Use of Drop and Dangle Rehabilitation Protocol to Increase Knee Flexion Following Total Knee Arthroplasty: A Comparison with Continuous Passive Motion Machine

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Background: *There are variations in the type of rehabilitation program and duration of using the continuous passive motion (CPM) machine to increase range of motion (ROM) following total knee arthroplasty (TKA).*
Objective: *To compare the outcomes of the 'drop and dangle' (D&D) protocol vs. a 3-hour daily CPM for the purpose of increasing flexion following TKA.*
Material and Method: *A prospective non-concurrent controlled intervention study was conducted on patients who underwent primary TKA at Lampang Hospital from December 2009 to August 2011 (D&D group, n = 36) and from September 2011 to December 2012 (CPM group, n = 33). The same surgeon using the same prosthesis design performed all surgeries. The legs in D&D group were placed into the knee immobilizer at 70° flexion and removed on postoperative day 1 (POD1). The passive ROM exercise was then started by dropping the affected leg over the bedside, and gently flexing and bending the knee with the help of the unaffected leg to achieve maximal flexion. The legs in the CPM group were immobilized with a Jones bandage in full extension for 24 hours, and then placed into CPM machine for three, 1-hour per day sessions. The clinical data were statistically compared between the two groups.*
Results: *Patient baseline characteristics in both groups were not different. The D&D group had more average passive flexion in POD1 (67.0°±14.2° vs. 59.1°±3.2°, p<0.001) and POD2 (76.6°±14.2° vs. 69.8°±13.3°, p = 0.008). Higher rates of flexion were observed in PODs 3-7 but they were not significant. Flexion at discharge in the D&D group was 100.6°±6.8° and 96.4°±10.2° in the CPM group (p = 0.005). At 6 weeks, rates of flexion in both groups were similar (D&D 99.8°±10.4°, CPM 103.9°±10.4°, p = 0.138). Rates of flexion were also similar at 1 year (D&D 112.0°±10.4°, CPM 111.6°±12.6°, p = 0.892).*
Conclusion: *D&D protocol provided more passive knee flexion than the use of CPM in the first two days after TKA and at discharge. These differences were not significant at 6 weeks and 1 year.*

Keywords: *Rehabilitation, Total knee arthroplasty, Continuous passive motion, Range of motion, Flexion*

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Knee range of motion (ROM) is a major factor used in assessing the successful outcome of total knee arthroplasty (TKA)[1]. Postoperative rehabilitation is also important with the objective of mobilizing the patient and regaining knee ROM. The use of the continuous passive motion (CPM) machine has thus been advocated to facilitate a more rapid recovery. The traditional postoperative program for TKA at Lampang Hospital indicated a fully-extended immobilization in a Jones bandage or slab for 24-48 hrs after surgery. The patients then started ROM exercise in the CPM until passive flexion beyond 90° was achieved prior to discharge. From 2009-2011, the authors implemented a rehabilitation program that would be used as an alternative to CPM. Specifically, the 'drop and dangle' (D&D) technique was adopted from a study by Kumar et al[2]. Their protocol started early passive knee flexion by standing at the bedside or sitting in the chair. With the affected foot firmly placed on the floor, the patient slowly moved his or her body forward until 90° knee flexion was achieved. The patient then remained in the flexed position for at least 20 minutes, twice per day.

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Their study found that ROM can be similarly achieved by using CPM for 10 hours daily.

For the present study, the authors modified the Kumar concept by positioning the patient to sit on the side of the bed. The patient then gently dropped the affected leg down to just above the floor, and dangled and bent the knee passively in an attempt to achieve maximal flexion. The leg was then extended; this was repeatedly performed. Rehabilitation by sitting on the side of the bed was found to be less time-consuming for clinical support personnel than standing or sitting in a chair. The authors believed that the short-term benefits of our D&D protocol would be similar to those of CPM. The goal of the present study was to compare the D&D protocol and the CPM protocol to assess differences in knee flexion outcomes within the first year following primary TKA.

Material and Method

The present study was approved by the Research Ethics Committee of Lampang Hospital. Each patient had to sign an informed consent waiver before being allowed to participate in the present study. A prospective, non-concurrent controlled intervention study was conducted on patients diagnosed with primary osteoarthritis and rheumatoid arthritis who underwent unilateral primary TKA at Lampang Hospital between December 2009 and December 2012. The exclusion criteria included flexion deformity of more than 30°, uncooperative patients and intra-operative complications that required the postponement of early knee motion. The patients who underwent TKAs between December 2009 and August 2011 were categorized as the D&D group. The patients who were operated upon between September 2011 and December 2012 were categorized as the CPM group. All TKAs were performed by the same surgeon (AP), who use mid-vastus approach and one design of posterior-stabilized knee prosthesis (NexGen LPS; Zimmer, Warsaw, Indiana, USA) with patellar resurfacing for all cases.

