Evaluative study

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Benefits of starting rehabilitation within 24 hours of primary total knee arthroplasty: randomized clinical trial

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Abstract

Objective: To compare the benefits of initiating rehabilitation treatment within 24 hours versus 48–72 hours after total knee arthroplasty for osteoarthritis.

Design: Experimental study with clinical trial design.

Subjects: Patients undergoing primary total knee arthroplasty for osteoarthritis were randomly assigned to experimental ($n = 153$) and control ($n = 153$) groups.

Interventions: Rehabilitation was started within 24 hours post surgery in the experimental group and between 48 hours and 72 hours post surgery in the controls.

Main measures: Measurement variables included joint range of motion, muscle strength, pain, autonomy, gait and balance.

Results: In comparison with the controls, the experimental group showed significantly shorter hospital stay (by (mean $\pm$ standard deviation) 2.09 ± 1.45 days; $P < 0.001$), fewer rehabilitation sessions until medical discharge (by 4.95 ± 2.34; $P < 0.001$), lesser pain (by 2.36 ± 2.47 points; $P < 0.027$), greater joint range of motion in flexion (by 16.29 ± 11.39 degrees; $P < 0.012$) and extension (by 2.12 ± 3.19; $P < 0.035$), improved strength in quadriceps (by 0.98 ± 0.54; $P < 0.042$) and hamstring muscles (by 1.05 ± 0.72; $P < 0.041$), and higher scores for gait ($P < 0.047$) and balance ($P < 0.045$).

Conclusion: Initiation of rehabilitation within 24 hours after total knee arthroplasty reduces the mean hospital stay and number of sessions required to achieve autonomy and normal gait and balance.

Keywords

Arthroplasty, barthel index, controlled clinical trial, gait, knee arthroplasty

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Introduction

Knee joint reconstruction because of osteoarthritis is increasingly frequent in developed countries, where this disease has been estimated to affect 75% of over 65-year-olds.[1] Osteoarthritis of the knee is associated with recurrent intense pain, joint deformity, gait changes and functional deterioration. Implantation of a knee prosthesis offers patients pain relief, functional recovery and improved quality of life.[2,3] The early initiation of rehabilitation treatment after surgery to increase joint range of motion and muscle strength is considered important for gaining the maximum benefit from knee arthroplasty.[4,5] Moreover, there is a general trend towards early hospital discharge to reduce the pressure on beds, leading to a significant decrease in the length of inpatient stay over recent years.[6–8]

Postoperative functional rehabilitation is beneficial for short-term function, range of motion, patient quality of life, and the prevention of postoperative complications.[9,10] A primary goal of joint replacement is to prevent complications while facilitating an early and safe discharge. Moffet et al.[11] reported that short- and mid-term functional capacity was improved by intensive functional rehabilitation during the subacute recovery period after primary total knee arthroplasty. A randomized clinical trial by Reilly et al.[12] showed a mean reduction of three days in the length of stay of patients undergoing an accelerated recovery protocol for unicompartmental knee arthroplasty. Another study demonstrated improvements in pain intensity, gait velocity, cadence and stride length as the result of a six-week gait rehabilitation programme after total knee arthroplasty.[13]

Rehabilitation costs may be increased if patients are transferred to a rehabilitation facility prematurely or cannot participate in intensive physical and occupational therapies because of acute medical or surgical complications. It has not been determined whether a more intensive therapy for high-risk joint replacement patients accelerates improvements or whether the outcome is independent of the amount of therapy delivered.[14,15] Likewise, it has not been established whether the early initiation of rehabilitation treatment in these patients reduces health costs when treatment is administered progressively rather than intensively. Exercises generally considered standard for patients after elective knee arthroplasty, despite the lack of supporting evidence, include static and isometric muscle contraction exercises, static quadriceps exercise, dynamic quadriceps exercise between 0 and 30 degrees of flexion, straight leg raise, and passive or active-assisted flexion exercises.[6]

