

Short-Term Strength and Pain Changes in Total Hip Arthroplasty Patients

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The purpose of this study was to report on three case studies of patients that underwent cementless, total hip arthroplasties. The primary emphasis of the study was on short-term changes in pain and strength. The MEED 3000 system was used to obtain bilateral strength measurements for hip abductors (HA), hip flexors (HF), knee extensors (KE), and for straight leg raising (SLR). A 10-point scale was used to assess pain intensity at rest and during each of the muscle strength tests. The postoperative pain was greatest and remained the longest for performing the SLR test. Increases and decreases in the strength of the operative and nonoperative hip tended to parallel one another over time. Throughout the period studied, strength differences between the operative and nonoperative sides for HF, SLR, and HE were large while the differences for HA were relatively small. The significant hip and knee muscle weakness of the total hip patients seems to support the need for a carefully monitored resistive exercise program following discharge from the hospital.

Total hip replacement has become a common orthopaedic procedure for today's aging population. Many parameters have been studied in the context of this surgical procedure. Relative to the total hip replacement, several investigations have addressed issues of functional status with follow-up periods up to 10 years, with the majority ranging from 6–24 months. The majority of these studies reported on factors such as range of motion, walking, pain, and roentgenography (4, 9, 11, 15). Some of these studies investigated muscle strength in a quantitative fashion, but these studies are limited to the abductor and adductor muscle groups (1–3, 5–8, 10, 12–14, 16, 17).

No studies could be located which quantitatively measured strength for multiple muscle groups over the short-term postoperative period. Also, the association between pain and strength over this short-term period has apparently not been investigated.

A dichotomy seems to exist. On one hand

there is a bonafide concern to avoid loosening of the implant, and on the other a need to advise the patient to perform exercise so that an optimal functional result is obtained. The short- and long-term postoperative exercise recommendations appear to be specific in terms of the type of exercise and frequency of performance while the intensity of the exercise is more at the discretion of the patient. Walking is a good exercise but requires a reasonably small percentage of the normal person's muscle strength capability. Higher levels of strength are no doubt needed for other activities of daily living such as climbing stairs and kneeling.

Postoperative programs tend to include straight leg raising, quadriceps setting, and hip abductor exercise. Objective information on the strength of these muscles is limited. Further, measurements are typically averaged for a group and, as such, the diverse responses of individual patients are lost. The variability as typically reported as a standard deviation for a group of patients is often so large that clinical interpretation is necessarily ambiguous.

The rate of return of muscle strength and reduction of hip pain are important in forming postoperative expectations and rehabilitation strategies. There appears to be a need for a standardized approach to quickly and safely as-

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ness strength of muscle groups relevant to the total hip procedure. If such an approach is possible, a foundation for better understanding of postoperative functional capability and of recommending exercise intensity would be provided.

The purpose of this study was to report three case studies of patients that underwent total hip arthroplasty. The primary emphasis of the study is short-term postoperative changes in muscle strength and pain.

METHOD

Three patients who underwent elective, unilateral, cementless, total hip replacement were studied. Each procedure was performed by the same surgeon. As tolerated postoperatively, in the supine position the following active exercises were carried out by the patient: quadriceps setting, straight leg raising, isometric hip abduction, gluteal setting, active hip and knee flexion, abduction of the hip, and internal and external rotation of the hip. The patients were first examined 1 day prior to the operation. Strength measurements were obtained for each extremity for the knee extensors, hip flexors, hip abductors, and for straight leg raising (SLR). Additional hip muscle groups were not tested because of a concern for the patients' exercise tolerance and the overall time required to perform the tests, particularly during the hospitalization period.

Torque measures (Nm) were obtained and calculated using the computerized SPARK Muscle Examination and Exercise Dosimeter (MEED) 3000 system (SPARK Instruments and Academics, Inc., P.O. Box 5123, Coralville, IA 52241). The MEED 3000 system consists of a transducer unit which houses the strain gauge and preamplification electronics. The transducer unit is connected to the control unit. The control unit is made up of a central processing unit, a keyboard for variable functions, and a digital display. The transducer unit is composed of specific couplers for use with differing attachments. Details of the method, validity, and reliability for the MEED System is reported in a previous study (18). The values for measurement linearity, measurement error, and hysteresis were all less than 0.30%. The interrater reliability ranged from $r = 0.85$ to $r = 0.98$, while intersession reliability ranged from $r = 0.67$ to $r = 0.90$.

