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Rehabilitation After Total Knee Arthroplasty

A Comparison of 2 Rehabilitation Techniques

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This study was conducted to compare postoperative total knee arthroplasty rehabilitation protocols. The hypothesis of this study was that patients undergoing total knee arthroplasty could achieve range of motion and hospital discharge in the same period using a postoperative rehabilitation protocol that did not use a continuous passive motion machine. This randomized prospective study compared 46 total knee arthroplasties in which a continuous passive motion machine was used with 37 total knees that were rehabilitated with early passive flexion of the knee (named drop and dangle protocol). Postoperative physical therapy regimens were otherwise the same for both groups. Surgical technique was the same for both groups except for closure which was performed in the drop and dangle group with the knee at 90° to 95° flexion. Only patients with osteoarthritis were included in the study, and in both groups of patients received the same prosthetic components. Patients in the drop and dangle group were discharged from the hospital 1 day earlier (p = 0.01) and had a statistically better extension range of 2.8° at 6 months (p = 0.03). Knees in the drop and dangle group had less drainage (p = 0.06). Range of motion and hospital discharge can be achieved in a similar time interval with the drop and dangle technique as with using a continuous passive motion device, and that such a device is not required for postoperative knee rehabilitation.

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In this decade of American health care reform, postoperative rehabilitation for total knee arthroplasty has gained in importance. The demands of decreasing hospital length of stay and lowering hospital costs have become paramount. Postoperative rehabilitation for primary total knee arthroplasty continues to be studied so that cost is decreased while still providing the quality of clinical results expected by the surgeon and the patient.

The use of a continuous passive motion machine for postoperative total knee arthroplasty rehabilitation has been promoted as a means to facilitate a more rapid recovery.[1,3–7,10,16,18] Coutts and coworkers[4,5] initiated the use of a continuous passive motion machine for postoperative rehabilitation for total knee arthroplasty and they reported favorable results. However, with subsequent studies, the effect of continuous passive motion machines on analgesia consumption, range of motion (ROM), hospital stay, and complications has been variable.[3,6,7,10–12,14–18] One investigator introduced the concept of a drop and dangle technique for postoperative ROM. With this technique, the knee is closed in flexion and the patient actively flexes the knee beginning on the first postoperative day to 90° (verbal communication, K Bramlett, MD. Suggested at the Joint Implant Surgery Research Foundation Symposium at Montreal, Canada, August 1993). He suggested that the use of this technique facilitates discharge from the hospital which will lower the cost of a total knee arthroplasty.

The hypothesis of this study is that the drop and dangle technique would achieve ROM and function more quickly than the use of a continuous passive motion machine, thereby decreasing hospital stay and cost. In addition, the ROM and muscle strength would be compared at 3 and 6 months to determine if ultimate function is improved.

MATERIALS AND METHODS

A randomized prospective study was conducted comparing 2 groups of patients undergoing unilateral primary total knee arthroplasty. Only patients with osteoarthritis were entered into the study. Seventy–three patients (83 knees) were entered into the study. A random number generator was used to assign patients before their surgery into 1 of 2 rehabilitation protocols: (1) continuous passive motion machine plus physical therapy or (2) drop and dangle plus physical therapy.

Patients were evaluated clinically preoperatively and postoperatively using the Knee Society scoring system. Postoperatively, patients were evaluated at 6 weeks, 3 months, and 6 months. Patient self assessment forms (Orthographics form SF-36, Orthographics, Salt Lake City, UT) were completed by the patients preoperatively and at 6 months postoperatively. Radiographs were obtained preoperatively and at the same postoperative intervals. Radiographs obtained included a standing anteroposterior 17 inch radiograph, a 17 inch lateral radiograph of the knee at 30° to 45° flexion, and a sunrise view of the patella. Range of motion was measured preoperatively by the surgical staff. Range of motion while in the hospital was measured by the physical therapy staff. Postoperative ROM was measured by the surgical staff. When comparing the ROM between the 2 groups, each patient was used as his or her own control. The preoperative range of extension and flexion for each patient was compared with that patient's postoperative extension and flexion range. The differences between each extension and flexion range for each patient were collated for an average gain or loss of extension and flexion range. For example, if the preoperative ROM was 10° extension to 110° flexion and the postoperative ROM was 0° extension to 120° flexion, the gain in extension range was +10° and the gain in flexion range was +10°.