Health systems are currently subjected to strong economic pressures, and a reduction in the length of hospital stay has become a priority aim.[16,17] Orthopaedics, especially knee replacement surgery, is one area that may lend itself to accelerated discharge.[18] Early mobilization after this surgery has been reported to decrease the risk of complications such as deep vein thrombosis, pulmonary embolism, chest infection and urinary retention,[19,20] and an earlier discharge could be expected to lower the risk of hospital-acquired infection.[20] We therefore postulated that early rehabilitation after total knee arthroplasty could accelerate the capacity of patients for daily life activities and reduce their hospital stay. With this background, the study objective was to analyse the advantages of initiating rehabilitation treatment within the first 24 hours versus 48–72 hours after total knee arthroplasty for osteoarthritis.

Methods

We performed an experimental clinical trial with an intervention group (rehabilitation onset within the first 24 hours) and control group (rehabilitation onset 48–72 hours post surgery). The target population comprised patients undergoing primary total knee arthroplasty for osteoarthritis at our hospital (in southern Spain). From 15 January 2005 to 31 May 2007, 753 primary total knee arthroplasties for osteoarthritis were conducted in the Orthopedic Surgery and Traumatology Department of the hospital.

Study inclusion criteria were: age between 50 and 75 years, and receipt of elective knee joint replacement surgery due to unilateral osteoarthritis. Exclusion criteria were: cardiac, renal or hepatic event in the previous year; prosthesis due to rheumatoid arthritis or cancer; and the presence of severe cognitive deficit, acute femoral fracture, infection, fever, low blood pressure or severe respiratory disease that might limit treatment or require implantation of a special prosthesis.

Out of the 753 patients undergoing total knee arthroplasty, 306 satisfied criteria for inclusion in the study and were randomly assigned (by sealed envelope) to an intervention group ($n = 153$) for rehabilitation onset within 24 hours of the surgery or a control group ($n = 153$) for rehabilitation onset between 48 hours and 72 hours post surgery (Figure 1). The baseline measurement of variables took place before the patients were randomly assigned to the intervention or control groups, and the researcher responsible for measuring outcome variables was also blinded to the group to which the patients belonged. Written informed consent was obtained from all participants in the study, which complied with the 2000 modification of the Helsinki Declaration and with current Spanish legislation for clinical trials (Royal Decree 223/2004 February 6) and was approved by the ethical and research committee of our hospital.

Before the surgery, data were gathered on: age, sex, affected knee (right/left), daily life activities (Barthel Index score), and the presence of concomitant diseases, including obesity (body mass index ≥ 30), dyslipidaemia (lipoprotein metabolism disorder, including lipoprotein overproduction or deficiency), polyarthritis (inflammation of >1 joint), and arterial hypertension. Baseline measurements were also recorded (see below) on autonomy, joint range of motion, muscle strength, pain, gait and balance. All patients received a daily 45-minute rehabilitation session during their hospital stay (except on Sundays), always from the same therapist (NSL). After completion of the rehabilitation therapy, the same variables as gathered at baseline were recorded, as well as the length of hospital stay (in days) and number of rehabilitation sessions received by the patient.

Outcome measures

Primary outcome measures were range of motion, muscle strength and pain; secondary measures were autonomy, gait and balance. Variables were recorded in the following order:

- Range of motion. The range of motion (distance and direction the joint can move between flexed and extended positions, expressed in degrees) was determined with the patient in prone position by means of a goniometer (Femto instruments, Valencia. Spain).[21]
- Muscle strength. The test developed by Daniels, Williams and Worthingham was used, which yields a numerical score from 0 = no activity to 5 = normal muscle response; each grade represents muscle quality in a particular movement (grade 0 = zero; 1 = trace, 2 = poor, 3 = fair, 4 = good, and 5 = normal).[22]
- Pain assessment. The intensity of pain experienced by the patient was measured by using a visual analogue scale ranging from 0 (no pain) to 10 (worst imaginable pain).[23]
- Autonomy. The Barthel index was used to measure the patient's capacity to perform 10 basic daily life activities, scoring the degree of dependence as: ≤ 20 (total), 20–35 (severe), 40–55 (moderate), ≥ 60 (mild) and 100 (independent).[24]
- Gait and balance. Gait and balance were assessed using the 22-item Tinetti test, which is divided into two subscales: static balance and balance during gait, each scored on a 3-point ordinal scale (0 = abnormal, 1 = adaptive; 2 = normal).[25]