The legs in the D&D group were placed into the knee immobilizer at 70° flexion position after finishing the surgery and were then removed on postoperative day 1 (POD1). ROM exercise was then started in a sitting position, by dropping the affected leg down to the bedside. The leg was allowed to dangle and the knee was passively flexed maximally with the help of opposite foot for 10 seconds. The affected knee was then actively extended with the bushing assistance of the opposite foot by pushing on the heel of the affected leg (Fig. 1, 2). This exercise was repeated for 1 hour, 3 times daily. The legs in the CPM group were immobilized in a Jones bandage in full extension and removed on POD1. They were then placed on the CPM machine (Kinetec Optima, Smith & Nephew, Tournes, France) for three, 1-hour sessions, starting from 0° to 60°. The ROM was increased 15° or more each day unless not tolerated by the patient. ROM was progressively increased until 110° was achieved.

Patients in both groups received patient education for other types of ROM exercise, including quadriceps strengthening, gait training, and transfers. They began full weight bearing exercise with a walker on POD2. ROM was measured in the sitting position on the bed (during admission) or examination table (during follow-up visits) with the leg dropping and

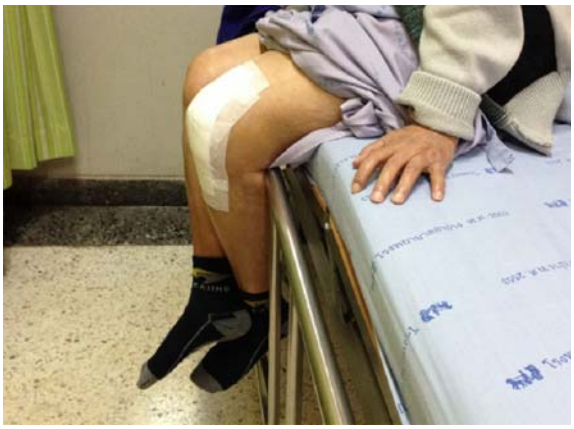

Fig. 1 In flexion, the operated leg was dropped down over the bedside and was passively flexed with the help of the opposite leg.

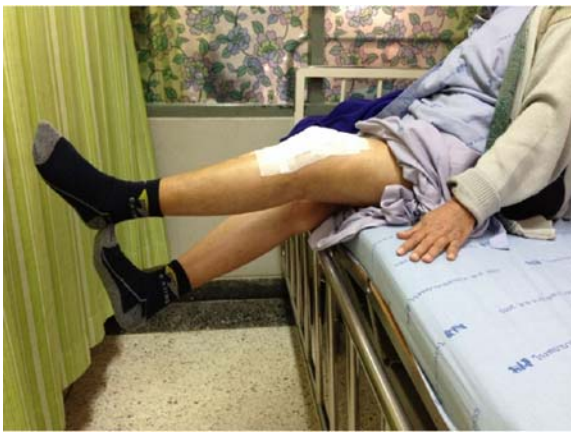

Fig. 2 In extension, the operated leg was actively extended by a pushing on the heel by the opposite leg.

dangling to the side of the bed or exam table. Measurement was performed by interns or trained attending nurses using a 2-degree-increment, handheld goniometer. The fulcrum was centered on the lateral femoral epicondyle. The proximal arm of the goniometer was aligned with the greater trochanter and the distal arm was aligned with the lateral malleolus[3]. Two readings were taken for each measurement and the average value was recorded.

The study sample size was calculated in order to detect a significant difference in postoperative ROM. The authors assumed a difference of more than 10° of knee flexion to be clinically relevant. It has been shown that ascending and descending stairs requires 90°-120° of flexion[4] and the mean postoperative ROM for previous TKAs in the authors' case series was 110.7° (SD 11°). With a two-sided type I error level of 0.05 and a 95% statistical power of detection, the sample size was calculated to be 32 subjects in each group.

Patient demographic information, operative time, postoperative blood loss, length of stay and Knee Society scores were recorded. Passive flexion ROM was compared between groups during admission, at 6-weeks and at 1-year follow-up. Statistical analyses were performed using STATA 10.1 (StataCorp, Texas, USA). The exact probability test was used to analyze categorical data. Wilcoxon's rank-sum test and student t-test were used to analyze continuous data. A *p*-value of 0.05 was regarded as significant.

