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SYMPOSIUM: ADVANCED TECHNIQUES FOR REHABILITATION AFTER TOTAL HIP AND KNEE ARTHROPLASTY

Early Discharge and Recovery with Three Minimally Invasive Total Hip Arthroplasty Approaches

A Preliminary Study

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Abstract Purported advantages of THA performed with minimally invasive surgical approaches include less muscle damage and faster recovery. The purpose of this preliminary investigation was to determine if differences existed between minimally invasive approaches in hospital discharge and early functional recovery in THA patients with a rapid rehabilitation protocol. Twenty-four consecutive patients were randomized to one of three minimally invasive surgical approaches (two-incision, mini-posterior, and mini-anterolateral) and enrolled in an aggressive postoperative rehabilitation program. Hospital discharge, early functional milestone recovery, and validated outcome measures (SF-36, WOMAC, Harris hip score, lower extremity activity scale) were collected. All patients met hospital discharge criteria no later than the first postoperative day. There was no difference in hospital discharge, functional milestone recovery, or validated outcome measures during the first year after surgery with the numbers available. There were no complications directly related to early hospital discharge or the aggressive rehabilitation protocol. While the data suggest earlier hospital discharge and rapid rehabilitation protocols may be implemented successfully we found no difference between the three minimally invasive approaches in early hospital discharge or early functional recovery utilizing a rapid rehabilitation protocol.
Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Introduction

Recently, minimally invasive surgical (MIS) techniques in THA have been introduced and reportedly offer advantages over standard surgical approaches. These advantages include shorter hospital stays and more rapid rehabilitation and recovery ostensibly owing to less muscle and tendon damage [4, 7, 8, 11, 17, 18, 26, 28]. However, there is little evidence to demonstrate whether any of the various minimally invasive surgical approaches provides faster recovery and return to function after THA. Furthermore, it remains controversial whether rapid rehabilitation protocols are warranted and result in faster recovery after THA.

We designed this preliminary investigation to compare the early hospital discharge, functional milestone recovery, and standardized outcomes (SF-365, WOMAC, Harris hip score, activity score) with three different minimally invasive surgical approaches to THA (two-incision, mini-posterior, and mini-anterolateral) utilizing a rapid rehabilitation protocol.

Materials and Methods

Twenty-seven hips in 25 patients were prospectively randomized into one of three groups: two-incision MIS

approach, mini-posterior approach, and mini-anterolateral approach. Upon enrollment, randomization to one of three surgical approaches was performed by computer randomization. We offered enrollment for all patients meeting the following criteria: (1) a primary diagnosis of degenerative arthritis, rheumatoid arthritis, or osteonecrosis; (2) an age of greater than 18 years and less than 75 years; (3) a body mass index less than or equal to 30; (4) no previous hip surgery, implants, arthrodesis, or infection; and (5) no neurologic, musculoskeletal, or medical conditions that would adversely affect the ability to comply with early weightbearing and encouraged early functional recovery in the postoperative period. Two of the 25 patients were unable to comply with the postoperative rapid rehabilitation program due to severe bilateral hip pain, stiffness, and subsequent gait disturbance. One patient declined due to apprehension of the randomization process and the uncertainty associated with the investigational nature of the study, leaving 22 patients (24 hips) for evaluation. One patient in the anterolateral MIS group suffered an early postoperative infection and underwent irrigation and débridement with component retention at 3 weeks. That patient's hospital discharge data were included in the results; however, the outcome data after the subsequent surgical procedure were excluded from the analysis. Thus, 23 hips (eight two-incision MIS approach, eight mini-posterior approach, and seven mini-anterolateral approach) in 21 patients were left with preoperative, 6-week, 3-month, 6-month, and 1-year followup data for evaluation and comparison. The mean patient age was 54 years (range, 38–74 years) with an average body mass index of 26 (range, 21–30). No patients were lost to followup and the patients obtained followup at all of the stated intervals during the first year. The minimum followup was 12 months (mean, 13.6 months; range, 12–24 months). There was no difference between the three study groups with regard to age, height, weight, or body mass index (all demographic p values greater than 0.63). Institutional Review Board approval was obtained and all patients provided informed consent before enrollment.