Treatment intervention

The same rehabilitation treatment protocol was administered to all patients[6] but was

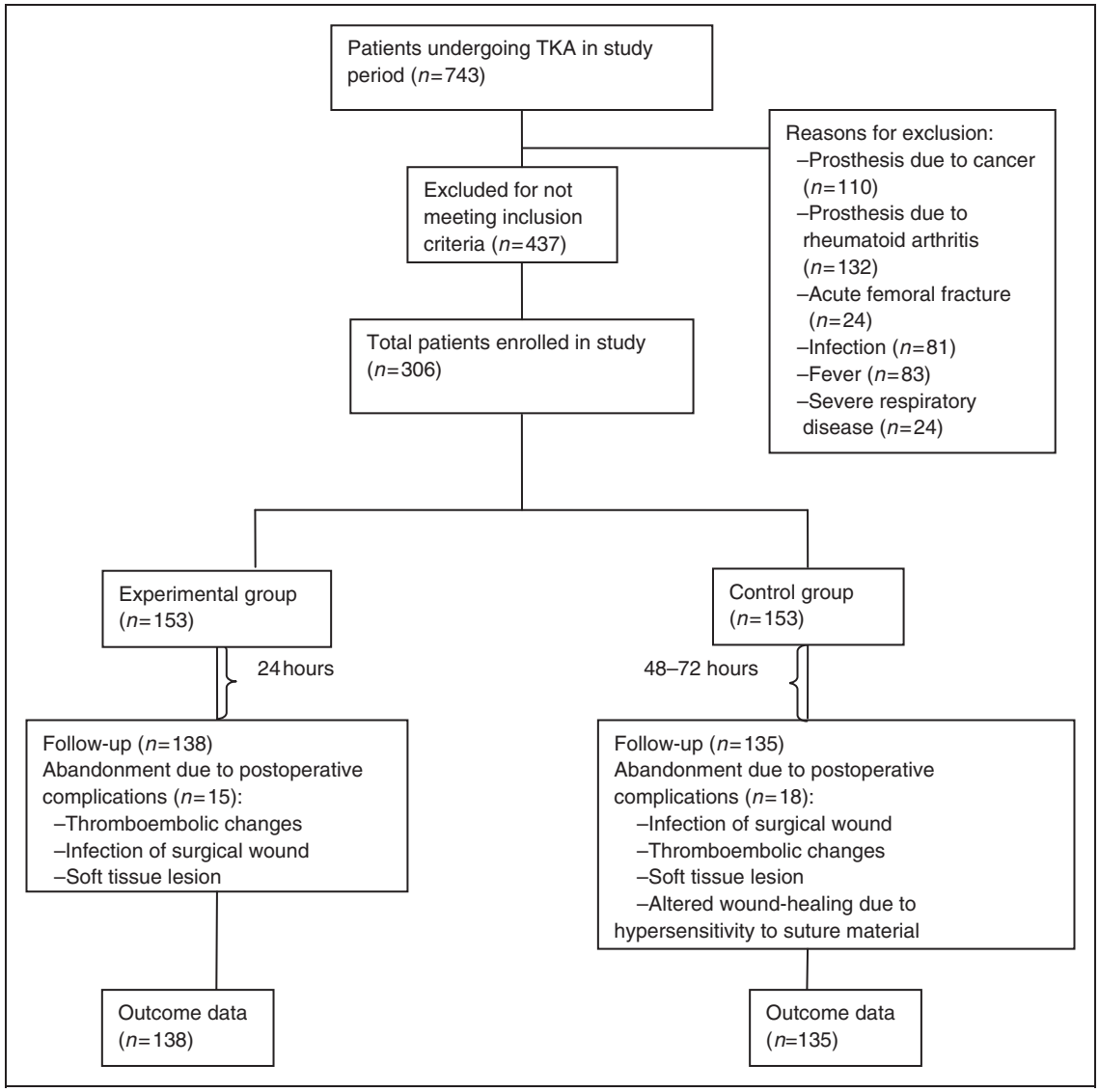

Figure 1. Flow of patients through the study.

initiated in the intervention group within the first 24 hours and in the control group between 48 and 72 hours post surgery. The patients in the control group remained at rest in bed or chair during the first 24 hours and received no treatment. Patients developing post-surgical complications at any time were excluded from the programme.