Results

Forty-five patients received the D&D protocol and 41 used CPM in the present study period. Seven patients were lost to follow-up at 1 year, four had intra-operative femoral condyle fractures, and four had bony reconstruction of tibial defects. Two cases had postoperative delirium and an acute gouty attack. Consequently, there were 36 cases in the D&D group and 33 cases in the CPM group that completed the study. Patient baseline characteristics were not significantly different between the two study groups regarding age, gender, BMI, diagnosis and ASA physical status. Knee ROM, radiographic alignment and Knee Society scores were also similar (Table 1). Flexion contracture in the D&D group was minimally higher than in the CPM group (5.7° vs. 2.4°, $p = 0.046$).

Postoperatively, no differences were observed in type of anesthesia, operative time, blood loss or length of stay. The D&D group had significantly more average passive flexion in POD1 and POD2 than the CPM group (67.0°$\pm$14.2° vs. 59.1°$\pm$3.2°, $p<0.001$ and 76.6°$\pm$14.2° vs. 69.8°$\pm$13.3°, $p = 0.008$, respectively). These higher rates of flexion continued from POD 3-7, but did not reach levels of statistical significance (Table 2). Mean flexion at discharge in the D&D group was 100.6°$\pm$6.8° and 96.4°$\pm$10.2° ($p = 0.005$) in the CPM group.

At the 6-week follow-up, the average flexion in the D&D group (99.8°$\pm$10.4°) was not different from the CPM group (103.9°$\pm$10.4°, $p = 0.138$). At 6 weeks, flexion contracture was not different between the two groups ($p = 0.334$). At the 1-year follow-up, flexion was again not different between the two groups (D&D 112.0°$\pm$10.4°, CPM 111.6°$\pm$12.6°, $p = 0.892$). Knee Society and function scores at 1 year were not significantly different (Table 3). Manipulation under anesthesia at 6 weeks was performed on one knee in each group. One knee in the D&D group had readmission at 2 weeks due to wound hematoma and surgical evacuation was performed. One knee in the CPM group had surgical wound bleeding that required re-operation for cauterization on POD6. One patient in the D&D group had superficial wound necrosis that healed by conservative treatment.

Discussion

The patients who underwent TKA and received the D&D rehabilitation protocol in this study had a significantly higher average passive knee flexion on POD1-2 and at discharge than patients who received CPM (mean difference 7.9° in POD1, 6.8° in POD2 and 4.2° at discharge). Earlier knee flexion in the D&D group was probably a result of the immediate postoperative splint at a 70° flexion position, instead of the full extension experienced by the CPM group. Immobilization in a high flexion angle helps to minimize joint hemarthrosis and periarticular edema resulting from hydrostatic pressure[5]. This concept of facilitating early knee motion was put forth in the study by Kumar et al[2]. They applied a knee immobilizer at 90° flexion for 1 day before starting exercise and found similar ROM on POD5 as the patients who had received CPM for ten hours, daily. Concerns may arise regarding surgical wound problems that could result because skin and subcutaneous circulation may be disturbed in a highly flexed position. This issue did not arise and results were not found to be different from the CPM group in both the present study and the study conducted by Kumar et al.

Short-term results in the present study favored the D&D protocol over CPM, whereas several other systematic reviews favored CPM in the early

Table 1. Preoperative patient characteristics

Demographic data	D&D (n = 36)	CPM (n = 33)	*p*-value
Age (yr)			
Mean (SD)	67.0 (6.2)	68.5 (6.8)	0.345
Range (95% CI)	57-81 (64.9-69.1)	54-82 (66.1-70.9)	
Gender			
Female: male	34: 2	29: 4	0.416
Body mass index (kg/m^2)			
Mean (SD)	24.4 (4.9)	24.2 (4.3)	0.836
Diagnosis (number, %)			
Primary OA	33 (91.7)	30 (90.9)	1.000
Rheumatoid arthritis	3 (8.3)	3 (9.1)	
ASA status (number, %)			
ASA 1	5 (13.9)	1 (3.0)	0.158
ASA 2	26 (72.2)	23 (69.7)	
ASA 3	5 (13.9)	9 (27.3)	
Passive knee flexion (degree)			
Mean (SD)	103.4 (12.3)	104.5 (9.1)	0.931
Range (95% CI)	70-120 (99.2-107.8)	90-120 (100.0-108.3)	
Flexion contracture (degree)			
Mean (SD)	5.7 (7.6)	2.4 (4.2)	0.046
Range (95% CI)	0-30 (3.1-8.3)	0-15 (0.9-3.9)	
Radiographic knee alignment (degree)			
Mean (SD)	Varus 6.0 (5.7)	Varus 4.7 (7.4)	0.762
Range	Valgus 16 to Varus 15	Valgus 15 to Varus 15	
Knee society score			
Mean (SD)	38.5 (11.5)	43.2 (8.1)	0.054
Knee society function score			
Mean (SD)	39.4 (8.1)	41.2 (7.4)	0.348

