Abstract: Pain control after arthroplasty has been a key concern for orthopedic surgeons. After total knee arthroplasty (TKA), a small group of patients developed a painful joint with suboptimal range of motion. Manipulation under anesthesia increases flexion and extension while decreasing pain in most cases. The objective of the present investigation is to assess the effect of a multimodal pain management protocol on arthrofibrosis in primary TKAs. A cohort of 1136 patients who underwent primary TKA was selected. Patients were divided into 2 groups: group A had 778 procedures performed using a traditional approach to pain control; group B included 358 procedures that received multimodal pain management. Group A had an incidence of manipulation of 4.75% (37/778). Of 357 patients, 8 required manipulation in group B, which is an incidence of 2.24%. We recommend that orthopedic surgeons consider using a multimodal pain management protocol for TKA.

Key words: pain control, manipulation, arthrofibrosis.

Pain control after arthroplasty has been a key concern for most orthopedic surgeons. Proper analgesia directly impacts the perceived success, functional outcome, and economic expenditure after the procedure [1]. A close and direct relationship exists between patient satisfaction after total joint arthroplasty and the levels of pain sustained during the preoperative period [2]. In total knee arthroplasty (TKA), achieving functional range of motion is also related with adequate analgesia in the preoperative period [3]. The normal physiologic response to pain in an extremity includes limitation of movement, which frequently leads to rapid muscle atrophy, weakness, and further pain [1]. Fortunately, most patients obtain long-term control of pain and satisfactory function after TKA as evidenced by improved patient-oriented quality of life, pain relief, and functional outcome measurements years after surgery [4].

After TKA, there is a relatively small group of patients who develop a painful joint with suboptimal range of motion despite optimal surgical technique and good radiographic appearance. Arthrofibrosis, for the most part, is an uncommon complication of primary TKA. It is thought to be caused by excessive fibroplasia, which results in the formation of adhesions that constrain the extensor mechanism [5]. In most knee arthroplasty centers, individuals who do not reach 90° of knee flexion within the first 4 to 6 weeks after surgery are scheduled for a manipulation under anesthesia (MUA). The exact etiology of arthrofibrosis remains largely unknown, but many conditions have been identified as risk factors and predictors of the development of a “stiff knee” [6]. Interestingly, the most important predictor of knee joint motion post-TKA is preoperative range of motion [7]. Higher preoperative pain scores as evidenced by visual analog scales have also been identified as a predictive risk factor for postoperative manipulation after TKA [7]. Manipulation under anesthesia after a primary procedure increases flexion and extension in stiff knees yielding long-lasting improvements in knee joint range of motion while decreasing pain in most cases [8].
Several preoperative multimodal pain management protocols have been introduced into the arthroplasty field in the last 5 years [9]. Most of these protocols use the principle of preemptive analgesia [9]. The objective of the present retrospective chart review was to assess the effect of a multimodal pain management protocol on arthrofibrosis in a series of primary TKAs. Knee joint range of motion was also measured as a secondary outcome. Our hypothesis was that an aggressive preoperative multimodal pain management protocol would reduce the incidence of stiffness after TKA, thus, minimizing the need for MUA.