Day 1. Within the first 24 hours post operation, the patient and family members received a short briefing on the planned rehabilitation treatment.

The treatment included: passive and active-assisted mobilizations in flexion–extension with range of motion from 0 to 40 degrees; isometric exercises for quadriceps and hamstring muscles,

with alternating 5-second contraction and relaxation periods; ankle flexion–extension for 10 minutes; active assisted anterior flexion of the leg in extension; diaphragmatic breathing exercises, and instruction on posture rules.

Day 2. After following the same protocol as on day 1, treatment started on: in-bed sitting posture; transfer (e.g. from bed to chair); standing and short-distance walking on flat ground; management of walking aids; learning of flexion–extension exercises while seated; and isotonic muscle work.

Day 3. The same protocol as on day 2 was followed, intensifying exercises on the use of walking aids, increasing the distance walked, and learning daily life activities.

Day 4 and consecutive days until hospital discharge. From day 4 post surgery active-resisted quadriceps exercises commenced; gait re-education continued, with a daily increase in distances walked; stair work began, using a simulator; muscle work was daily intensified; and work increased on adaptation to daily life activities.

Statistical analysis

SPSS 18.0 (SPSS Inc., Chicago, IL, USA) was used for the data analyses. The reliability and validity of the model was studied by analysing the residual independence, normality and variance homogeneity. Residual independence was verified by plotting observed against residual values, finding data points to be randomly distributed with no discernable trends. Residual normality was confirmed by Q–Q plot, and variance homogeneity was established by means of the Levene test. After a descriptive study of variables, intergroup comparisons were performed with a paired *t*-test for independent samples and intragroup comparisons with a paired *t*-test for related samples. Baseline values were subjected to repeated-measures analyses. Relationships between variables were evaluated by calculating Pearson correlation coefficients. The confidence interval was 95% ($\alpha = 0.05$) in all tests.

Results

Out of the 306 patients initially enrolled in the study, 15 patients in the experimental group and 18 in the control group dropped out due to post-operative complications (Figure 1). The final study sample therefore comprised 138 patients in the experimental group and 135 patients in the control group. The mean age of the sample was 66.02 years (standard deviation (SD) 5.37). The groups did not significantly differ in leg side (right/left) or clinical characteristics, with the exception of a greater frequency of arterial hypertension in the control group (Table 1).

The experimental group had significantly fewer days of hospital stay (6.37 (1.16) vs. 8.46 (2.63), $P < 0.001$) and rehabilitation sessions before discharge from this treatment (14.92 (1.18) vs. 19.87 (4.30), $P < 0.001$) (Table 1). Repeated-measures analyses of baseline values showed significant differences between the groups in arterial hypertension ($F = 1.169$; $P < 0.044$), pain VAS ($F = 1.037$; $P < 0.045$) and range of motion in extension ($F = 9.746$; $P < 0.001$). After rehabilitation treatment, the experimental group showed significant improvements versus baseline values in: pain VAS (6.46 (2.94) vs. 3.01 (2.35), $P < 0.005$), range of motion in flexion (54.89 (23.22) vs. 88.11 (2.35), $P < 0.003$) and extension (3.71 (4.94) vs. 0.68 (1.84), $P < 0.006$) and muscle strength in quadriceps (1.75 (0.51) vs. 3.91 (0.56), $P < 0.009$) and hamstring muscles (2.04 (0.78) vs. 4.02 (0.82), $P < 0.011$). The control group also showed significant improvements versus baseline in: pain VAS (7.08 (2.31) vs. 5.36 (2.54), $P < 0.014$), range of motion in flexion (51.75 (21.65) vs. 71.82 (16.81), $P < 0.022$) and extension (6.55 (6.01) vs. 2.80 (1.10), $P < 0.003$) and muscle strength in quadriceps (2.66 (0.47) vs. 3.01 (0.52), $P < 0.018$) and hamstring muscles (1.94 (0.59) vs. 2.97 (0.59), $P < 0.016$). Significant intergroup differences were found in pain VAS (3.01 (2.35) vs. 5.36 (2.54), $P < 0.027$),

