

# Manipulation After Total Knee Arthroplasty

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**Background:** Following total knee arthroplasty, some patients who fail to achieve  $>90^\circ$  of flexion in the early perioperative period may be considered candidates for manipulation of the knee under anesthesia. The purpose of this study was to assess the outcomes of manipulation following total knee arthroplasty.

**Methods:** One hundred and thirteen knees in ninety patients underwent manipulation for postoperative flexion of  $\leq 90^\circ$  at a mean of ten weeks after surgery. Flexion was measured with a goniometer prior to total knee arthroplasty, at the conclusion of the operative procedure, before manipulation, immediately after manipulation, at six months, and at one, three, and five years postoperatively.

**Results:** Eighty-one (90%) of the ninety patients achieved improvement of ultimate knee flexion following manipulation. The average flexion was  $102^\circ$  prior to total knee arthroplasty,  $111^\circ$  following skin closure, and  $70^\circ$  before manipulation. The average improvement in flexion from the measurement made before manipulation to that recorded at the five-year follow-up was  $35^\circ$  ( $p < 0.0001$ , paired t test). There was no significant difference in the mean improvement in flexion when patients who had manipulation within twelve weeks postoperatively were compared with those who had manipulation more than twelve weeks postoperatively. Patients who eventually underwent manipulation had significantly lower preoperative Knee Society pain scores (more pain) than those who had not had manipulation ( $p = 0.0027$ ).

**Conclusions:** Manipulation generally increases ultimate flexion following total knee arthroplasty. Patients with severe preoperative pain are more likely to require manipulation.

**Level of Evidence:** Therapeutic Level III. See Instructions to Authors for a complete description of levels of evidence.

Although relief from pain is usually achieved following total knee arthroplasty, limited postoperative range of motion can compromise the restoration of function. At least  $90^\circ$  of flexion is necessary to perform daily activities such as climbing stairs or rising from a chair<sup>1,2</sup>. The goal of manipulation following total knee arthroplasty is to increase knee flexion in patients who have failed to achieve approximately  $90^\circ$  of flexion postoperatively.

Two previous studies of manipulation following total knee arthroplasty showed enduring gains in flexion following manipulation<sup>3,4</sup>, whereas a third study showed that the gain in flexion was lost within one year after manipulation<sup>5</sup>.

The purposes of this study were to determine whether any specific factors could be identified as predictors of the need for manipulation and to determine whether manipulation resulted in an enduring improvement in knee flexion.

## Materials and Methods

Between 1987 and 2001, 6297 posterior cruciate-retaining knee replacements with Anatomic Graduated Components (AGC; Biomet, Warsaw, Indiana) were performed in 4063 patients at our institution. Of those knees, 113 (1.8%) in ninety patients underwent manipulation because of limited flexion following total knee arthroplasty.

Fifty-five (61%; sixty-six knees) of the ninety patients who underwent manipulation were women. The average age of the patients who had manipulation was sixty-five years (range, thirty-four to eighty-four years). Eighty-eight patients (111 knees; 98%) had undergone total knee arthroplasty because of a diagnosis of osteoarthritis.

Our indications for recommending manipulation were a failure to obtain  $\geq 90^\circ$  of flexion by two months postoperatively. Patients who declined manipulation at the two-month follow-up evaluation and had not been in a supervised physi-

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cal therapy program were entered into one. If knee flexion did not increase after one month on this program, the patients were encouraged to undergo manipulation.

Our rehabilitation protocol after total knee arthroplasty includes walking on postoperative day 1, active and passive knee flexion on day 2, and hospital discharge when active flexion of  $\geq 80^\circ$  is obtained. Continuous passive motion was not used in our patients. The surgical technique was the same throughout the study except that, after 1997, the epicondylar axis was used to determine femoral component rotation. While the protocol remained unchanged, the average inpatient length of stay decreased from five days to three days over the course of the study.

All range-of-motion measurements were performed with use of a goniometer by a physical therapist or an independent reviewer. Flexion was measured before total knee arthroplasty, intraoperatively after skin closure, at two months, at six months, and at one, three, and five years postoperatively. The average duration of follow-up was 4.6 years (range, six months to fifteen years). Knee Society scores and tibiofemoral alignment were calculated for each patient preoperatively and postoperatively.

#### Manipulation Protocol

After induction of general anesthesia and with the hip flexed to  $90^\circ$ , the knee was gently manipulated into flexion until audible and palpable lysis of adhesions was complete.