All operations were performed by 2 surgeons (EJM and LDD) using the Apollo Knee System (Intermedics Orthopedics, Austin, TX) (Fig 1). According to a concomitant ongoing study, patients either received a cruciate retaining or posterior stabilized Apollo knee replacement. In each knee, all components were cemented and all patellae were resurfaced. The tibia was prepared to create a neutral (90°) surface to the mechanical axis of the tibia with a 7° posterior slope using intramedullary instrumentation. Distal femoral cuts were made to create 5° to 7° valgus anatomic axis for the leg. Soft tissue releases were performed to balance the knee in extension and in flexion. A tourniquet was used unless the patient had diabetes or absent peripheral pulses. The tourniquet was inflated to 250 mm Hg with the knee fully flexed and was deflated after the components had been cemented. No drains were used in these knees.

An epidural catheter was used in all patients in the operating room. Some patients had additional general anesthesia. Postoperative analgesia was given by a continuous perfusion pump using Duramorph (Astra, Westborough, MA). The epidural catheter was removed on the second postoperative day and subsequent analgesia was administered by oral medication.

For antibiotic coverage, 1g of Cefazolin (Marsam Pharmaceutical, Cherry Hill, NJ) was administered intravenously before the incision and was given every 8 hours for 48 hours or until the Foley catheter was removed after discontinuing the epidural catheter.

Anticoagulation prophylaxis used in this study included the use of antiembolic stockings (TED hose, Kendall, Mansfield, MA), pneumatic foot compression devices, (PlexiPulse, NuTech, San Antonio, TX), Toradol (Syntex, Palo Alto, CA),