Table 2. Perioperative clinical characteristics and postoperative ROM during admission

Characteristics	D&D (n = 36)	CPM (n = 33)	*p*-value
Anesthesia (number, %)			
Spinal morphine	32 (88.9)	30 (90.9)	0.602
Spinal morphine + femoral nerve block	1 (2.8)	2 (6.1)	
General anesthesia	3 (8.3)	1 (3.0)	
Operative time [minutes, mean (SD)]	89.4 (9.0)	91.6 (13.4)	0.428
Postoperative blood loss [ml, mean (SD)]	338.2 (172.7)	330.9 (187.5)	0.878
Length of stay [days, mean (SD)]	8.3 (1.7)	7.4 (2.1)	0.060
Passive flexion [degree, mean (SD)]			
POD1	67.0 (14.2)	59.1 (3.2)	<0.001
POD2	76.6 (14.2)	69.8 (13.3)	0.008
POD3	86.4 (12.1)	84.7 (12.2)	0.246
POD4	91.3 (10.0)	91.9 (9.2)	0.325
POD5	95.7 (6.0)	92.4 (10.7)	0.147
POD6	98.1 (5.9)	96.4 (7.5)	0.186
POD7	98.2 (7.2)	97.5 (5.0)	0.865
At discharge	100.6 (6.8)	96.4 (10.2)	0.005

rehabilitation phase after surgery[6-8]. The latest systematic review found that CPM increases knee flexion at 6 weeks, but the improvement is too small to be clinically worthwhile (mean difference 2° of passive

Table 3. Postoperative knee ROM and function scores at follow-up

Characteristics	D&D (n = 36)	CPM (n = 33)	*p*-value
Passive flexion [degree, mean (SD)]			
6 week	99.8 (10.4)	103.9 (10.4)	0.138
1 year	112.0 (10.4)	111.6 (12.6)	0.892
Flexion contracture [degree, mean (SD)]			
6 week	7.1 (7.1)	5.3 (5.3)	0.334
1 year	1.5 (4.2)	1.9 (4.1)	0.638
1-year knee score [points, mean (SD)]			
Knee society score	88.8 (8.9)	92.0 (7.1)	0.101
Knee society function score	89.0 (7.4)	91.1 (7.2)	0.249

flexion and 3° of active flexion)[7]. The difference in knee flexion in the present study was not evident between the groups at the 6-week and 1-year follow-ups. This was similar to most of the previous studies that found no long-term benefit of CPM[9]. The lack of improvement with CPM in recent studies may be due to the current practice of permitting patients to start flexion immediately following surgery[10].

The CPM was applied for 3 hours per day in the present study, a time that is comparatively shorter in duration than in previous studies, because of the limited number of the machines at our hospital. The Cochrane systematic review in 2010 found little or no effect of CPM duration on short-term passive knee flexion ROM. That is, trials that used CPM for 24 hours per day for several days did not report more flexion than those who applied CPM for 2 hours in few days[7]. Similarly, the average 96° of flexion at discharge resulting from using CPM for 3 hours per day in the present study was as high as previous protocols that used CPM 4-12 hours daily[2,6,11-13].

The present study had some limitations. Firstly, it was not a randomized trial due to the period of non-available CPMs in our hospital from 2009-2010. The allocation of subjects might not be homogeneous when comparing groups. However, patient demographic data were not significantly different in either group, except minimally higher flexion contracture in the D&D group. Secondly, this was not a concurrent study that might be biased by the period effect, especially regarding surgeon experience and changing of the corresponding nurses. The TKAs in the present study period were performed by the same experienced surgeon and the authors used only one prosthesis design. Standardized surgical techniques and implants with the same surgeon eliminated the variations between different surgeons' experience, implant designs, and the complexity in results analysis. The corresponding nurses who measured the ROM by goniometer remained the same ones on each ward during the study. The sample size in this study was increased to reach a 95% power of detection, whereas general studies advocate only 80%. A prospectively controlled design also helped to eliminate some selection bias and enhance data validity. The authors believe in the reliability of these findings. The authors encourage other hospitals to adopt this simple, yet effective rehabilitation technique for nurses without depending on CPM or a physical therapist.