Physical therapy was instituted in the recovery room within thirty minutes after the manipulation procedure. With the hip flexed to  $90^\circ$ , the knee was flexed maximally and held by the therapist for thirty to sixty seconds and then the hip and knee were allowed to extend. This maneuver was repeated five times. Between active-assisted flexion and extension by the therapist, the hip and knee were positioned at  $90^\circ$  of flexion. The patients were progressed by a physical therapist to active and active-assisted range-of-motion exercises as soon as they were awake enough to follow commands. Cryotherapy, in the form of ice packs placed on the distal part of the thigh and anterior aspect of the knee, was used for all patients at the discretion of the nursing staff and the physical therapy staff. Out-

patient physical therapy sessions were continued three times a week and included active and passive-assisted range-of-motion and muscle-strengthening exercises. At the discretion of the operating surgeon, twenty-two patients (24%) received, in addition to the standard anesthetic protocol, an indwelling epidural catheter for twenty-four hours.

#### Statistics

Two-sample t tests were utilized for side-by-side comparisons of multiple variables, including average age, body mass index, and preoperative flexion in the cohorts managed with and without manipulation; postoperative flexion at one and five years in the manipulation group; ultimate flexion in patients with preoperative flexion of  $>90^\circ$  or  $\leq 90^\circ$ ; ultimate flexion when epidural or general anesthesia was used; and ultimate flexion when manipulation was performed within twelve weeks or more than twelve weeks after the primary total knee arthroplasty.

The Wilcoxon test was used to compare preoperative pain scores in the cohorts managed with and without manipulation. Two pain categories—severe or moderate continuous pain and moderate occasional pain—were compared with use of chi-square analysis. The two groups were also compared with respect to postoperative pain scores and tibiofemoral alignment with use of analysis of variance. Logistic regression was used to evaluate the predictive value of gender, age, or preoperative alignment on the need for manipulation. A p value of 0.05 was considered significant.

#### Results

The mean rate of patients who had manipulation during the study period was 1.8% (range, 0.7% to 3.1%) per year. Several preoperative factors were significantly associated with an increased risk of manipulation (Table I). The average age in the manipulation group was significantly younger (sixty-five years compared with seventy-one years;  $p < 0.0001$ ). Logistic regression analysis revealed that younger patients had a higher risk of manipulation, with the odds of manipulation being 1.47 times less for every ten-year increase in age. The mean amount of preoperative flexion was less in the group that had

**TABLE I Comparison of Groups Managed with and without Manipulation with Respect to Preoperative Factors**

Preoperative Factor	Manipulation	No Manipulation	P Value
Average age (yr)	65	71	<0.0001
Gender			0.8866
Female	61%	60%	
Male	39%	40%	
Average body mass index ( $kg/m^2$ )	28.8	29.9	0.0650
Average tibiofemoral alignment	0.1° of valgus	0.1° of varus	0.7936
Average preoperative flexion	102°	110°	<0.0001
Average Knee Society pain score (points)	11.3	14.2	0.0027
Percentage of patients with moderate continuous pain or severe pain	70	55	<0.0001

TABLE II Pain Score Distribution at Different Time-Periods in Groups Managed with and without Manipulation

	6 Mo	1 Yr	3 Yr	5 Yr
Average pain score* (points)				
Manipulation	43	46	45	46
No manipulation	47	49	48	48
No pain				
Manipulation	45%	70%	71%	73%
No manipulation	65%	73%	79%	80%
Mild or occasional pain				
Manipulation	36%	21%	16%	18%
No manipulation	29%	23%	16%	15%
Moderate occasional pain				
Manipulation	4%	0	2%	0
No manipulation	2%	1%	1%	1%
Pain while climbing stairs				
Manipulation	4%	0	2%	6%
No manipulation	1%	1%	2%	1%
Pain during walking and climbing stairs				
Manipulation	9%	4%	4%	0
No manipulation	2%	2%	2%	2%
Moderate continuous pain				
Manipulation	0	3%	2%	0
No manipulation	<1%	<1%	1%	1%
Severe pain				
Manipulation	1%	1%	4%	3%
No manipulation	<1%	<1%	<1%	<1%

\*A comparison of the groups managed with and without manipulation demonstrated a significant difference in pain scores at all time-periods ( $p < 0.0001$ ).

manipulation (102° compared with 110°;  $p < 0.0001$ ). The risk of manipulation was 1.31 times less for every 10° increase in preoperative flexion. The preoperative Knee Society pain scores were lower in the manipulation group ( $p = 0.0027$ ). Seventy percent of the patients in the manipulation group reported severe or moderate continuous pain compared with only 55% in the group that had not had manipulation ( $p < 0.0001$ ). Although body mass index was not significantly different between the two groups, the risk of manipulation was 1.76 times less for every increase of 10 kg/m<sup>2</sup> in body mass index (logistic regression). Gender and preoperative tibiofemoral alignment did not appear to have an influence on the need for manipulation.