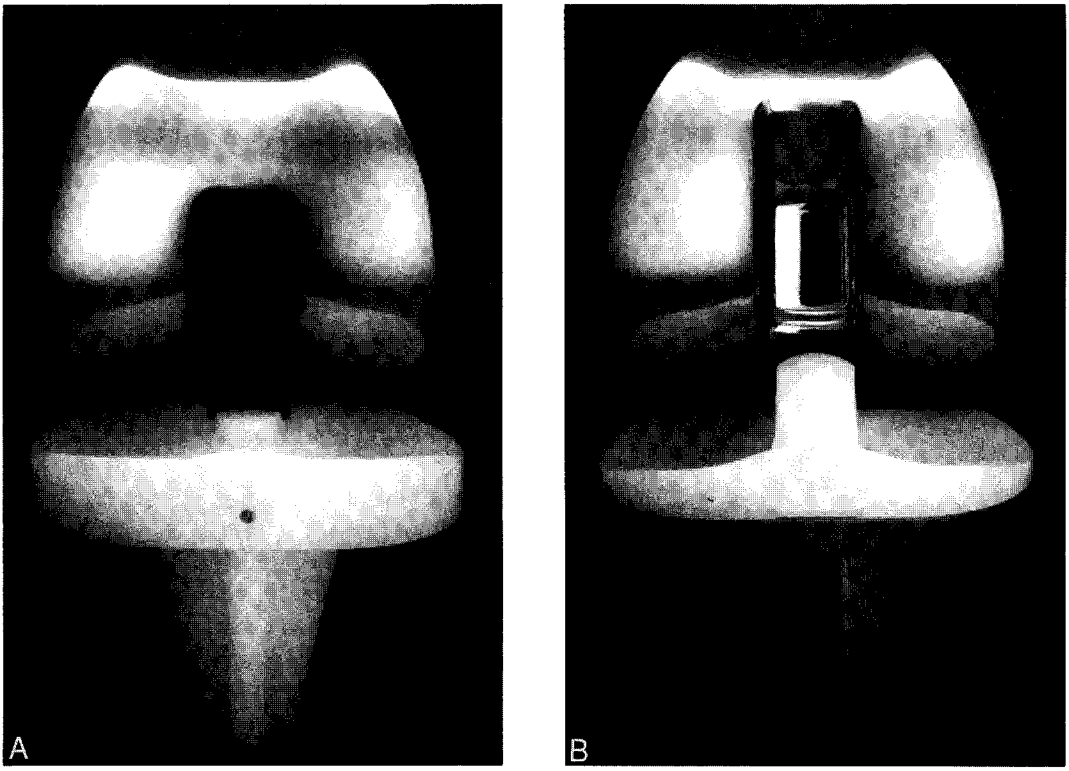

Fig 1A–B. Photographs of the total knee system used in this study. (A) The Apollo cruciate retaining knee with an all polyethylene tibial tray. (B) An Apollo posterior stabilized knee with a metal backed tibial tray. The articulation surface is the same as the cruciate retaining knee and the contract area is the same because the anterior tibial eminence position avoids rollback.

aspirin or Persantine (UDL Labs, Rockford, IL). A TED hose and a pneumatic foot compression device (PlexiPulse) were applied to the nonoperative leg during surgery. The TED hose for the operated leg was applied on the second postoperative day. The TED hose were worn continually for 4 weeks. The contralateral PlexiPulse was applied in the recovery room. The PlexiPulses were discontinued when the patients could walk 100 feet and could do independent transfers. Toradol was administered intravenously in the recovery room at a dose of 60 mg, and then a dose of 30 mg was administered intravenously every 8 hours for 24 hours. After the use of Toradol, 650 mg of aspirin was given twice daily for 4 weeks.

Patients remained in the acute surgical unit until they met criteria for discharge which included a dry wound, a minimum of 80° knee flexion, 300 feet ambulation twice a day with a single crutch or single point cane, and independent transfers. Patients who did not meet these criteria by the fifth postoperative day were discharged to the hospital rehabilitation unit. Patients selected for admission to the rehabilitation unit were usually elderly patients who lived alone and often needed additional therapy for independent living, or patients with multiple medical conditions who were not in good physical condition.

Patients entered into the continuous passive motion protocol had the arthrotomy and subcutaneous tissue and skin closed in extension after deflation of the pneumatic tourniquet. A compressive dressing was applied for approximately 36 hours. Patients were started on the continuous passive motion machine (Kinetec, Smith and Nephew, Memphis, TN) in the recovery room with an initial setting of 0° to 90°. The continuous passive motion machine was used approximately

10 hours per day. In the evening the leg was placed into a knee immobilizer and elevated on a pillow until the next morning.

Patients entered into the drop and dangle protocol had the arthrotomy and subcutaneous tissue and skin closed with the knee positioned at 90° to 95° flexion after deflation of the tourniquet. A loose dressing was applied with the knee in 90° flexion. The leg was placed into a knee immobilizer. On postoperative Day 1, the immobilizer was removed and passive ROM was begun. The patient was positioned at the side of the bed or in a chair and the foot was placed on the floor by the therapist. With the foot firmly on the floor, the patient moved his or her body forward until 90° knee flexion was achieved. The patient then remained with the knee in the flexed position for a minimum of 20 minutes twice a day. Pain medication was administered as needed to attempt to achieve 90° flexion at each session. Not every patient could achieve 90° flexion at every session. As pain and swelling diminish, the time that the patient kept the knee in the flexed position was extended to 30 to 45 minutes for each session.

In both groups, patients received 2 hours of daily physical therapy consisting of isometric exercises, passive ROM, active assisted ROM, quadriceps and hamstring strengthening, and gait training that included stairs. Functional electrical stimulation was used when there was an extensor lag more than 30°, or if the patient could not perform an independent straight leg raise on the third postoperative day. Ambulation began on the first postoperative day. A knee immobilizer was worn during ambulation until the patient demonstrated adequate quadriceps control.

