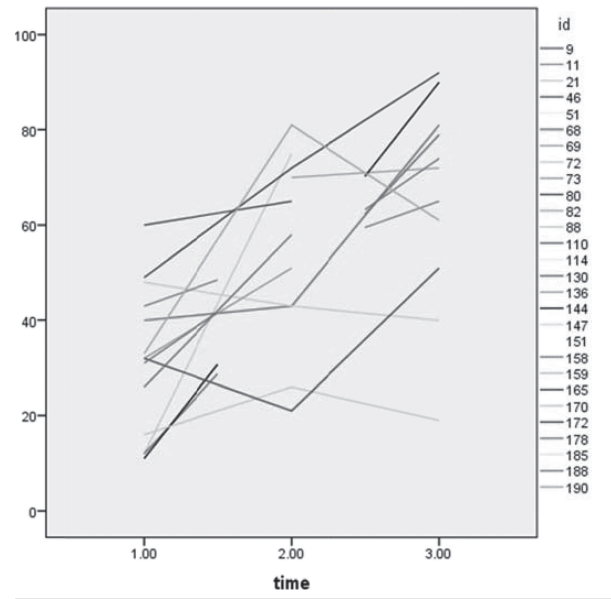

Figure 1. KOOS trajectories, RR group.

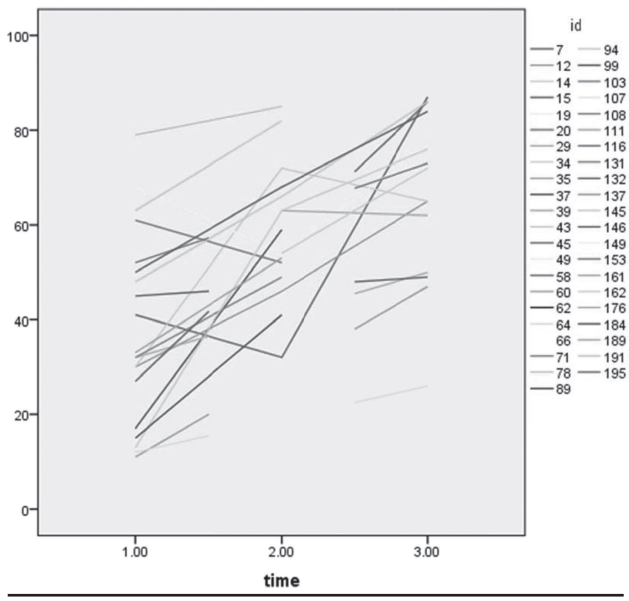

FIGURE 2. KOOS trajectories, control group.

Of the 75 subjects, 54 (74%) were identified as an "early case," and of these, 50 were medically cleared for RR. However, of the 50 subjects, only 30 (63%) actually received PT on POD 0. This was most likely due to availability of physical therapists to initiate the first rehabilitation session.

Physical therapy treatment sessions were evaluated in terms of actual goals achieved versus expected goals. The results found for the major control and experimental groups and their subgroups are shown in Table 3. A comparison of final PT goal achievement means between the groups estimated a greater improvement in patients who received rapid rehabilitation intervention ($M = 2.32$, $SD = 1.59$) than those who did not ($M = 1.69$, $SD = 1.72$). However, these results were not statistically significant, $t(62) = 1.50$, $p = .263$. To account for premeasure scores, postoperative time 0 measure of rehabilitation scores were added as a covariate in the model; still participation in RR did not have an estimated significant treatment effect on patients' rehabilitative functioning [$F(2, 58) = .59, p = .18$]. The patients' individual-level rehabilitation trajectory data were not significantly different between groups. However, the individual trajectories between patients within each group (Figures 3 and 4) demonstrate the large intragroup (and patient-level) variance in rehabilitative functioning scores across the rehabilitative period.

Patients' rehabilitation trajectories varied greatly both within and between groups (Figures 3 and 4). Positive slopes indicated increasing rehabilitation trajectory scores over time. These slopes were estimated with constructed 50% confidence intervals around slope estimate. In the intervention (RR) group, 16% of the patients had a negative slope, 17% had a flat slope, and 67% had a positive slope. In contrast, the control group had 27% of patients with a negative slope, 29% with a flat slope, and only 44% of patients with a positive rehabilitation slope. Patients with a positive rehabilitation slope were analyzed in contrast to patients with a negative or flat trajectory grouped together as failed rehabilitation scores by treatment group. Patients in the RR group were 2.5 (95% CI [0.958, 6.53]) times more likely to have a positive rehabilitation trajectory than patients in the non-RR group.