Each patient was tested in the supine position. The orientation of the lower extremity during each test follows: anatomical or zero position for the hip abductors (HA), hip flexed 45° for the hip flexors (HF), knee bent 30° for the knee extensors (KE), and the hip was flexed at 10° for straight leg raising (SLR). The strength tests are illustrated in Figures 1-4.

From the application of force on the limb, the

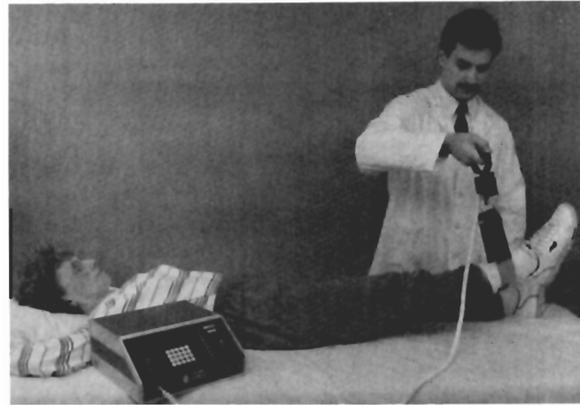


Figure 1. Muscle Examination and Exercise Dosimeter (MEED) System and test position for 1) measuring the torque contribution of the lower extremity, and 2) measuring the external force generated by the patient for straight leg raising.

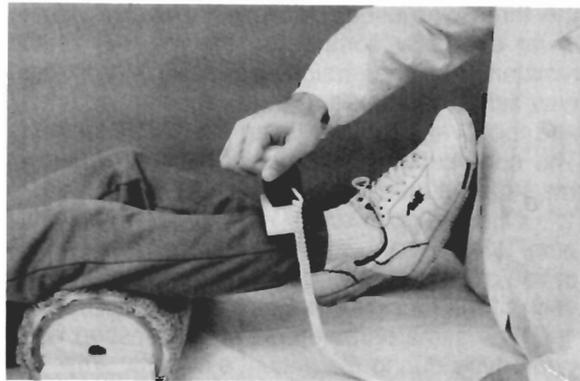


Figure 2. Test position for measuring knee extensor strength.

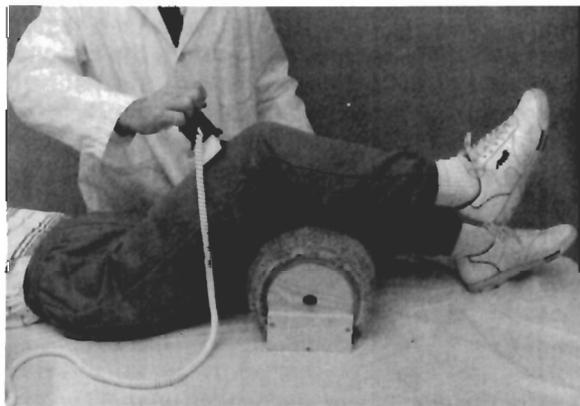


Figure 3. Test position for measuring hip flexor strength.

moment arm distance was the lateral femoral epicondyle to distal shank for the knee measures, the tip of the greater trochanter to distal thigh for the abductor and flexor hip strength measures and greater trochanter to distal shank for SLR. Isometric strength measures were obtained as



Figure 4. Test position for measuring hip abductor strength.

torque measures (Nm) about the hip joint for all tests except for the knee extensors. Each muscle group was given three trials and an average of the three was used. Because the weight of the lower extremity contributed the majority of the resistance for the straight leg raising, the patient was asked to relax and the weight of the shank and foot was obtained using the MEED system. The contribution of this weight was included in the strength measurement.

On a ten-point scale (10 = highest imaginable pain, 0 = no pain), the patients provided an indication of pain at rest, during walking, and during each of the four exercise strength tests.

The same parameters were assessed postoperatively during the patient's hospital stay. The patients were tested postoperatively on the first day they felt they could accomplish isometric measurements without significant pain. This day ranged from postoperative day (POD) 4 to postoperative day 6. The patients were then tested daily until the day of discharge from the hospital (range POD 6–9). When possible, the patients were again tested on return visits to the clinic.