Table 1. Characteristics of the study groups

Characteristics	Experimental ($n = 138$)	Control ($n = 135$)	*P*-value
Left (L) or right (R) TKP, *N* (%)	R 89 (64.49) L 49 (35.51)	R 79 (58.52) L 56 (41.48)	0.383
Sex, *N* (%)	F 101 (73.19) M 37 (26.81)	F 110 (81.48) M 25 (18.52)	0.229
Mean age (SD)	65.48 (4.83)	66.36 (5.03)	0.162
Days of hospital stay (SD)	6.37 (1.16)	8.46 (2.63)	0.001*
Sessions until discharge (SD)	14.92 (1.18)	19.87 (4.30)	0.001*
Arterial hypertension, *N* (%)	37. 89 (27.46)	53.54 (39.66)	0.044*
Obesity, *N* (%)	118.85 (86.12)	105.61 (78.23)	0.074
Dyslipidaemia, *N* (%)	127.60 (92.47)	115.64 (85.66)	0.267
Diabetes, *N* (%)	61.59 (44.63)	71.91 (53.27)	0.095
Polyarthritis, *N* (%)	92.06 (66.71)	99.17 (73.46)	0.316
Knee osteoarthritis, *N* (%)	47.25 (34.24)	39.38 (29.17)	0.735
Articular infiltrations, *N* (%)	58.82 (42.62)	49.88 (36.95)	0.103
Treatment with analgesics, anti-inflammatories, and gastric protector, *N* (%)	138 (100)	135 (100)	–

SD, standard deviation; TKP, total knee prosthesis.
*Statistically significant difference ($P < 0.05$; 95% confidence interval).

range of motion in flexion (88.11 (2.35) vs. 71.82 (16.81), $P < 0.012$) and extension (0.68 (1.84) vs. 2.80 (4.10), $P < 0.035$) and muscle strength in quadriceps (3.91 (0.56) vs. 3.01 (0.52), $P < 0.042$) and hamstring muscles (4.02 (0.82) vs. 2.97 (0.59), $P < 0.041$), finding more favourable results for the experimental group in all of these variables (Table 2).

In comparison to pre-surgical values, the experimental group showed a significant improvement in mild autonomy (0(0) vs. 8 (5.80), $P < 0.027$) and independent autonomy (0(0) vs. 124 (93.48), $P < 0.001$) and the control group showed a significant improvement in mild autonomy (0(0) vs. 13 (9.63), $P < 0.017$) and independent autonomy (0(0) vs. 113 (88.15), $P < 0.001$). No significant differences in Barthel Index scores were found between the groups. Both groups showed significant differences versus baseline in the proportions with normal and abnormal balance ($P < 0.001$), although they significantly differed between them in the percentage with normal balance (136 (98.55) vs. 125 (92.59), $P < 0.047$). In the post-therapy gait assessment, both groups showed significant differences versus baseline in the percentages with normal and abnormal gait ($P < 0.001$), although they significantly differed between them in the percentage with normal gait (134 (97.10) vs. 121 (89.63), $P < 0.045$) (Table 3).