In conclusion, the D&D rehabilitation protocol provided more passive knee flexion than the CPM protocol in the first two days after TKA and at the day of discharge. However, the differences were not significant at the 6-week and 1-year follow-ups.

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Potential conflicts of interest

None.

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ผลของกายบริหารเข่าวิธี 'drop and dangle' ภายหลังการผ่าตัดเปลี่ยนข้อเข่าเทียมเปรียบเทียบกับการใช้เครื่องช่วยงอเข่าแบบอัตโนมัติ

อนุวัตร พงษ์คุณากร, ดวงรักษ์ สวัสดิ์ภาพ

ภูมิหลัง: มีความหลากหลายของวิธีกายบริหารเข่าและระยะเวลาของการใช้เครื่องช่วยงอเข่าแบบอัตโนมัติ (CPM) ในการเพิ่มพิสัยการงอเข่าภายหลังการผ่าตัดเปลี่ยนข้อเข่าเทียม

วัตถุประสงค์: เพื่อศึกษาผลของกายบริหารเข่าวิธี 'drop and dangle' (D&D) ในการเพิ่มพิสัยการงอเข่าภายหลังการผ่าตัดเปลี่ยนข้อเข่าเทียมเปรียบเทียบการใช้ CPM วันละ 3 ชั่วโมง

วัสดุและวิธีการ: เป็นการศึกษาแบบ prospective non-concurrent controlled intervention study ในผู้ป่วยที่ได้รับการผ่าตัดเปลี่ยนข้อเข่าเทียมในโรงพยาบาลลำปาง ระหว่างเดือนธันวาคม พ.ศ. 2552 ถึงเดือนสิงหาคม พ.ศ. 2554 (กลุ่ม D&D, จำนวน 36 ราย) และเดือนกันยายน พ.ศ. 2554 ถึง เดือนธันวาคม พ.ศ. 2555 (กลุ่ม CPM, จำนวน 33 ราย) กลุ่ม D&D ได้รับการดามขาในท่างอเข่า 70° ทันทีหลังผ่าตัดด้วยเบาะรองและเอาออกหลังผ่าตัด 1 วัน เริ่มบริหารข้อเข่าด้วยการนั่งห้อยขาข้างเตียง แล้วใช้เท้าอีกข้างหนึ่งช่วยกดขาให้เข่างอเข้ามาให้มากที่สุด สลับกับการเหยียดเข่า กลุ่ม CPM ได้รับการดามขาในท่าเข่าเหยียดสุดด้วยสำลีม้วนและเอาออกหลังผ่าตัด 1 วัน เริ่มบริหารข้อเข่าด้วย CPM 1 ชั่วโมง วันละ 3 ครั้ง บันทึกข้อมูลทางคลินิกและเปรียบเทียบทางสถิติระหว่างกลุ่ม

ผลการศึกษา: ลักษณะพื้นฐานของผู้ป่วยทั้ง 2 กลุ่มไม่แตกต่างกัน ผู้ป่วยกลุ่ม D&D งอเข่าได้มากกว่ากลุ่ม CPM ในวันแรก (67.0°±14.2° และ 59.1°±3.2° ตามลำดับ p<0.001) และวันที่ 2 (76.6°±14.2° และ 69.8°±13.3° ตามลำดับ p = 0.008) แต่ไม่ต่างกันในวันที่ 3-7 เมื่อจำหน่ายกลับบ้าน ผู้ป่วยกลุ่ม D&D งอเข่าได้ 100.6°±6.8° และกลุ่ม CPM งอได้ 96.4°±10.2° (p = 0.005) ไม่พบความแตกต่างในการงอเข่าของกลุ่ม D&D และกลุ่ม CPM หลังผ่าตัด 6 สัปดาห์ (99.8°±10.4° และ 103.9°±10.4° ตามลำดับ p = 0.138) และ 1 ปี (112.0°±10.4° และ 111.6°±12.6° ตามลำดับ p = 0.892)

สรุป: กายบริหารเข่าวิธี D&D ช่วยให้งอเข่าได้มากกว่าการใช้ CPM ใน 2 วันแรกภายหลังผ่าตัดเปลี่ยนข้อเข่าเทียมและก่อนจำหน่ายกลับบ้าน แต่ไม่พบความแตกต่างกันของทั้ง 2 วิธีภายหลังผ่าตัด 6 สัปดาห์และ 1 ปี