RESULTS

Figures 5–13 depict strength and pain measures for each patient for which results are described in this section.

Patient 1

This man's age, height, and weight were 67 years, 178 cm, and 90 kg, respectively. The patient presented with severe degenerative joint disease at the hip with pain at rest and nocturnal symptoms which interfered with sleep. The balance of his medical history was unremarkable.

Compared to the other subjects in this study, patient 1 exhibited higher levels of extremity strength at the operative hip. There was a precipitous postoperative dropoff in strength but his

gains for the muscle groups were large 8 weeks after surgery. The least strength gain was seen for SLR. The patient had no pain at 8 weeks, although his preoperative and immediate postoperative pain was equivalent to that of the other patients tested. Eight weeks after surgery the patient elected to use a cane when walking.

It should be noted that from the time of hospital discharge this patient conscientiously performed, as tolerated, resistive isometric exercise for the hip muscles. The patient indicated that the exercises were performed 30 times each day.

Patient 2

This patient was a 50-year-old male industrial worker who was 77 cm in height and weighed 84 kg. The patient reported a history of bilateral idiopathic aseptic necrosis at both hips, with the left side being worse than the right. Intermittent pain at the left hip had occurred over a 5-year period. Approximately 2 years prior to this study, the patient was treated with phemister core decompression and a tibial bone graft. Results from the strength test revealed a marked discrepancy in preoperative strength most evident in KE, HF, and SLR. This was accompanied by preoperative hip pain at rest (rating of 1.2) and significant hip pain when walking (rating of 8.7). Pain was elicited during the strength tests on his operative side (range of ratings = 2.9–3.8).

Postoperatively, with the exception of the hip abductors, the strength at the nonoperative hip dropped in all areas tested but the strength had returned to preoperative levels by POD 8. In the nonoperative hip the abductor strength more than doubled from the preoperative measurement to POD 8. The strength in the operative hip was approximately the same as the preoperative measurements on the first day tested (POD 6). Strength improved during the next 2 days in the operative hip, with the patient being discharged with approximately twice the preoperative strength in SLR, HA, HF. The patient had greater than 10-fold increase in knee extension strength in the operative hip side as compared to the preoperative level. At POD 8, the patient continued to have pain at rest (rating of 1.3) and similar pain during each exercise (range of ratings = 2.4–3.1). The patient also had pain in his operative hip during measurement of strength in the nonoperative hip (range of ratings = 0.9–1.5). The pain was consistently described as a deep sharp hip pain.

Six weeks after surgery, the patient had a continued increase in hip strength in both nonoperative and operative hips. In the operative hip, improvement was greatest in KE followed by HA, HF, and SLR. Nonoperative strength was similar

Strength--Straight Leg Raising

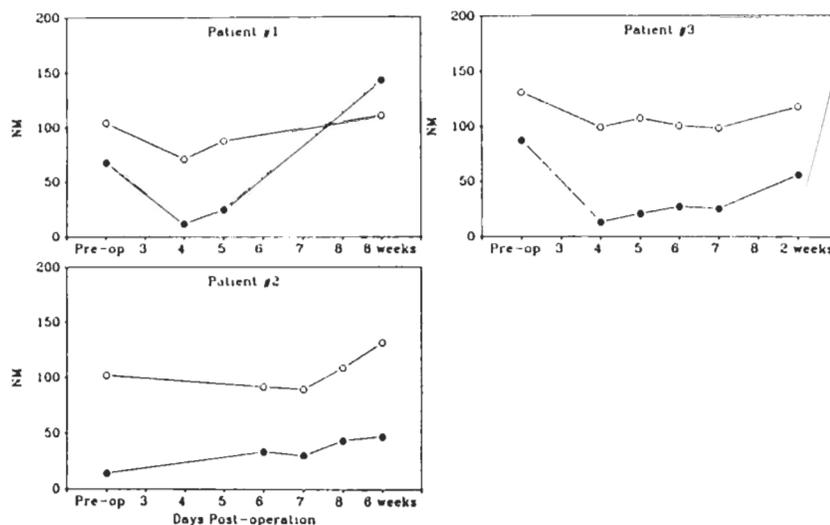


Figure 5. Strength—straight leg raising. (●), Operative hip; (○), nonoperative hip; NM, Newton meters.