At the end of the rehabilitation programme, obesity was significantly correlated in the experimental group with range of motion in flexion ($r = 0.423$; $P < 0.007$) and extension ($r = 0.532$; $P < 0.006$), moderate loss of autonomy ($r = 0.321$; $P < 0.047$), adaptive balance ($r = 0.346$; $P < 0.028$) and adaptive gait ($r = 0.497$; $P < 0.002$). The presence of dyslipidaemia was significantly associated with moderate loss of autonomy ($r = 0.325$; $P < 0.038$), adaptive balance ($r = 0.514$; $P < 0.010$) and adaptive gait ($r = 0.467$; $P < 0.005$). The presence of polyarthritis was associated with range of motion in flexion ($r = 0.356$; $P < 0.027$) and extension ($r = 0.413$; $P < 0.008$), moderate loss of autonomy ($r = 0.352$; $P < 0.033$), and adaptive gait ($r = 0.425$; $P < 0.004$).

Table 2. Comparison between groups in pain score, joint range of motion and muscle strength

	Pre-operative			Post-operative		
	EG ($n = 138$) *M* (SD)	CG ($n = 135$) *M* (SD)	*P*-value	EG ($n = 138$) *M* (SD)	CG ($n = 135$) *M* (SD)	*P*-value
VAS	6.46 (2.94)	7.08 (2.31)	0.045*	3.01 (2.35)	5.36 (2.54)	0.027*
Range of motion in flexion (°)	54.89 (23.22)	51.75 (21.65)	0.095	88.11 (2.35)	71.82 (16.81)	0.012*
Range of motion in extension (°)	3.71 (4.94)	6.55 (6.01)	0.001*	0.68 (1.84)	2.80 (1.10)	0.035*
Muscle strength: quadriceps	1.75 (0.51)	2.66 (0.47)	0.089	3.91 (0.56)	3.01 (0.52)	0.042*
Muscle strength: hamstring muscles	2.04 (0.78)	1.94 (0.59)	0.164	4.02 (0.82)	2.97 (0.59)	0.041*

Values are presented as mean (standard deviation).
*Statistically significant difference ($P < 0.05$; 95% confidence interval).
EG, experimental group; CG, control group; VAS, visual analogue scale.

Table 3. Differences between groups in autonomy, gait and balance

	Before surgery			After rehabilitation treatment		
	EG ($n = 138$)	CG ($n = 135$)	*P*-value	EG ($n = 138$)	CG ($n = 135$)	*P*-value
Barthel Index, *N* (%)/*M* (SD)						
≤20 Total dependence	42 (30.43)/ 17.96 (1.37)	44 (32.59)/ 18.51 (0.99)	0.953	0 (0)	0 (0)	–
20–35 Severe	94 (68.12)/ 29.79 (4.13)	84 (62.22)/ 32.02 (2.73)	0.051	0 (0)	0 (0)	–
40–55 Moderate	2 (1.45)/ 51.48 (3.26)	7 (5.19)/ 47.92 (5.83)	0.327	6 (0.72)/ 45.85 (4.29)	9 (2.22)/ 42.01 (1.27)	0.143
≥60 Mild	0 (0)	0 (0)	–	8 (5.80)/ 67.86 (3.14)	13 (9.63)/ 71.48 (8.93)	0.134
100 Independent	0 (0)	0 (0)	–	124 (93.48)/ 100 (0)	113 (88.15)/ 100(0)	0.056
Tinetti balance, *N* (%)						
Normal	0 (0)	0 (0)	–	136 (98.55)	125 (92.59)	0.047*
Adaptive	3 (2.17)	7 (5.19)	0.217	2 (1.45)	10 (74.07)	0.223
Abnormal	135 (97.83)	128 (94.81)	0.084	0 (0)	0 (0)	–
Tinetti gait, *N* (%)						
Normal	0 (0)	0 (0)	–	134 (97.10)	121 (89.63)	0.045*
Adaptive	7 (5.07)	2 (1.48)	0.128	4 (2.90)	14 (10.37)	0.052
Abnormal	131 (94.93)	133 (98.52)	0.821	0 (0)	0 (0)	–

*Statistically significant difference ($P < 0.05$; 95% confidence interval).
Barthel values are presented as mean (SD).
N, number of patients; EG, experimental group; CG, control group.