To minimize confounding variables, the surgical implants, anesthesia, preoperative teaching, patient education and expectations, and rapid rehabilitation protocols were identical in every patient in all three study groups. All prosthetic implants consisted of a press-fit acetabular component (Trilogy®; Zimmer, Inc, Warsaw, IN) and a cementless fully porous-coated femoral component (VerSys® Beaded FullCoat; Zimmer). All acetabular components were supplemented with two screws and all modular acetabular liners were made of highly crosslinked polyethylene (Longevity®; Zimmer). A relatively constant acetabular-femoral head ratio was achieved, while maintaining a minimum 6-mm polyethylene thickness. Therefore, all hips with a Size 56 or greater acetabular component received a 32-mm-diameter head and all acetabular components Size 54 or smaller received a 28-mm femoral head.

The three MIS surgical approaches were carried out as commonly performed and described by other investigators [4–8, 12]. The mini-anterolateral approach is a modification of the Hardinge approach [15]. The performing surgeon received comprehensive training in all three surgical techniques in residency and in fellowship. In addition to comprehensive training by surgeon developers and investigators [7, 22] of the two-incision MIS approach in residency and fellowship, the surgeon completed the industry-required training for the procedure. Specialized MIS instruments that included lighted retractors and cutout acetabular reamers were used in all cases. A deep surgical drain was used in every case.

Every patient in all three groups was managed with an identical comprehensive multimodal anesthesia protocol. The protocol is based on the principle investigator's (RMM) prior experience with the two-incision MIS approach [7, 22] in combination with modifications initiated at our institution by our pain management anesthesia service. On the morning of surgery, preemptive analgesia and antiemetic medications were administered orally, along with a scopolamine patch. The preoperative medications included acetaminophen, oxycodone SR (OxyContin®; Purdue Pharma, Stamford, CT), celecoxib (Celebrex®; Pfizer, Inc, Princeton, NJ), famotidine (Pepcid®; Johnson & Johnson-Merck Consumer Pharmaceuticals Co, Fort Washington, PA), hydroxyzine (Atarax®; Pfizer), and ondansetron (Zofran®; GlaxoSmithKline, Inc, Research Triangle Park, NC). All patients received a single-shot spinal of long-acting anesthetic plus intrathecal preservative-free morphine in the preoperative holding area and a general anesthetic during surgery. Long-acting local anesthetic was injected into the superficial wound and deep tissues, superficial to the fascia, and a sterile dressing was applied to the wounds. In patients who were selected to undergo an MIS single-incision approach, long-acting local anesthesia and a phantom dressing were placed at the location where the anterior incision would have been had a two-incision approach been utilized. A dedicated pain management service managed the patients' postoperative analgesia and parenteral opioids were avoided. The patients were given scheduled doses of oxycodone SR every 12 hours for 72 hours and celecoxib for 5 days postoperatively. Short-acting oral narcotics were used for breakthrough pain.

To limit study bias in the assessment of speed of recovery and length of hospital stay, the patient, nursing staff, and physical therapist were blinded to the surgical incisions and the randomly assigned surgical approach. This was accomplished by the placement of two similar

operative dressings on every patient regardless of approach used, which included the phantom anterior dressing in all patients with a single-incision MIS approach. The dressings were maintained throughout the entire hospital stay and removed just before discharge. The operating room personnel were not allowed to communicate the surgical approach to any other members of the healthcare team and long-acting local anesthetics were used in all incisions to limit the patient's perception of incision location in the immediate postoperative period. The blinding of the surgical approach was maintained only while the patient was in the hospital and ceased with the removal of the surgical dressings at discharge.

All patients received a single preoperative physical therapy session to orient them to the postoperative physical therapy protocol and expectations. All patients received an identical postoperative rehabilitation protocol, which included inpatient physical therapy and occupational therapy starting the day of surgery. All study patients were scheduled as the first case of the day to allow ample recovery and time to undergo the first physical therapy session in the afternoon the day of surgery. All patients were weightbearing as tolerated and were instructed to employ universal hip precautions that avoided hip flexion with internal rotation and combined hip external rotation and full extension while weightbearing. No attempt was made to perform the surgery on an outpatient basis and no patients were allowed to discharge home the day of surgery; however, every patient was given identical preoperative instructions and expectations to discharge home the first postoperative day if able to safely. Every patient in all three groups was subjected to identical objective discharge criteria, which mandated patients could safely and independently perform all of the following activities: transfer out of bed to standing and into bed from standing, rise from a chair to standing and sit from standing, ambulate 100 feet, and ascend and descend a flight of four stairs. Once these criteria were met, the patient's pain was adequately controlled with oral pain medications, and medically stable, the patient was discharged from the hospital. The physical therapy session in which the patient completed all of the above required items for discharge was documented and compared between each study group, as well as the day of discharge from the hospital.