Eighty-one (90%) of the ninety patients had improvement in ultimate knee flexion following manipulation. Six months postoperatively, the manipulation group had, on the average, lower pain scores than the group managed without manipulation (43 and 47 points, respectively;  $p < 0.0001$ ) (Table II). Although the average score improved at one year, the differences remained significantly lower even at five years ( $p < 0.0001$ ). Eighty percent of the knees treated without manipulation were rated as pain-free, whereas 73% of the knees

treated with manipulation were rated as having no pain at five years postoperatively (Table II).

Before manipulation, the mean flexion had decreased from 102° (range, 30° to 130°) preoperatively to 70° (range, 30° to 100°) ( $p < 0.0001$ ) (Table III). After intraoperative manipulation, flexion significantly increased to a mean of 111° ( $p < 0.0001$ ). Six months after manipulation, the average flexion was 94° ( $p < 0.0001$ ). This improvement was maintained up to five years, with an ultimate mean flexion of 105° ( $p < 0.0001$ ), resulting in an overall mean increase of 35° of flexion.

In knees treated with manipulation that had flexion of >90° before total knee arthroplasty, the average flexion intraoperatively and at each follow-up period was significantly higher than that of the knees with flexion of ≤90° before total knee arthroplasty (Table IV).

No significant difference in the results was detected on the basis of the postoperative timing of manipulation (less than or greater than twelve weeks;  $p < 0.3597$ ), the type of anesthesia (general or epidural), or the type of postoperative pain management (patient-controlled analgesia or continuous epidural;  $p = 0.1023$ ).

**TABLE III Comparison of Preoperative and Postoperative Flexion in Patients Who Had Manipulation After Total Knee Arthroplasty**

Time	Mean Flexion (Range)	P Value
Preoperative measurement	102° (30°-130°)	
Before manipulation	70° (30°-100°)	<0.0001*
Intraoperative measurement	111° (75°-130°)	<0.0001†
Postoperative measurements		
6 mo	94.0° (40°-120°)	<0.0001†
1 yr	96.9° (48°-130°)	<0.0001†
3 yr	101.0° (50°-150°)	<0.0001†
5 yr	105.0° (50°-130°)	<0.0001†

\*Comparison with measurement made before total knee arthroplasty. †Comparison with measurement made before manipulation.

### Complications

One patient with osteoporosis sustained a supracondylar femoral fracture either intraoperatively or postoperatively while under epidural anesthesia. Nine knees in patients with continuous pain did not gain flexion with manipulation.

Five knees (4%; five patients) in the manipulation group underwent subsequent revision total knee arthroplasty compared with twenty-four (0.5%) of 4583 knees that had not had manipulation in a previously reported cohort ( $p = 0.02$ )<sup>6</sup>. Two of the five revision arthroplasties in the manipulation group were performed for hematogenous infection at five and ten years postoperatively. The three other revision arthroplasties were performed for the treatment of tibial component loosening, femoral component loosening, and a late supracondylar femoral fracture in one knee each.

### Discussion

The results of the present study indicate that manipulation can result in significant and lasting improvement in knee flexion. The average increase in flexion from the measurement made before manipulation to that at the most recent follow-up was 35°, which is consistent with two previous studies of manipulation following total knee arthroplasty<sup>3,4</sup>; however, it does not support the findings of a third study that indicated

an initial gain in flexion following manipulation was lost within one week after manipulation<sup>5</sup>. While the flexion from week to week following manipulation was not considered in the current study, we did observe a steady increase in the average flexion at each of the follow-up periods up to five years postoperatively.

Nine patients (10%) with continuous knee pain failed to gain flexion following manipulation. Interestingly, the revision rate was higher in this group and involved a variety of failure mechanisms seemingly unrelated to manipulation.

With the numbers available, we did not find that the use of adjunctive epidural anesthesia for twenty-four hours significantly improved the gain in flexion following manipulation. The interval between primary total knee arthroplasty and manipulation did not affect the amount of improvement in flexion achieved following manipulation. When comparing patients who had manipulation within twelve weeks after total knee arthroplasty with those who underwent manipulation between twelve and forty-four weeks, we did not find that earlier manipulation was more successful at achieving greater flexion.