Statistical analysis was performed on Microsoft Excel version 7.0. (Microsoft, Redmond, WA) Demographic data were analyzed by the chi square test. Comparison of the 2 study cohorts was performed using the single tail study t test. Multivariate analysis was used to compare the 2 groups for the factors of age, weight, gender, preoperative ROM, cruciate retaining knee design, and posterior stabilized knee design.

RESULTS

The study groups consisted of 40 patients (46 knees) in the continuous passive motion group and 33 patients (37 knees) in the drop and dangle group. The average age of the continuous passive motion group was 69.3 years (range, 52–86 years) versus 68.1 years (range, 42–88 years) in the drop and dangle group ($p = 0.53$). There were 17 men, 5 having bilateral total knee arthroplasties, and 23 women, 1 having bilateral total knee arthroplasties, in the continuous passive motion group. In the drop and dangle group there were 11 men, 1 having bilateral total knee arthroplasties, and 22 women, 3 having bilateral knee arthroplasties ($p = 0.16$). The average followup for the continuous passive motion group was 4.76 months (range, 3–6 months) and in the drop and dangle group it was 4.1 months (range, 3–6 months), ($p = 0.67$).

Knee scores, radiographic data, and preoperative ROM are summarized in Table 1. Preoperative knee scores and function scores were recorded for all patients. Postoperative knee scores were obtained at 6–month followup. Twenty-six patients in the continuous passive motion group and 20 patients in the drop and dangle group had 6–month followup postoperatively.

Radiographic analysis on preoperative anatomic axial alignment showed that 29 of the knees in the continuous passive motion group and 23 of the knees in the drop and dangle group had an anatomic axis of less than 0° (a varus anatomic alignment). Postoperative anatomic axis in the continuous passive motion group showed 1 patient with an anatomic axis of less than 0°. No knee in the drop and dangle group had an anatomic axis less than 0°. Forty–four of the knees in the continuous passive motion group and 36 knees in the drop and dangle group had an anatomic axis between 0° and 10°. One knee each in the continuous passive motion and drop and dangle group had an anatomic axis greater than 10° ($p = 0.66$).

Ten of the knees in the continuous passive motion group and 4 in the drop and dangle group had their tibial component either in more than 3° varus or 3° valgus ($p = 0.18$).

TABLE 1. Continuous Passive Motion Versus Drop and Dangle: Anatomic Axial and Function

Clinical and Radiographic Assessments	Alignment Parameters	Continuous Passive Motion	Drop and Dangle	p
Preoperative Knee Society score		37.8	43.2	0.08
Preoperative Knee Society function score		44.5	47.4	0.38
Postoperative Knee Society score		82.7	80.7	0.78
Postoperative Knee Society function score		71.8	70.5	0.84
Preoperative anatomic axial alignment on radiograph	< 0°	29	23	0.44
	0°–10°	14	8	
	> 10°	3	5*	
Postoperative anatomic axial alignment on radiograph	< 0°	1	0	0.66
	0°–10°	44	36	
	> 10°	1	1	
Anteroposterior femoral alignment on preoperative radiograph	0°–10°	43	35	0.83
		3	2	
	< 0° or > 10°			
Anteroposterior tibial alignment on postoperative radiograph	–3°–3°	36	33	0.18
	<–3° or > 3°	10	4	
Lateral femoral alignment on postoperative radiograph	0°–10°	36	25	0.27
		10	12	
	<–10° or >10°			
Lateral tibial alignment posterior slope	0°–10°	39	35	0.15
	< 0° or >10°	7	2	
Patellar tilt on radiograph	–5°–5°	31	23	0.78
	<–5° or > 5°	14**	9†	
Patellar displacement on radiograph	–5–5 mm	16	15	0.31
	<–5 or > 5 mm	29	17	
Preoperative range of motion		104.2 (30–120)	108.1 (83–135)	0.29

* Missing 1 knee radiograph.

** Missing 1 knee radiograph.

† Missing 5 knee radiographs.

Ten of the patients in the continuous passive motion group and 12 of the patients in the drop and dangle group had their femoral component fixed in either greater than 10° extension or 10° flexion (p = 0.27).