Materials and Methods

The implant registry at the Orthopedic Institute at Mercy Hospital (Miami, Fla) was used to select all patients with a minimum follow-up of all cases being 2 years (range, 2-9 years). The patients were divided into 2 groups. Group A consisted of 778 procedures performed using a traditional approach to pain control that consisted of contemporary techniques used at the time, including patient-controlled analgesia pumps and opioid medications on demand. Patients received cruciate-retaining devices (Duracon, Stryker Orthopaedics, Mahwah, NJ, Howmedica, Stryker Howmedica Osteonics, Mahwah, NJ, and AMK Depuy, Johnson & Johnson, Warsaw, Ind). All patients were given standard preoperative instructions. Group B included 358 procedures that received a multimodal preemptive pain management protocol (see below). This group also received cruciate-retaining implants (Nexgen, Zimmer, Warsaw, Ind). The senior author visited 3 nationally recognized arthroplasty centers (RA Berger [Chicago], LDM Dorr [Los Angeles] and AJ Tria [New Brunswick], oral communication, 2003). These visits occurred during the months of October to November of 2003. From those visits and throughout the next 6 months, a combination of all the multimodal pain protocols observed and the concept of smaller incisions for the arthroplasty were incorporated into the practice (RA Berger [Chicago] and LDM Dorr [Los Angeles], oral communication, 2003). In addition to the pain protocol, these patients were informed that they would be getting a “small incision TKA,” which consisted of reduced skin and tendon incisions. Patients were considered for inclusion if they were consenting adults scheduled for primary TKA. Patients with cognitive impairment were excluded. Other than the smaller incision and lower profile instruments, surgical technique was identical for both groups. Range of knee joint flexion and extension was recorded before and after surgery during active and passive assessments.

Multimodal Pain Management Protocol

This protocol included a number of pain control techniques used as part of the multimodal pain management approach. To reduce levels of anxiety and pain, all patients were educated during their preoperative visits on the type of procedure and the degree of function and pain they would expect during and after surgery. Expectations were discussed with the patient and family regarding outcomes and natural progression of recovery, to reduce dissatisfaction stemming from unrealistic expectations, which are frequently encountered in joint arthroplasty patients [2,9]. Pharmacologic pain management is administered before, during, and after the surgical procedure. Blockage and synergistic activity of medications by blocking transmission of pain impulses at the periphery, at the spinal cord, and/or at the central nervous system (thalamus) is the goal of the multimodal approach. The following is the sequence of modalities used in the present study:

1. The night before surgery, all patients take 200 mg of Celebrex (Pfizer, New York, NY).
2. Preoperative medications. Given in the preoperative unit the same day of surgery 30 minutes before incision with a sip of water. These include OxyContin (Purdue Pharma, Stamford, Conn) 10 mg (oxycodone of controlled release) and celecoxib (Celebrex 200 mg) given once again for a total dose of 400 mg before surgery. The third medication given is acetaminophen (2 Tylenol [McNeil PPC, Inc, Fort Washington, Penn] 325-mg tablets), which is then followed by intravenous Zofran (Glaxo Smith Kline, Triangle Park, NC) 4 mg (ondansetron).
3. Peripheral femoral nerve block. In the holding area 30 minutes before surgery, the anesthesiologist places a femoral nerve block in the corresponding limb and injects a bolus of ropivacaine 0.25% 40 mL. The nerve is located using a nerve stimulator, and an indwelling sheathed nerve catheter is left in place for 48 hours, attached to a peripheral nerve pump. Nerve location is verified after obtaining adequate quadriceps muscle (or patella) twitch with a current of 0.4 mA or less. Care is taken in advising the anesthesiologist to locate the catheter proximal to the tourniquet site in the proximal thigh. Doing so preserves its functionality during tourniquet installation and undraping. The pump is initiated after surgery in the recovery room and set to infuse bupivacaine 0.125% at a rate of 10 mL per hour. An additional bolus is occasionally injected by the anesthesiologist before the patient leaves the operating room.
4. Spinal anesthesia. Using standard techniques, the patient is given a spinal anesthesia using bupivacaine 0.125%. The anesthesiologist places the patient in the lateral decubitus position on the side operated on for a period of 10 minutes.
5. Intraoperative injections. Two different mixtures of medications are used at different moments during the surgical procedure.

- Infiltration of the surgical incision. Once the patient is draped and ready for surgery, the tourniquet is elevated and the incision site is infiltrated with 10 mL of 2% plain lidocaine 2%, locally over the
planned incision 30 seconds before cutting skin to block local pathways.