Discussion

This study found that the initiation of rehabilitation within 24 hours of total knee arthroplasty reduced the hospital stay and the number of sessions required for patients to achieve autonomy and normal gait and balance in comparison to a later commencement of this treatment (48–72 hours post surgery). The earlier onset of treatment also reduced pain and improved the range of motion and muscle strength.

The predominance of females in our series, as also found in other studies on this surgery, is explained by the higher incidence of gonarthrosis among women.[26] Numerous factors influence the achievement of a good functional outcome after knee arthroplasty, including the previous articular balance and a correct surgical technique and rehabilitation treatment. The superior performance of patients starting rehabilitation in the first 24 hours is consistent with the results of other studies on early interventions.[18,27] At two or three days post surgery, many patients reported a marked lessening of the pain experienced before and immediately after the surgery, with a progressive improvement after the first few postoperative days.[18]

The main outcome measure in most studies on total knee arthroplasty is the range of motion in active flexion of the knee.[18,28–30] Davies et al.[28] reported that patients with $\leq$60 degrees range of motion are more likely to suffer postoperative complications and consume more health services, proposing that patients should be capable of $\geq$60 degrees range of motion inflexion at discharge from rehabilitation. It was also found that functional recovery was greater in patients achieving 80 degrees range of motion in flexion during the first postoperative week.[28] Mean post-rehabilitation values of 70 degrees were described by Lessen et al.,[1] very similar to findings by Beaupre et al.,[29] Kumar et al.[30] and Bennet et al.[31] In our study, the group starting rehabilitation within 24 hours after surgery achieved a mean range of motion in flexion of 88.11 degrees. The strength of knee flexor–extensor muscles, especially the quadriceps muscle, is crucial to functional recovery after total knee arthroplasty.[29,31] Range of motion in flexion and extension was markedly superior at the end of the rehabilitation in both groups. A previous study also found a significant increase in the strength of flexor–extensor muscles after the early initiation of rehabilitation following total knee arthroplasty.[32]

The mean hospital stay of the patients receiving earlier treatment was 6.37 days, longer than the mean post-surgical stay of 4.1 days reported by Lessen et al.,[18] with immediate postoperative physical therapy, and the 5.5 days described by Schneider et al.[5] with an accelerated rehabilitation protocol following total knee arthroplasty. In this study, in which patients received daily physiotherapy sessions, significant differences were found between the groups. A study in which two daily sessions were received by an experimental group and one by a control group found no intergroup difference in the primary outcome measure (range of motion in flexion),[18] which may indicate that a more intense treatment does not markedly improve range of motion in comparison to the usual rehabilitation protocol following total knee arthroplasty.[6,33–36]

In the present study, the number of sessions received before hospital discharge was higher in the control group. Physiotherapists report enormous pressure to increase throughput and achieve earlier discharges, and demands to reduce the length of stay affect clinicians in both acute care and rehabilitation facilities.[17] In our series, superior total independence (by Barthel Index) and balance and gait (by Tinetti test) were shown by those starting physical therapy in the first 24 hours versus 36–72 hours post surgery.

Rehabilitation treatment yields greater patient benefits if started earlier after total knee arthroplasty (<24 hours vs. 36–72 hours post surgery) and reduces the hospital stay. Earlier treatment onset reduces the number of sessions required to achieve autonomy and normal gait and balance and improves pain, joint range of motion, and muscle strength.

One study limitation was the impossibility of analysing the health costs for these patients due to restrictions on the publication of these data by the public health authority to which the hospital belongs. A further weakness is that the study did not include a group of patients receiving no therapy following surgery. It would also be interesting to assess the effect of pre-surgical therapy, but this is not contemplated in the protocol for these patients in our hospital system.

Clinical messages

- An early initiation of physical recovery in patients subjected to knee arthroplasty for osteoarthritis may contribute to improving pain, range of joint motion, and muscle strength.
- Physical therapy in the first 24 hours after knee arthroplasty improves autonomy in daily life activities, balance, and gait, and reduces hospital stay in comparison to therapy applied at 48–72 hours post surgery.

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