Patients with less preoperative flexion had lower ultimate flexion after total knee arthroplasty compared with patients with greater preoperative flexion. While patients with

**TABLE IV Comparison of Preoperative and Postoperative Flexion in Patients Who Had Manipulation After Total Knee Arthroplasty**

Time	Mean Flexion (Range)		P Value
	Knees with Preop. Flexion of $\leq 90^\circ$ (N = 35)	Knees with Preop. Flexion of $> 90^\circ$ (N = 78)	
Preoperative measurement	81° (30°-90°)	111° (94°-100°)	<0.0001
Before manipulation	67° (30°-85°)	72° (42°-100°)	0.0626
Postoperative measurements			
6 mo	89° (40°-115°)	97° (55°-120°)	0.0245
1 yr	90° (50°-115°)	100° (40°-130°)	0.0025
3 yr	93° (50°-120°)	105° (95°-130°)	0.0106
5 yr	93° (50°-125°)	111° (95°-130°)	0.0014

preoperative flexion of  $\leq 90^\circ$  had an average improvement of  $26^\circ$  with manipulation, they had less flexion at all follow-up periods than patients with preoperative flexion of  $>90^\circ$  (Table IV).

The patients who had manipulation were significantly younger than those who did not have manipulation. Daluga et al. also reported that the patients in their study who required manipulation were younger than those who had not required it<sup>7</sup>. Unfortunately, while the differences in age and pain scores were significant, they may not be clinically important because the absolute differences between pain scores and age are probably not helpful in identifying patients preoperatively who might require manipulation.

The knees that had manipulation in the current study represent only 1.8% of the knees that had primary total knee arthroplasty at our institution during the same time-period. This is a considerably lower rate of manipulation than previous studies have described<sup>3,4,8</sup>.

In a previous study of total knee replacements done at our institution, the survival rate of the prosthesis was 98.9% at fifteen years<sup>6</sup>. However, the rate of revision total knee arthroplasty was significantly higher in the patients who underwent manipulation (4%) than the rate that is normally observed for total knee arthroplasties done at our institution. These revisions were done for late infection in two patients, tibial collapse and loosening in one, femoral loosening in one, and distal femoral fracture in one patient.

It is interesting that the manipulation rate at our institution has not varied substantially over the last eighteen years, even with improvements in femoral alignment and orientation, thus indicating that the need for manipulation may be

related to the pain perception of the patient and the preoperative flexion rather than to the surgical technique of total knee arthroplasty.

In this study, the need for manipulation was associated with preoperative pain perception, younger age, decreasing weight, and decreased preoperative flexion. Although these data do not provide absolute predictors of the need for manipulation, they do imply that preoperative factors are quite important in determining postoperative results.

It also appears that manipulation can be performed more than twelve weeks postoperatively and still be beneficial in gaining flexion. However, in the patients who underwent manipulation, the ultimate revision rate was significantly higher than that in the cohort managed without manipulation for reasons that we cannot explain.

The present study supports the use of manipulation as an effective procedure to improve and maintain flexion after total knee replacement in knees that do achieve  $90^\circ$  of flexion in the period up to and beyond twelve weeks postoperatively. ■

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## References

1. Lee DC, Kim DH, Scott RD, Suthers K. Intraoperative flexion against gravity as an indication of ultimate range of motion in individual cases after total knee arthroplasty. *J Arthroplasty*. 1998;13:500-3.
2. Schurman DJ, Parker JN, Ornstein D. Total condylar knee replacement. A study of factors influencing range of motion as late as two years after arthroplasty. *J Bone Joint Surg Am*. 1985;67:1006-14.
3. Esler CN, Lock K, Harper WM, Gregg PJ. Manipulation of total knee replacements. Is the flexion gained retained? *J Bone Joint Surg Br*. 1999;81:27-9.
4. Maloney WJ. The stiff total knee arthroplasty: evaluation and management. *J Arthroplasty*. 2002;17(4 Suppl 1):71-3.
5. Fox JL, Poss R. The role of manipulation following total knee replacement. *J Bone Joint Surg Am*. 1981;63:357-62.
6. Ritter MA, Berend ME, Meding JB, Keating EM, Faris PM, Crites BM. Long-term followup of anatomic graduated components posterior cruciate-retaining total knee replacement. *Clin Orthop Relat Res*. 2001;388:51-7.
7. Daluga D, Lombardi AV Jr, Mallory TH, Vaughn BK. Knee manipulation following total knee arthroplasty. Analysis of prognostic variables. *J Arthroplasty*. 1991; 6:119-28.
8. Mauerhan DR, Mokris JG, Ly A, Kiezbak GM. Relationship between length of stay and manipulation rate after total knee arthroplasty. *J Arthroplasty*. 1998; 13:896-900.