- **Pain cocktail.** After the final implants have been cemented and the trial insert has been chosen, the posterior capsule is injected with 10 mL of a mixture of the following medications: Duramorph (Wyeth-Ayerst Laboratories, Philadelphia, Penn) 10 mg/2 mL + Toradol (Roche Pharmaceuticals, Nutley, NJ) 30 mg/3 mL + bupivacaine 0.25% 10 mL.

The remaining 5 mL of pain cocktail is delivered to the proximal quadriceps tenotomy once sutured and before closure of the subcutaneous tissue. A deep drain coupled to a cell saver device is then placed laterally to the incision. The drain is removed during the first postoperative day rounds.

6. **Postoperative medications.** The following medications are ordered as postoperative analgesia medications to be administered around the clock after the patient leaves the postoperative recovery unit: OxyContin 10 mg twice daily, Celebrex 200 mg twice daily, and Tylenol 650 mg every 8 hours.

7. **Coadjuvant medications.** Additional medications ordered as part of the postoperative management have been shown to increase the effectiveness of pain control (RA Berger [Chicago] and LDM Dorr [Los Angeles], oral communication, 2003): Restoril (Mallinckrodt Pharmaceuticals, Hazelwood, Mo) 15 mg at night for an adequate sleep period; Protonix (Wyeth Pharmaceutical, Philadelphia, Penn) 40 mg orally once a day; Zofran 4 mg IV every 8 hours until the patient tolerates fluids. Breakthrough narcotic medications are also ordered as needed: OxyIR (immediate release) 10 mg or morphine 10 mg in 3-mL boluses of a 10-mL saline dilution. These medications are administered every 3 to 6 hours at the discretion of the floor nurse whenever the patient feels the need of additional analgesia. Patients older than 65 years receive Darvocet (Xanodyne, Florence, Ky) instead of OxyContin. No additional monitoring was done.

8. **Discharge medications include Darvocet N-100 every 6 hours as needed for pain, Celebrex 200 mg once a day, and Tylenol 650 mg every 8 hours. Additional discharge medications include Prevacid (TAP Pharmaceuticals, Lake Forest, Ill) 30 mg daily, Restoril 15 mg daily, and Colace (Purdue Pharma) 100 mg twice daily. Coumadin is used as the standard for deep venous thrombosis prophylaxis for 4 weeks with a target international normalized ratio of 1.5 to 2.5. Compressive thrombo-embolic deterrent hoses are also ordered for a total of 4 weeks.

**Continuous Passive Motion.** Continuous passive motion (CPM) is begun in the recovery unit. The settings start at 0° to 30° increasing 10° a day. The CPM is used continuously whenever the patient is in bed during the hospitalization and discontinued when the patient reaches a target of 85° to 90° of flexion.

**Physical Therapy.** Physical therapy was begun in the afternoon if the patient was operated on in the morning and the next day if the surgery was performed after midday. Assisted full weight-bearing is allowed on the first postoperative day with the aid of a knee immobilizer. Patients began ambulation using a walker the following day after surgery. Two therapy sessions were given every day. The knee immobilizer was used until the patient could actively raise the operated extremity in full extension. The patient was discharged to home on the third or fourth postoperative day in the absence of complications or to specific impatient rehabilitation unit or skilled nursing facility, according to a social worker evaluation and to assessment of patient independence and home support.

**Follow-Up.** Each patient was seen at the office 1 week after discharge and weekly if the range of motion was not at 90°. Additional physical therapy was prescribed if a patient had suboptimal range of motion. In our practice, the threshold for manipulation was 90°. Any patient with flexion below this threshold at week 3 was given extra pain medications and daily physiotherapy. If the motion did not improve more than 90° by week 4, the patient was encouraged to schedule a mobilization under anesthesia. The same postoperative pain protocol was used after the procedure.