TABLE 3. GOALS OF THE PT PROTOCOL ACHIEVED BY SUBJECTS IN CONTROL AND EXPERIMENTAL GROUPS

Group	PT Goals: Ratio of Observed/Expected	Case Count
Control		
BMI ≤ 35	0.47	29
BMI > 35	0.43	16
All	0.46	45
Experimental		
BMI ≤ 35	0.54	20
BMI > 35	0.55	10
All	0.54	30
All subjects	0.49	75

Note. BMI = body mass index; PT = physical therapy.

Discussion

These data confirmed previous findings regarding a reduction in the ALOS for patients receiving RR. The reduction of 0.5 days in ALOS between the control group and the experimental group was statistically significant. The difference in average age between the control group and the experimental group was also statistically significant. However, BMI categorization appeared to influence these parameters, in contrast to some findings in the literature (Lozano et al., 2015). The control and experimental groups were each subdivided into those with BMI ≤ 35 and those with BMI > 35. In the subsets with BMI ≤ 35, there were no significant differences found in ALOS or average age between the control and experimental groups. However, in the subsets with BMI > 35, there were significant differences found between the control and experimental groups: ALOS was longer and average age was greater in the control group. It is not clear if age impacted ALOS in this study but RR intervention should be considered for those with BMI > 35. While goal attainment trajectories in PT appeared to be more positive for the experimental group, there was no appreciable difference in KOOS trajectories for those receiving RR as compared with the control group.

Limitations include a small sample size that increases the chance of Type II errors due to low power. Our final power obtained in the study was 0.31, which is insufficient to detect even a hypothesized large effect. Participants' KOOS responses varied from the projected 4- and 12-week intervals. In addition, to maximize responses, the follow-up KOOS surveys were administered to some of the participants by phone, yielding a slight difference in methodology between subjects. Use of a convenience sample from a single institution limits generalizability. More importantly, the assignment to treatment mechanism (participation in RR or not) was not done randomly. Time of surgery was the instrumental variable for assignment to treatment group. The two

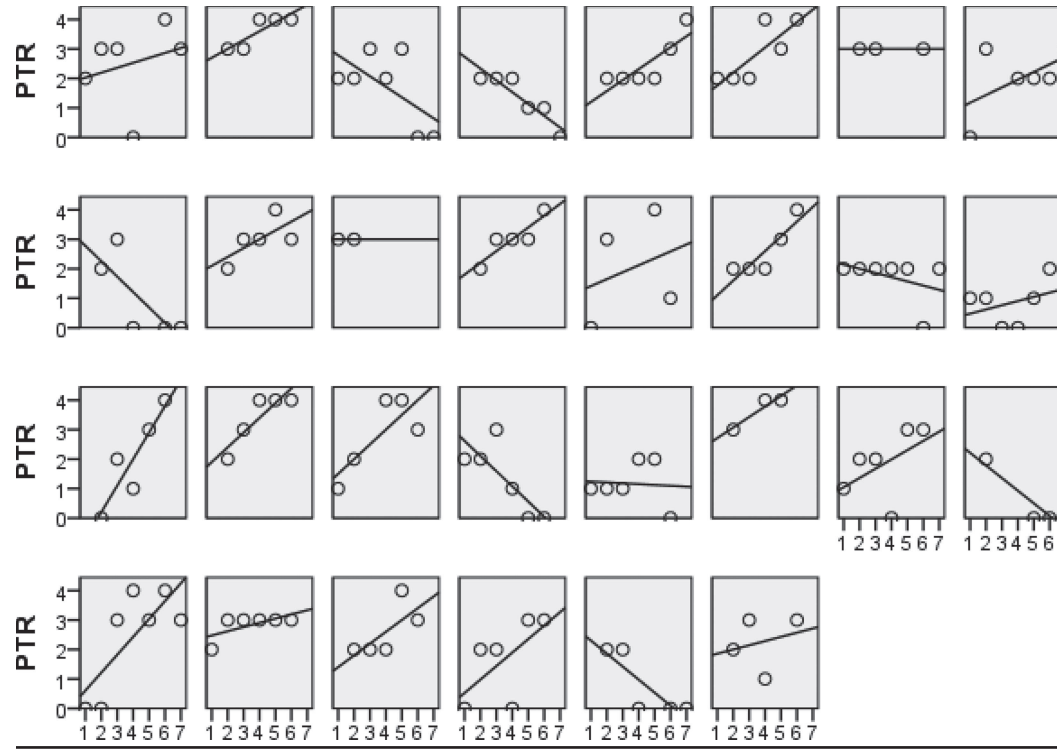

FIGURE 3. Physical therapy clinical pathway trajectories, RR group.

groups of participants did vary significantly on key demographic covariates. As this was a quasi-experimental design, the nonrandomness of assignment to treatment must be noted as it can limit causal inference.