Lateral tibial alignment in 39 of the knees in the continuous passive motion group and 35 knees in the drop and dangle group had their tibial component fixed between 0° and 10° posterior slope.

Preoperative flexion in the continuous passive motion group showed an average of 104.2° with a range of 70° to 120° compared with the drop and dangle group with an average of 108.1° with a range of 83° to 135° (p = 0.29). Preoperative extension was an average of 8° with a range of 0° to 40° for the continuous passive motion group compared with an average of 5.2° with a range of 0° to 20° in the drop and dangle group (p = 0.06).

In the continuous passive motion group, 21 knees received a cruciate retaining design compared with 18 knees in the drop and dangle group. Twenty-five knees in the continuous passive motion group and 19 knees in the drop and dangle group received a posterior stabilized design. In the continuous passive motion group, the average ROM of the cruciate retaining knee at 3 months followup was 4.3° to 112.3°, compared with 4.3° to 110.3° in the posterior stabilized group (flexion p = 0.54) In the drop and dangle group at 3 months, the ROM for the cruciate retaining design was 3.6° to 111.5°, compared with 2.5° to 117.2° in the posterior stabilized group (flexion p = 0.16). At 6 months in the continuous passive motion group for the cruciate retaining design, extension was 3.1° and flexion was 116.2°. In the posterior stabilized design group, extension was 3.9° and flexion was 114.3° (flexion p = 0.72). At 6 months with drop and dangle in the cruciate retaining design group, extension was 1.1° and flexion was 114.4°. The posterior stabilized group had extension of 0° with flexion of 113° (flexion p = 0.8).

Net gain or loss of flexion or extension was evaluated using the patients' preoperative and postoperative measurements. For extension, knees at 6 months had a gain of 2.3° ± (–20°– +15°) in the continuous passive motion group and a gain of 4.9° ± (–2°– +15°) in the drop and dangle group (p = 0.22). For flexion at 6 months, the continuous passive motion group showed an average gain of 2.4° (–30– +35°) compared with 0.7° (–25– +20°) in the drop and dangle group (p = 0.71).

Hospital admission data are summarized in Table 2. Twenty–seven knees (23 patients) from the continuous passive motion group and 21 knees (18 patients) from the drop and dangle group were admitted to the rehabilitation unit. The only statistical difference is for those patients who were discharged directly home. The average hospital stay for patients in the drop and dangle group was on average 1 day less than the continuous passive motion group.

The flexion and extension ROM of the 2 groups are summarized in Tables 3 and 4. Table 3 compares the flexion range of the 2 groups at succeeding time intervals. There was no significant difference between the drop and dangle and the continuous passive motion group at all stages of followup. Extension range is compared in Table 4 and

TABLE 2. Hospital Admission Data

Study Parameter	Continuous Passive Motion	Drop and Dangle	p
Patients discharged home (knees)	(n = 17) (19)	(n = 15) (16)	0.74
Patients sent to rehabilitation (knees)	(n = 23) (27)	(n = 18) (21)	
Average length of stay in days for all patients (range)	12.1 (5–41)	12.5 (3–30)	0.77
Average length of stay in days for patient discharged home (range)	7.1 (5–11)	5.5 (3–8)	0.01
Average length of acute stay days for patients sent to rehabilitation (range)	5.2 (3–19)	5.9 (3–15)	0.49
Average length of rehabilitation days for patients sent to the rehabilitation department (range)	10.9 (4–35)	11.8 (5–21)	0.53

TABLE 3. Passive Flexion Range of Motion

Range of Motion (°)	Continuous Passive Motion	Drop and Dangle	p
Average flexion Postoperative Day 5 (range)	83.1 (56–102)	84.5 (52–100)	0.55
Average flexion 6 weeks postoperative (range)	104.9 (65–110)	104.1 (82–135)	0.79
Average flexion 3 months postoperative (range)	111.1 (90–130) (n = 40)	114.6 (100–140) (n = 34)	0.19
Average flexion 6 months postoperative (range)	115.2 (90–135) (n = 27)	113.9 (105–140) (n = 14)	0.71

there is a significant difference in extension range at 6 months with the drop and dangle group doing better (p = 0.03). Extension lag averaged 6.8° in the continuous passive motion group and 8.3° in the drop and dangle group at Day 5. Six weeks postoperatively, extension lag was 1.3° in the continuous passive motion group and 0.6° in the drop and dangle group (p = 0.52). There was no patient in either group with an extension lag at 3 months followup or 6 months followup.