Pain During Straight Leg Raising

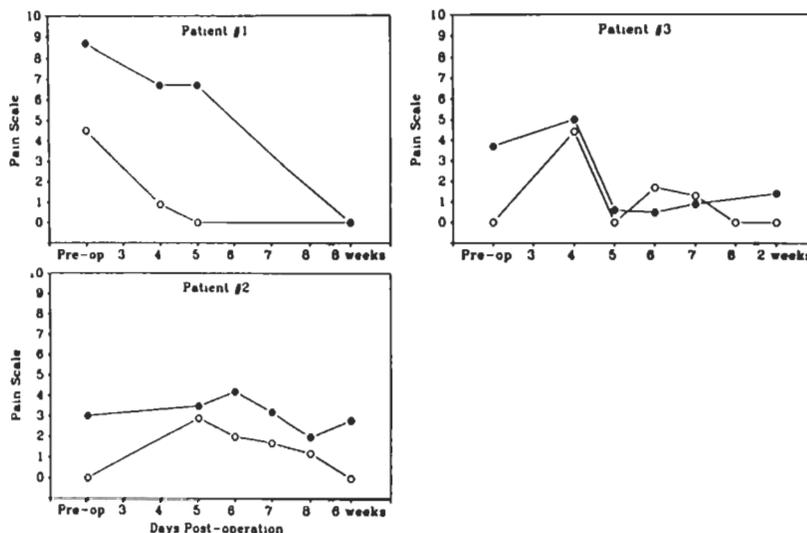


Figure 6. Pain during straight leg raising. (●), Pain at operative hip during muscle strength test; (○), pain at operative hip while nonoperative side was being tested for muscle strength; Pain scale, 0–10; 10 = most pain; 0 = no pain.

to preoperative in KE, HF, and SLR, but was greatly improved in HA. At 6 weeks, the patient continued to have operative hip pain while walking (rating of 1.4), but no rest pain. The patient experienced the greatest pain during SLR (3.6), with pain during KE, HF, and HA being considerably less (range of ratings = 1.9–2.0). The patient relied heavily on a cane when walking.

Patient 3

This patient was 67 years old, height was 178 cm, and he weighed 86 kg. In 1961 he had a Pipkin Type I femoral head fracture. Symptoms consistent with osteoarthritis progressed over the

years despite conservative management. In addition, the patient reported a history of coronary artery disease and hypertension. Two years prior to this study he underwent coronary artery bypass surgery. Before surgery, patient 3 had no rest pain but had pain when walking (rating of 6.5), SLR (rating of 4.7), KE (rating of 1.8), HF (rating of 2.8), and HA (rating of 1.6). Before surgery, the patient was somewhat stronger in the nonoperative hip in SLR, HF, and KE while HA was essentially the same. Postoperatively, strength decreased markedly in the operative hip in all but KE, which remained the same. By the day of discharge (POD 7), the patient's SLR and HF

Strength--Knee Extension

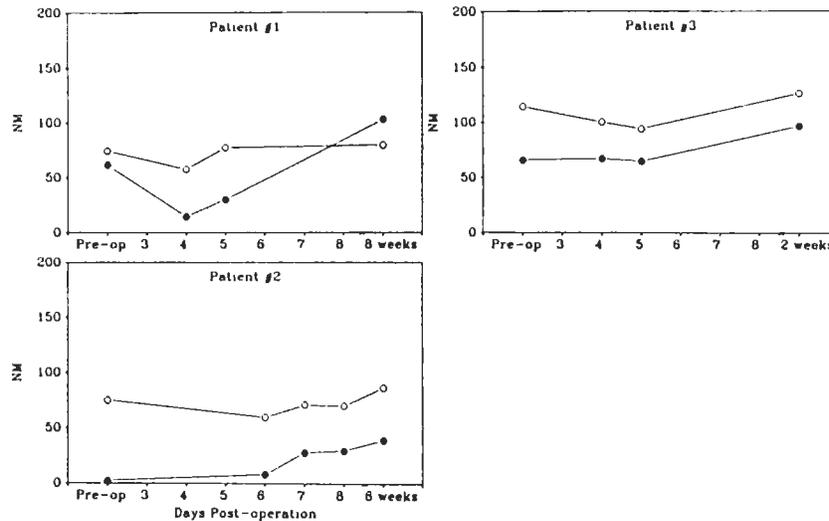


Figure 7. Strength--knee extension. (●), Operative hip; (○), nonoperative hip; NM, Newton meters.