Of note is the fact that in spite of a protocol endorsing RR for all eligible patients, only 63% of those cleared for RR received PT on POD 0. While not clearly specified, possible reasons were lack of available PT staff to

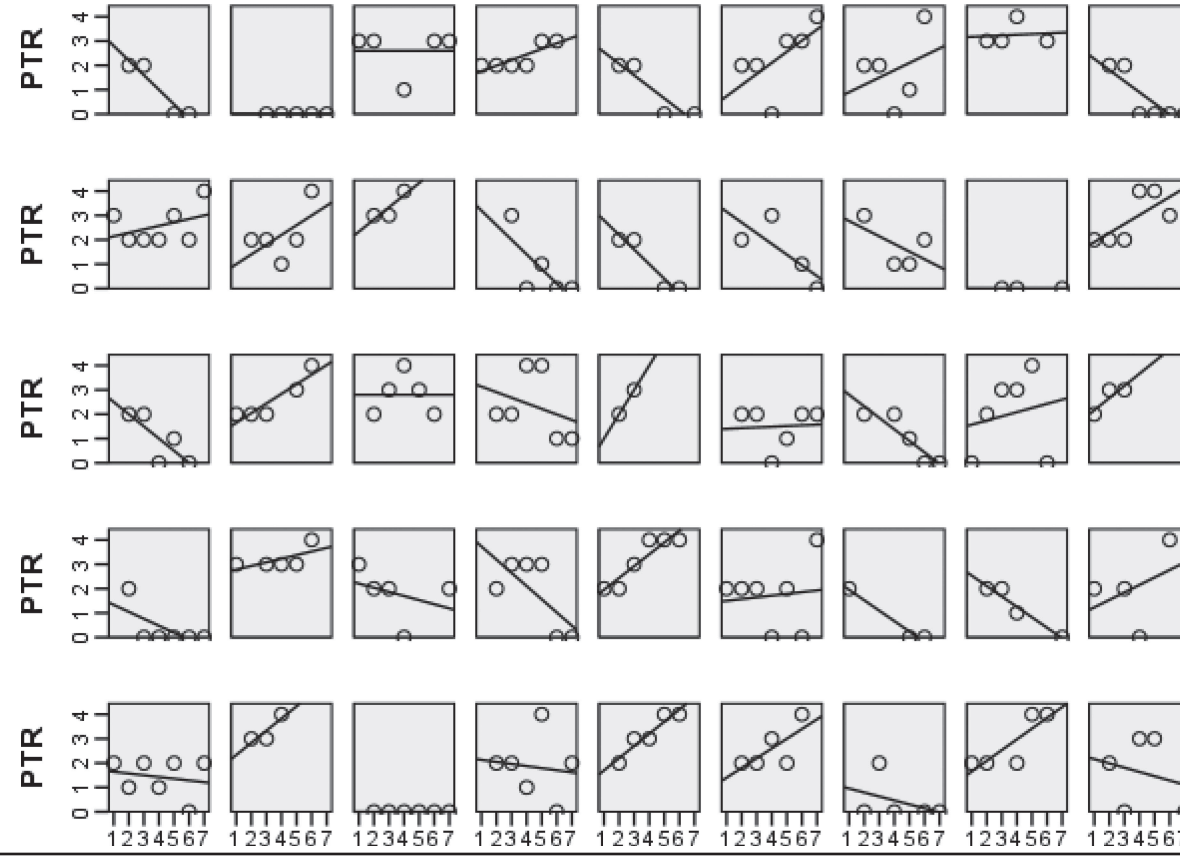

FIGURE 4. Physical therapy clinical pathways, control group.

perform late day or evening treatment sessions, duration of spinal or epidural anesthesia, unstable vital signs in the PACU, and pain management issues. Further investigation of these possible obstacles could reveal measures to increase the rate of RR implementation.

Timing of surgeries scheduled later in the day also poses a challenge to the implementation of RR for all TKA patients. Implementation of staffing enhancement for physical therapists over all shifts is a necessary and planned intervention to ensure greater availability of RR for all eligible patients.

Significantly fewer ($p < .01$) members of the control group were cleared for RR, which could have contributed to group differences at the outset. As with all longitudinal studies, missing data from experimental mortality is a threat to the validity of findings.