Eleven knees had wound drainage that required withholding physical therapy in the continuous passive motion group versus 3 in the drop and dangle group (p = 0.06). Three knees in the continuous passive motion group and 1 in the drop and dangle group required hematoma evacuation (p = 0.21). Closed manipulation was performed in 1 knee in the continuous passive motion group and in 3 knees in the drop and dangle group (p = 0.11). No knees in either the continuous passive motion group or drop and dangle group had a deep venous thrombosis. One patient in the drop and dangle group had a documented pulmonary embolism on ventilation and per-

TABLE 4. Passive Extension Range of Motion

Extension Range of Motion (°)	Continuous Passive Motion	Drop and Dangle	p
Average extension postoperative Day 5 (range)	9.3 (0–18)	9.2 (0–22)	0.96
Average extension 6 weeks postoperative (range)	5.8 (0–34)	6.4 (0–15)	0.84
Average extension 3 months postoperative (range)	4.3 (0–15)	2.3 (0–15)	0.28
Average extension 6 months postoperative (range)	3.5 (0–20)	0.7 (0–5)	0.03

fusion lung scan with a negative doppler scan of his lower extremities ($p = 0.26$)

DISCUSSION

The hypothesis in this study was that the drop and dangle technique would achieve ROM and function more quickly, thereby decreasing hospital stay and costs. This study proved that discharge from the hospital was accomplished more quickly with the drop and dangle technique. Cost is positively affected because the cost for the use of the continuous passive motion machine is eliminated and 1 day of hospitalization cost is eliminated. Furthermore, this savings in hospital time and cost is accomplished without any increase in complications. There is no difference between the number of patients who required admission to the rehabilitation unit between the 2 groups. Admission to the rehabilitation unit was more a function of the age and home situation of the patient than of the rehabilitation technique.

Previous studies have documented that the use of a continuous passive motion machine for total knee arthroplasty rehabilitation improves flexion range, decreases length of hospital stay, and lowers the amount of narcotic use.[3–5,7,10,11,16–18] However, none of these previous studies compared the continuous passive motion rehabilitation against a protocol where the knee wound was closed at 90° flexion and the drop and dangle technique was used. In this study the use of the continuous passive motion machine did not diminish complications such as knee stiffness, wound drainage, and deep vein thrombosis.

A concern in the drop and dangle group was extension lag. With the drop and dangle technique, the knee is closed in 90° to 95° flexion, and because of this the extensor mechanism is relatively loose in extension. In actuality, the extension range of the knees in the drop and dangle group was no different at 6 weeks and 3 months, and was better at 6 months followup. Closure of the knee arthrotomy in flexion does not hinder knee extension. Knee flexion for the drop and dangle knees was better at discharge, but at all subsequent intervals the knee flexion did not differ between the 2 rehabilitation techniques. Quadriceps strength, as measured by the presence of an extensor lag, did not differ between the 2 rehabilitation techniques at 6 weeks and was eliminated by 3 months postoperative in both groups. Muscle strength is not hindered by closing the knee in flexion.

This study would suggest that the most cost effective technique for postoperative rehabilitation of total knee arthroplasty is the drop and dangle protocol. Epidural analgesia in the first 48 hours postoperatively is very effective in permitting the patients to accomplish the goals of this therapy. The cost savings is both a decrease in hospital stay and the elimination of the use of the continuous passive motion machine. The drop and dangle technique was equally effective for both cruciate retaining and posterior stabilized knees. This study also confirms that ultimate postoperative ROM is directly correlated to preoperative ROM more than the type of knee used or the postoperative rehabilitation technique.

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