Pain During Knee Extension

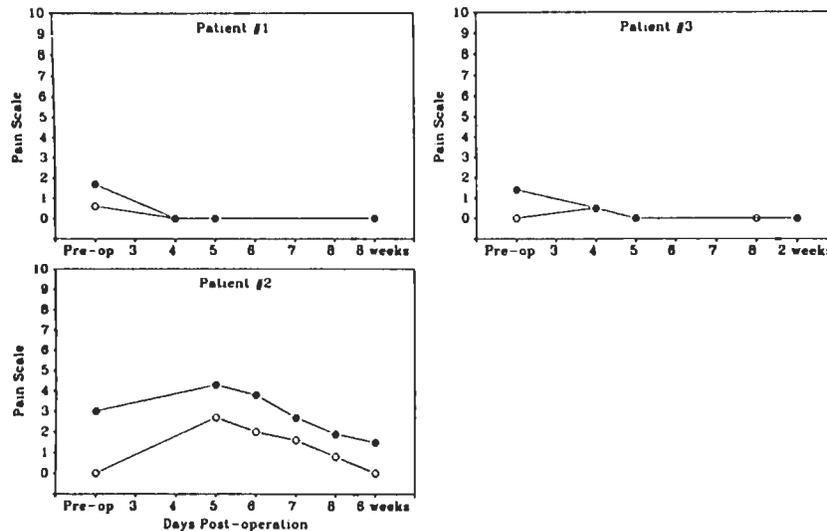


Figure 8. Pain during knee extension. (●), Pain at operative hip during muscle strength test; (○), pain at operative hip while nonoperative side was being tested for muscle strength. Pain scale, 0-10; 10 = most pain; 0 = no pain.

strength improved but was still less than one-half the preoperative strength in the operative leg. Strength in the nonoperative hip increased in HF and KE and decreased in HA.

The patient had no pain at rest or with HA at the time of discharge but did have pain with SLR (rating of 1.2), KE (rating of 0.9), and HF (rating of 2.1). Two weeks after surgery, the patient only had pain with SLR (rating of 1.8) and HA (rating of 0.2).

DISCUSSION

Preoperatively, the three patients had different levels of strength in the operative hip. Although

all were significantly weaker than the nonoperative hip, HA was relatively stronger in all patients as compared to HF, SLR, and KE. Patients had pain in the operative hip when walking (range of ratings = 6.0-8.7) and during all four of the exercises. Hip abductor strength may be less compromised than other hip muscle groups so perhaps historically the focus on the abductors has been too narrow.

The first postoperative measurement indicated that, of two patients, the strength of the operative leg dropped considerably, while in the other patient there was no change in strength. In two of the three patients, discharge from the

Strength--Hip Flexion

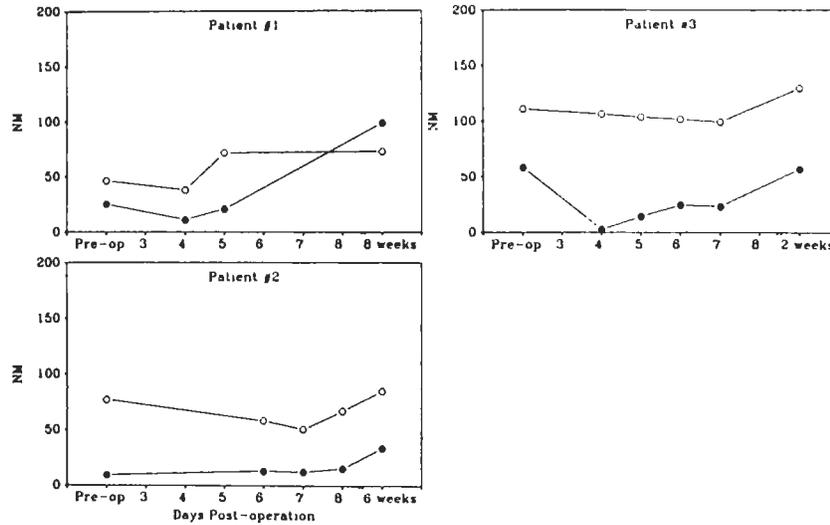


Figure 9. Strength—hip flexion. (●), Operative hip; (○), nonoperative hip; NM, Newton meters.