**Manipulation Method.** Patients were manipulated under general anesthesia and muscle relaxation. Patients were placed in the decubitus supine position in the operating table with the ipsilateral hip flexed to 90°. The knee was carefully but firmly brought into flexion with the limb held at the proximal third of the tibia to prevent excess lever arm forces. Flexion was continued until an audible and or palpable lysis of adhesion was noted, indicating that a firm end point is reached. Gravity passive flexion is then repeated several times to further verify completeness of the procedure. Physical therapy was begun immediately including the use of CPM.

**Statistics**

We used descriptive statistics to examine our results and describe incidence of manipulation and time to manipulation. An independent $t$ test was used to assess for differences between groups with respect to incidence of manipulation. We also used independent $t$ tests to compare active and passive knee flexion and extension range of motion between those who had manipulation after having the traditional pain protocol and those who had manipulation while previously having the multimodal pain management program. $\alpha$ was set at .05.

**Results**

Group A had an incidence of manipulation of 4.75%: 37 of 778 cases required manipulation within the first 6 weeks postoperatively (Fig. 1). Thirty (78.9%) were female, and 7 (21.1%) were male. The average age of
this group was 63.2 years (range, 31-93 years), and their mean BMI (weight in kilograms divided by the square of height in meters) was 31.2 kg/m² (range, 23.2-40.2 kg/m²). Twenty-six were Hispanics (70.2%), 9 (24.3%) were white, and 2 (5.4%) were African American. The average time between the index procedure and the day of manipulation was 42.5 days (range, 5-76 days). None of the patients required a second manipulation, and the restoration of flexion was retained at the latest follow-up. Of the 778 procedures in this group, 309 were on the right knee and 277 on the left knee; 96 were bilateral.

Of 357 patients, a total of 8 required manipulation in group B, which is an incidence of 2.24%. This represents approximately a 50% reduction in the incidence of manipulation with respect to group A (Fig. 1). Of these patients, 3 (37.5%) were male and 5 (62.5%) female. The average age was 74.22 years (range, 66-86 years) and their average BMI (kg/m²) was 31.4 (range, 15.7-38.12 kg/m²). The average time to manipulation was 38 days (range, 7-58 days). At the latest follow-up, all the patients had retained their improved range of motion. One procedure in this group was in the right knee and 7 were on the left. One patient had bilateral manipulation. No complications secondary to the manipulation in either group were noted, and no subject refused to have MUA. All protocols were standardized; however, the “on-demand” drugs were based on patient requirements and age. Administration of drug may have been different from patient to patient. No additional monitoring was needed, and there were no intensive care unit transfers or complications related to oversedation.

For active knee joint extension and flexion before surgery, there was no difference between those who had manipulation after having the traditional pain protocol (1.94 ± .87, 102.38 ± 3.26, n = 8) and those who had manipulation while previously having the multimodal pain management program (1.25 ± 1.25, 101.25 ± 3.87, n = 8). After surgery, there was no difference in active knee joint extension and flexion between those who had manipulation after having the traditional pain protocol (1.94 ± .87, 102.38 ± 3.26, n = 8) and those who had manipulation while previously having the multimodal pain management program (1.25 ± 1.25, 101.25 ± 3.87, n = 8). After surgery, passive knee joint extension and flexion was not different between those who had manipulation after having the traditional pain protocol (1.83 ± .87, 105.60 ± 3.17, n = 37) and those who had manipulation while previously having the multimodal pain management program (0.63 ± 0.62, 106.88 ± 4.81, n = 8).

**Discussion**

Arthrofibrosis after TKA continues to be a significant complication for orthopedic surgeons [4]. In some series of revision TKA, arthrofibrosis has been present in almost 17% of cases [4]. The reported incidence of manipulation after TKA shows inconsistent rates [10-12]. The threshold for manipulation, on the other hand, is relatively consistent with most authors manipulating the knees that do not bend past 90° at 4 to 6 weeks. Our study showed 37 manipulations in the group of 778 patients managed with traditional pain protocols (4.75%) and 8 manipulations for the group of 357 patients in which a new multimodal pain management was used (2.24%).