Once discharged from the hospital, the patients continued physical therapy either in their homes or at an outpatient physical therapy facility. To minimize the variability among therapists and create uniformity of postoperative physical therapy among all patients in the study arms, we provided standardized instructions to the physical therapists outside our institution to delineate a strict rehabilitation protocol. The patient and therapist were encouraged to advance as quickly as safely possible. Patients were able to progress to a cane as tolerated and encouraged to use a cane until they felt comfortable and safe, at which point the patient was able to discontinue the cane. Patients were also encouraged to resume activities as tolerated. Patients who were employed were encouraged to return to work as soon as they felt comfortable enough to do so.

Functional outcome measures included the SF-36 [27] WOMAC osteoarthritis index [3], Harris hip score [16], and lower extremity activity scale (LEAS) [25]. The mental component and physical component scores of the SF-36 were reported separately. Each patient received a patient diary into which was recorded when functional milestones were reached. The functional milestones included discontinuation of walker, cane, or other assistive device, discontinuation of oral narcotics, return to work, and resumption of driving. The clinical study coordinator (SAS) obtained the SF-36, WOMAC, Harris hip, and LEAS scores preoperatively and at the 6-week, 3-month, 6-month, and 1-year postoperative intervals. These outcome measures were compared between the three surgical approach groups utilizing the measured improvement from the preoperative level as determined by the difference between values at a given time interval and preoperatively. A comparison between the three study groups of the mean number of days to reach the functional milestones was also performed.

We used one-way analysis of variance to compare the number of physical therapy sessions after surgery required to meet discharge criteria, postoperative day of hospital discharge, number of days required to reach functional milestones, and the recovery of validated outcome measures among the surgical approach groups. We also used one-way analysis of variance to compare the differences in outcome measures from preoperative baseline values among the three groups at the four time intervals. A post hoc Tukey test was performed when an F test was significant at the 0.05 level.

Results

All study patients met the study-mandated physical therapy discharge requirements by the third therapy session (Table 1), and with no difference ($p = 0.417$) in the mean numbers of sessions between the three surgical approach groups. Nineteen of the 24 hips were medically stable, satisfied the physical therapy discharge criteria, and were discharged on the first postoperative day after surgery. Three hips in two patients (one patient underwent bilateral THA separated by 10 months, both randomized to two-incision approaches) remained an additional postoperative

Table 1. Mean hospital discharge and milestone achievement data

Milestone	Two-incision approach	Mini-posterior approach	Mini-anterolateral approach	p Value
Number of physical therapy sessions to reach discharge criteria	2.0	1.8	1.5	0.42
Discharge hospital postoperative day	1.5	1.6	1.3	0.70
Off walker (days)	6.6	10.9	15.1	0.41
Off all assist (days)	15.1	27.4	32	0.17
Off pain medicines (days)	30.9	23.8	29.6	0.58
Return to work (days)	49.7	37.5	53	0.52
Resume driving (days)	16.5	25.1	30.3	0.09

day due to anxiety related to early hospital discharge. There was no difference ($p = 0.796$) in the mean day of hospital discharge among the three surgical approach groups.

There was no difference among the surgical approach groups in the recovery time required to reach functional milestones (Table 1). The mean time for all hips to discontinue a walker for a cane was 9.3 days (range, 1–26 days) and the mean time to discontinue the cane was 22.4 days (range, 3–57 days). Patients discontinued the use of narcotic pain medications at a mean of 15.2 days (range, 4–34 days), with no difference observed among study groups. The recovery time to resume driving was similar for the three groups at a mean of 23.7 days (range, 8–67 days), and the time to return to work full time was also similar among groups with a mean of 46.7 days (range, 19–94 days).

Improvements in the mean SF-36 physical component scores, LEAS scores, WOMAC scores, and Harris hip scores were observed at all postoperative time intervals compared to the preoperative values in all groups (Table 2). However, there was no difference among groups with regard to the improvement of mean SF-36 physical and mental component scores, LEAS scores, WOMAC scores, and Harris hip scores at any of the time intervals compared to the preoperative values (Table 2).