Pain During Hip Flexion

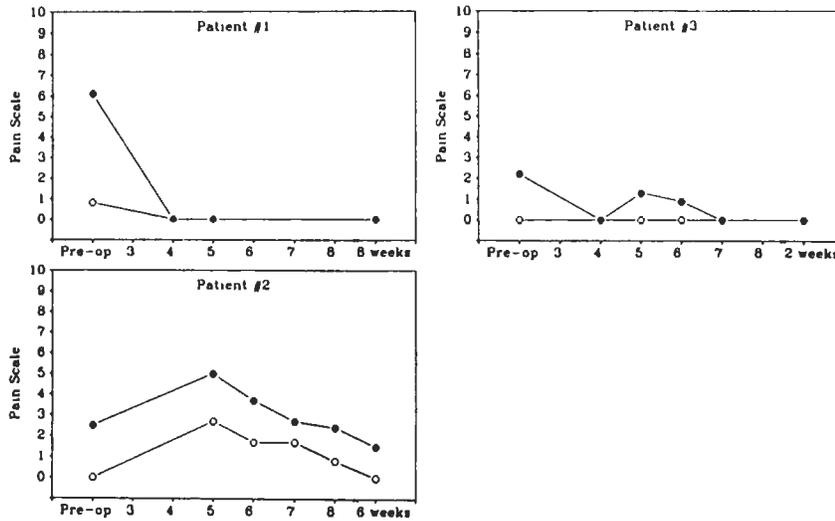


Figure 10. Pain during hip flexion. (●), Pain at operative hip during muscle strength test; (○), pain at operative hip while nonoperative side was being tested for muscle strength. Pain scale, 0-10; 10 = most pain; 0 = no pain.

hospital was made with much less hip strength in the operative leg than there had been before surgery. All patients continued to have pain during the exercises at the time of discharge. Patients continued to show improvement when they returned to the clinic. The patients that returned at 6 and 8 weeks had greater strength in the operative leg over preoperative strength in all four muscle groups tested. Patient 1 had nearly equal strength in both legs with HA and KE. This was in contrast to the other two patients who had discrepancies in strength in all muscle groups. Strength gains in patient 3 were thought to be due to hip abductor exercises the patient did on

a daily basis at home. In general, all patients had equal or better strength at clinic visits at 2, 6, and 8 weeks than the strength they had before surgery. If a patient had a large discrepancy in leg strength, this seemed to carry through the post-operative period. The patient who returned at 8 weeks had no pain during the exercises. The patients who returned at 2 and 6 weeks continued to have pain at a minimal level. It is difficult to predict which patient will continue to have pain after surgery as it does not appear to correlate with pain before surgery.

The results of this study suggest that if the hip replacement is done when there is a high level

Strength--Hip Abduction

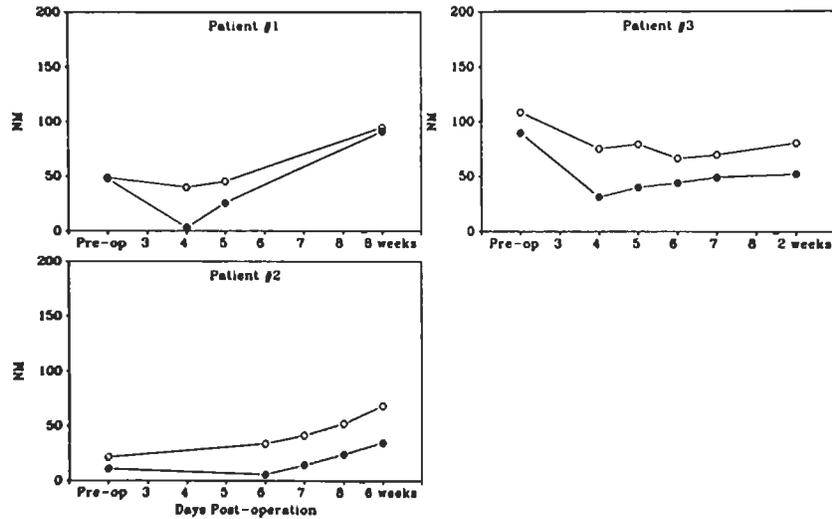


Figure 11. Strength—hip abduction. (●), Operative hip; (○), nonoperative hip; NM, Newton meters.