Spicer et al [13] reported 376 manipulations in a group of 1656 procedures, which represent 22.7% with 90° as trigger point. Similarly, Maloney [14] reported in an article published in 2002 a manipulation rate of 11% in a cohort of 214 patients of which 24 underwent the procedure. Branden et al [7], describing the natural history of postoperative pain after TKA, reported a rate of 10.7% (14/130) patients who required manipulation, of which a greater percentage had reported a preoperative pain score of 40 or more in a visual analog scale. The later studies reported rates of manipulation similar to our control group and 2 times that of the multimodal protocol patient group.

According to recent projections, the number of TKAs performed in the United States will be more than 3.5 million by the year 2030 [15]. Conservative estimates would project about 50 000 manipulations performed yearly. In a conversation, C. Ranawat (2003) emphasized the fact that 85% of the patients will recover successfully after a TKA regardless of the postoperative protocol followed. The other 15% is susceptible to the development of arthrofibrosis (C. Ranawat, oral communication, 2003). The costs and patient burden of this problem could be significant. Strategies to diminish this complication would greatly assist orthopedic surgeons in their mission to improve already excellent outcomes. The most common
complaint of patients who do not bend in the early postoperative period is excessive pain. An exaggerated pain response will make the patient not move the leg during the critical stages of healing, and excessive fibroplasia with rapid intraarticular scar formation will probably occur, thus “freezing” the knee in an unfavorable arc of motion.

The multimodal pain management protocol currently used in our unit may have decreased the incidence of this complication by about 50%. Although not assessed in our study, we believe that improvements in pain management impact the range of motion after TKA by reducing the spikes of pain observed with the “on demand or only when it hurts” pain control approach used by most community surgeons (Fig. 2). Preemptive pain management will avoid large pain spikes (Fig. 3) and keeps the pain at a tolerable level. This lower level of pain in the first days after surgery should allow the range of motion to be maintained and reduce the risk of developing adhesions and scars. Muscle strength should be recovered at an earlier time and muscle wasting reduced to a minimum [11]. In addition, total narcotic consumption and their most undesirable side effects (oversedation, constipation, pruritus, and abdominal intolerance) should significantly diminish [16]. With the on-demand pain protocol, susceptible patients would fixate on the pain felt during the spikes and could get “frozen” low levels of flexion. Our data suggest that the preemptive pain management with aggressive perioperative pain control will result in the lowering of the MUA rates.

The results of this investigation demonstrate an impressive 47.1% reduction in the number of MUAs performed in the group managed with a multimodal pain protocol with respect to the group that did not receive the protocol. Although there was no significant difference in range of motion after surgery between those who had manipulation after having the traditional pain protocol and those who had manipulation while previously having the multimodal pain management program, individuals who had manipulation

within the multimodal pain group had slightly greater knee flexion. Because of the small sample size, we recommend further, much larger studies address the effect of pain protocols on range of motion and function. The magnitude of this reduction clearly suggests significant benefits deriving from adequate pain management protocol. This effect has also been observed in other subspecialties of orthopedic surgery [16]. Although we do not know which portion of the multimodal protocol is the most important factor in the reductions observed, the combination certainly has shown an effect in the overall rate of manipulation observed in our cohort. A significant weakness of our study is that it is not a randomized prospective series. We also did not compare group characteristics. In addition, this pain protocol did not have any complications directly resulting from the protocol. We recommend that orthopedic surgeons consider using a multimodal pain management protocol with preemptive analgesia for TKA.

Fig. 2. Pain spikes grow with increasing time after surgery, at which moment patients use the patient-controlled anesthesia pump or demand intravenous narcotics that cause a sharp but short plunge of pain levels below the threshold of perception.

Fig. 3. With multimodal pain management and preemptive analgesia, pain medications are present before the painful stimulus begins and in sufficient amounts for an adequate period, preventing the formation of pain spikes beyond the threshold.

References