There were no intraoperative femoral fractures in any group. There was a minimally displaced greater trochanteric fracture observed at the 3-month followup in two patients; one underwent a two-incision approach and the other a mini-anterolateral approach. Both patients were asymptomatic at final followup without Trendelenburg gait and with full symmetric abductor strength. Two patients in the two-incision approach required a single blood transfusion due to postoperative anemia. Five of the eight hips in the two-incision approach group suffered a lateral femoral cutaneous nerve neuropraxia postoperatively. Three of the five neuropraxias had resolved by the 1-year followup, and two hips had persistent anterolateral thigh numbness.

Table 2. Mean functional outcome measure data

Outcome measure	Two-incision approach	Mini-posterior approach	Mini-anterolateral approach	Δ p Value
SF-36 PCS				
Preoperative	30.6	28.7	36.9	
6 weeks	47.2	42.9	41.6	0.17
3 months	52.7	50.3	50	0.23
6 months	52.4	48.4	52.7	0.66
1 year	55.4	54.4	55.3	0.36
SF-36 MCS				
Preoperative	46.2	51.7	53.2	
6 weeks	58.7	53.2	60.2	0.2
3 months	59.5	57.9	59.7	0.47
6 months	58.2	56.8	57.6	0.43
1 year	58	54.4	55.3	0.37
WOMAC				
Preoperative	41.6	52.2	54.8	
6 weeks	87.2	81.6	87.7	0.13
3 months	91.4	92.7	93	0.46
6 months	94.5	95.6	95.4	0.56
1 year	95.2	97.3	96.4	0.55
Harris hip score				
Preoperative	41.8	47.8	46.4	
6 weeks	79.4	77.5	81.5	0.57
3 months	92.9	90	89.4	0.41
6 months	93.1	87.3	95.8	0.44
1 year	95.1	95.5	95.4	0.77
LEAS				
Preoperative	9.9	9.5	9.9	
6 weeks	10.6	10	10	0.99
3 months	12	11.8	11.6	0.99
6 months	12.6	13.1	12.7	0.66
1 year	12.6	13.4	12	0.63

Δ p value = p value among groups of the change, or delta (difference), between preoperative value and the value at the specified followup interval; PCS = physical component score; MCS = mental component score; LEAS = lower extremity activity scale.

Discussion

MIS approaches to THA remain controversial. Some investigators report MIS techniques result in faster rehabilitation and rapid recovery after THA [4, 7, 8, 11, 17, 18, 26, 28]. Currently, conclusive evidence is lacking to support that a certain surgical approach provides a faster recovery and return to function. This preliminary investigation was designed to compare the early hospital discharge and early recovery with three different MIS approaches to THA, including the two-incision approach, utilizing a rapid rehabilitation protocol.

The main limitation of this study is the relatively small patient numbers in each cohort. However, we believe the strict patient selection criteria, adherence to the experimental design, and the employment of a randomized, prospective, inpatient blinded study enhance the value of the data. While MIS techniques for THA have generated substantial clinical interest from arthroplasty surgeons and patients, they have not been studied with the scientific rigor to match the level of patient and surgeon enthusiasm, as well as marketing emphasis and resources. Furthermore, we minimized confounding variables by developing standardized protocols for preoperative expectations and teaching, perioperative pain, and rehabilitation and strictly adhering to them. Nonetheless, this study should be considered a preliminary investigation due to the small cohort numbers.

Early hospital discharge has been recently reported with MIS techniques and has been attributed to the surgical approach by some authors [7, 12, 13]. In an initial report, Berger et al. [7] reported 97% of a series of 100 consecutive patients who underwent THA through a MIS two-incision approach were performed as an outpatient and 100% were discharged from the hospital within 23 hours. A retrospective cohort study of two-incision versus mini-posterior approaches reported a shorter length of hospital stay in the two-incision approach [13]. A mean time to discharge of 30.7 hours in the two-incision group was reported, compared to 44.6 hours in the mini-posterior approach group [13]. In a prospective, randomized, blinded trial comparing MIS and conventional posterior approach THA, Dorr et al. [12] reported a decreased average hospital stay in the MIS group of 63.2 hours compared to 73.6 hours in the traditional approach group. In an early report of a consecutive series, the mean time to discharge was shorter for two-incision approach THA patients compared to standard, traditional posterior approach patients at 2.8 days and 5.2 days, respectively [20]. However, the authors noted a rapid rehabilitation protocol or expectations for early hospital discharge were not employed [20]. In a more recent prospective, randomized clinical trial, Pagnano et al. [22] reported there was no difference between the two-incision approach and the mini-posterior approach in hospital discharge, with both groups having a mean hospital stay of 2.6 days. However, all patients had an indwelling femoral nerve catheter that was not discontinued until the morning of the second postoperative day [22].