Pain During Hip Abduction

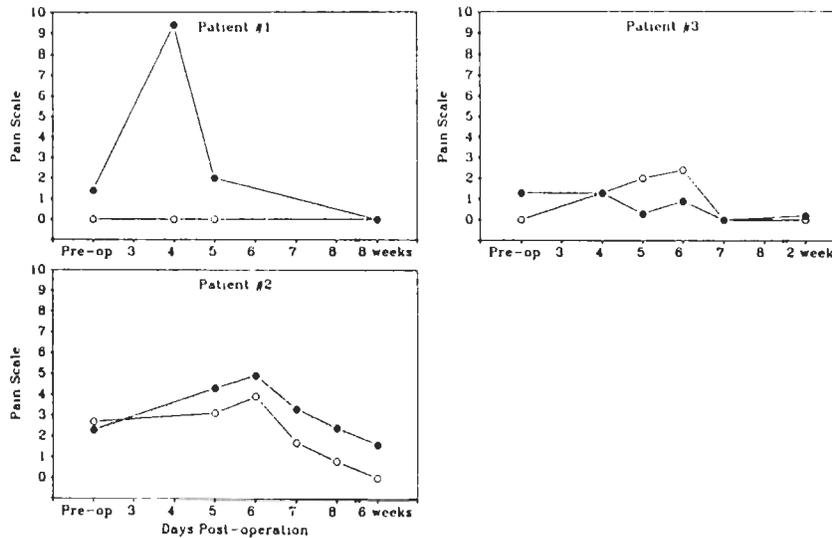


Figure 12. Pain during hip abduction. (●), Pain at operative hip during muscle strength test; (○), pain at operative hip while nonoperative side was being tested for muscle strength. Pain scale, 0-10; 10 = most pain; 0 = no pain.

of strength in the leg, the patient will have rapid return to his preoperative strength. If the patient has poor strength before surgery, improvement may occur but the muscles will tend to be much weaker than in his other leg. This can affect one's preoperative expectations for a patient; that is, typically the patients with the best preoperative functional status will correspondingly have a better postoperative result and vice versa.

Since pain persisted for SLR, perhaps isolated exercise for the hip and for the knee might be considered. That is to say that if SLR (a combined hip flexion, knee extension) exercise is

painful, the same physiological effect might be accomplished by separately exercising the hip flexors and knee extensors. For the hip flexors, the hip and knee can be placed in a flexed position and resistance applied at the distal thigh. For the knee extensors, padded support can be provided under the back of the knee and resistance applied at the distal shank. Further study is needed on the effectiveness of exercise protocols both before and after surgery.

This study has demonstrated the feasibility of quantifying the strength of relevant lower extremity muscles during the early postoperative

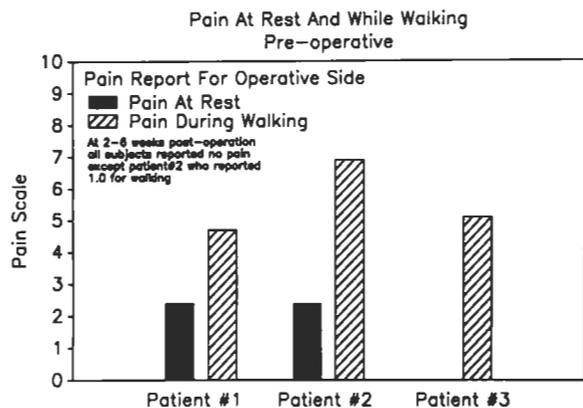


Figure 13. Pain at rest and while walking before surgery.

course for total hip arthroplasty patients. The method used was easy to administer. Early post-operative values for strength and pain should help clarify the rate of progress and time frame until maximal function is attained.

SUMMARY

For patients who underwent cementless, total hip arthroplasties, increases and decreases in the strength of the operative and nonoperative hip tended to parallel one another over time. Throughout the period studied, strength differences between the operative and nonoperative extremities for HF, SLR, and KE were large while the difference for HA was relatively small. The postoperative pain reported during the SLR test was greater and remained longer than the pain during the other tests. The significant hip and knee muscle weakness of the total hip patients seems to support the need for a carefully monitored resistive exercise program following discharge from the hospital. □

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