Although not statistically significant, there appeared to be differences in the ratio of PT goals expected to goals obtained between groups, with the RR group trending higher than the control group. Both groups were equivalent in terms of degree of flexion demonstrated by each subject. It is not clear why this ratio did not increase over time as expected in the PT postoperative protocol. This represents an area for further investigation.

The data from this study were consistent with previous research regarding the effect of RR on LOS. Further research is needed to assess variations in outcomes based on BMI and whether RR has an impact on longer term functional recovery.

Lessons Learned

A core team of nurses, physical therapists, and nursing and PT administrators conducted this study. Although physical therapists implemented the rehabilitation clinical pathway, nurses played a pivotal role in the process. They assessed patients for hemodynamic stability by performing vital signs, orthostatic blood pressure monitoring when indicated, checking laboratory results, and administering fluids. Nurses also evaluated patients for recovery from anesthesia using the Aldrete score and assessed and reassessed for pain after administering the appropriate pain medication. Once the patient was determined by the nurse to be stable, the licensed independent practitioner was informed that the patient was eligible for a PT visit.

The research team did not anticipate the duration of the study and the time commitment that would be needed to complete the project. Team members had to juggle the high priority demands of day-to-day patient care while attempting to meet the requirements of conducting a research study. For participating staff, there were points along the continuum of the study that weakened its overall success: the enrollment process in preadmission testing, managed by a busy group of nurses and with competition by other studies seeking willing patients; the logistics of identifying the discharge status of consenting subjects; and the difficulty in follow-up to obtain the KOOS surveys in the postdischarge period. Utilizing PT doctoral students to coordinate the data input and follow-up phone calls had its challenges because of their limited availability. The lack of consistency made it difficult to coordinate the work flow process. Keeping a large interdisciplinary team on task over the course of the 2-year study was also a challenge, despite regularly scheduled meetings, phone conferences, and e-mails.

Funding for a research coordinator would have facilitated efficient management of the longitudinal and day-to-day tasks that needed to be completed. This project needed weekly monitoring at a case level; however, all of those involved had full-time jobs preventing any one of them from taking on this responsibility.

Implications for Orthopaedic Nurses

This study supports previous findings that RR is associated with shorter LOS for patients undergoing unilateral TKA. Shorter lengths of stay translate to lower costs, higher patient satisfaction, and fewer hospitalization-related complications, although further investigation is needed to assess the effect of RR on longer term functional recovery.

In the face of this evidence, it is critical that the team of nurses and physical therapists maximizes the number of patients who can receive RR. Orthopaedic nurses need to be aware of the benefits of RR. This mindfulness needs to be at the forefront during the immediate postoperative period and RR should be incorporated into the patient's plan of care. Orthopaedic nurses monitored postsurgical patient status, helping identify and remedy any adverse conditions and monitor for any complications that would impair patient ability to begin RR and comply with the PT clinical pathway. Nurses and physical therapists assessed elements necessary for eligibility and readiness for patient participation including stable vitals, estimated blood loss, and muscle strength for both the operated lower extremity and the nonoperative lowery extremity. Muscle strength was assessed by a straight leg raise on the nonoperative side and testing the quadriceps with the patient sitting on the edge of the bed. These helped the clinicians assess patient stability, avoid orthostatic hypotension, and become aware of other signs of exercise intolerance. Delivery of optimal pain management by the orthopaedic nurses was also critical for enabling patients to participate in all of their PT sessions and achieve their goals (Walker, 2012).

The lack of available physical therapists later in the day clearly limited the numbers of patients who, even though judged stable by the nurses and eligible to participate in a PT session on POD 0, were able to receive RR. Efforts were made to change the hours of two physical therapists from the original 8 am to 4 pm scheduled time initially to 10 am to 6 pm and then later to 11 am to 7 pm. The original 8 am to 4 pm working hours allowed RR for 1–2 patients and the expanded hours captured approximately 6–8 patients. This allowed for most of the first operative cases and some of the second operative cases to receive their PT visit on POD 0. Further adjustment of physical therapist hours or increases in staff would be necessary to cover all eligible patients. Savings due to shorter lengths of stay for patients having RR should be documented and compared to costs of additional physical therapist coverage hours, thus justifying increased personnel costs.

A team approach between nurses and physical therapists can lead to enhanced communication, information exchange, and a seamless rehabilitation trajectory for patients undergoing unilateral TKA. Working together and knowing the benefits of implementing RR, the orthopaedic nurse and the physical therapist can maximize the positive outcomes for patients undergoing TKA.

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