Our data demonstrate patients undergoing THA with a MIS approach, a standardized, advanced perioperative anesthesia protocol, preoperative teaching, and appropriate patient expectations can reliably be discharged from the hospital on the first postoperative day, regardless of the surgical approach. Nineteen of 24 hips (18 of 22 patients) discharged from the hospital on the day after surgery and all patients met the objective physical therapy goals for discharge by the afternoon the day after surgery. Early discharge from the hospital does not appear to be dependent on surgical approach as has been suggested in published reports [7]. Even in the comparative studies that report a shorter hospital stay with MIS approaches [12, 13], the differences are in hours, which we believe are irrelevant among the many factors related to patient discharge. Furthermore, our study shows early discharge can be consistently achieved on the first postoperative day with a mini-posterior or mini-anterolateral approach.

The functional milestone recovery data in this study is somewhat inconsistent with the reports by Berger et al. [7], who reported a mean time for discontinuation of narcotic medications and assistive devices of 6 and 9 days, respectively, with the two-incision MIS approach. The patients in our study were able to discontinue narcotics and resume walking without an assist device at a mean of 15 and 22 days, respectively. These conflicting results may be due to the avoidance of a selection bias in our study, as all patients were enrolled consecutively if they met inclusion criteria regardless of personality characteristics, general fitness, or motivation. Also, there was no observed benefit with the two-incision compared to the mini-posterior and mini-anterolateral approaches in recovery of functional milestones with the available numbers. These data are consistent with those recently reported by Pagnano et al. [22], who documented no difference between the two-incision and mini-posterior approach with regard to functional milestone attainment in a prospective, randomized trial. They reported discontinuation of narcotics at a mean of 15 and 17 days, discontinuation of all assist devices at 33 and 24 days, and resumption of driving at 31 and 27 days in the two-incision and mini-posterior approaches, respectively [22]. While the results of these studies fail to provide conclusive evidence for one MIS approach over another, the data do provide evidence that MIS techniques in general can offer a relatively rapid recovery when combined with rapid rehabilitation protocols, patient education, and advanced perioperative anesthetic techniques.

However, there is evidence that implementation of a patient education and rapid rehabilitation program may expedite patient recovery in traditional THA [10]. In addition, a recent randomized, prospective study revealed an accelerated preoperative and postoperative rehabilitation program resulted in faster recovery, rather than if a MIS surgical technique was used [23].

Health-related quality-of-life measures document THA improves the quality of life in patients with osteoarthritis [14, 24]. The mean SF-36 physical component and WOMAC scores of our patients improved over the preoperative values although we found no difference among the three MIS surgical approaches at any time interval. The LEAS is a self-administered activity scale questionnaire, validated as an effective instrument for the assessment of patient activity levels [25]. We observed no difference between the three surgical approaches by this outcome measure; however, all three study groups improved by the 6-week followup over the preoperative level and continued to improve at the 1-year followup. All patients demonstrated an improvement in the Harris hip score at 6 weeks and continued to improve over the first year, yet no difference was seen among the surgical approach groups.

We noted an increased incidence of complications, including five lateral femoral cutaneous nerve palsies, a late trochanteric avulsion fracture, and two blood transfusions, in the two-incision approach. These findings are consistent with other reports documenting increased complications with the two-incision MIS surgical approach [1, 2, 20].

Despite the small patient numbers, our data along with existing reports in the literature [9, 19, 21, 22], fail to demonstrate a clear benefit in rapid recovery when utilizing one MIS technique over another. Along with other investigations, these data provide evidence that early hospital discharge and recovery of function are possible when MIS techniques are utilized with comprehensive modern perioperative anesthesia, proper patient education and expectations, and a rapid rehabilitation protocol; however, the latter factors are more likely to result in faster recovery than the surgical technique [23].

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