

ORIGINAL REPORT

CHANGES IN PAIN AND PHYSICAL FUNCTION DURING WAITING TIME AND 3 MONTHS AFTER KNEE JOINT ARTHROPLASTY

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Objective: To determine changes in physical and social function during a prolonged preoperative waiting period and at 3 months after total knee arthroplasty.

Subjects: Forty-three patients were evaluated on the day that surgery was decided, the day before surgery, and 3 months afterwards.

Methods: Knee pain and function were assessed using a visual analogue scale and a functional assessment system. Isometric knee flexion extension strength and mobility were measured.

Results: Knee pain and muscle strength remained unchanged during the mean waiting time of 10 (standard deviation 8) months. On the affected side, knee extension strength was 19% weaker than on the contralateral side and did not change pre-operatively. Post-operatively, knee pain decreased by 50%. Knee extension strength decreased by 26% and flexion strength by 12% compared with the initial assessments. Knee extension strength of the operated side was 42% lower than on the non-operated side. Knee flexion mobility was decreased by 8%, while the initially detected knee extension deficit of 10° (SD 7) remained unchanged. The functional assessment system did not detect any changes in function.

Conclusion: Waiting time did not affect knee pain or isometric knee extension/flexion strength. Three months post-operatively, knee pain had decreased significantly, but the strength of the operated knee was significantly lower than the pre-operative level.

Key words: osteoarthritis, knee arthroplasty, physical function, pain.

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INTRODUCTION

Osteoarthritis (OA) is a common joint disease that leads to a decrease in functional ability (1). In Finland, the prevalence of OA of the knee is approximately 5% among men and 7% among women (2). Primary osteoarthritis develops with age, whereas secondary arthritis is associated with underlying joint diseases,

injury or growth disorders (3). Factors predisposing to OA of the knee are hereditary factors, overweight, female gender, excessive knee angle (valgus, varus), trauma to the knee, inflammatory joint diseases and heavy physical work (4, 5).

In its early stages OA of the knee causes pain during walking and in the later stages pain is present often at rest (6). As the disease progresses, the range of knee joint motion decreases, the joint becomes deformed and disability increases. OA leads to a reduction in thigh muscle strength (6–8). The conservative treatment options in the initial phases of OA are analgesic medication, physical therapies with cold and heat, electrotherapy, mobilization and acupuncture (3). Physical exercise has also been shown to improve the performance of activities of daily living (ADL) and to have a pain-relieving effect (1, 9, 10).

The decision to refer the patient for total knee arthroplasty (TKA) is based on knee pain, limited range of motion (ROM), deformity, degree of arthritis and limitation in physical function (11). In Finland, TKA was performed on 124/100,000 inhabitants in 2003 (12). At that time public health sector patients had to wait an average of one year for TKA surgery. Pre-operatively, poor knee joint ROM and high body mass index have been shown to be predictors of poor recovery after surgery at a 2-year follow-up (13).

Many studies have shown no increase in pain or deterioration in physical function in patients during a short preoperative waiting time ranging from 2 to 4 months (14–17). However, little is known about the effect of a longer waiting time on preoperative or early post-operative function.

Previous studies have mostly used subjective measures of pain and disability questionnaires. After joint replacement, recovery mostly occurs during the first 3 months (15, 18). The aim of this study was therefore to determine changes in patient's subjective symptoms as well as objectively assessed knee function during a prolonged preoperative waiting period and short postoperative time of 3 months after TKA.

PATIENTS AND METHODS

Subjects

A total of 60 patients referred for TKA were tested. Of these, 9 patients were not operated on during the 2 data collection periods and thus were excluded (4 patients decided not to have surgery and 5 had their surgery rescheduled). Of the 51 operated patients 43 (84%) returned for

follow-up measurements at 3 months post-operatively. Of the 8 patients lost to follow-up, one had died, one knee prosthesis became infected, and 6 declined a check-up visit despite personal telephone contact. The demographic and clinical data of the excluded patients did not differ from those of the other subjects, except that dropouts reported shorter duration of knee pain. The majority of the subjects were women (86%) and the mean age of the subjects was 70 (standard deviation (SD) 5) years (Table I). The inclusion criterion for the study was OA of the knee rating 3–4 in the Ahlbäck classification (19). Exclusion criteria were age over 80 years, inflammatory joint disease, early knee arthroplasty and medically diagnosed serious disease, such as cancer. The study plan was approved by the ethics committee of the Central Finland Hospital District.

Methods

Pain and function. Physical and social disability, as well as pain, were assessed using the modified functional assessment system (FAS), which has been validated for the evaluation of lower-extremity dysfunction in patients undergoing knee or hip replacement surgery (20, 21). The scale consists of 20 variables divided into 5 different sections: hip function, knee function, physical disability, social disability and pain (Table II). Each variable is scored between 0 and 4 (0=no difficulty, 4=significant difficulty or inability to complete).

Muscle strength measurements. Isometric knee flexion and extension strength were measured at 80° knee flexion and 70° hip flexion using the David-200 dynamometer (Outokumpu, Finland) (22). Three submaximal warm-up sessions were performed before testing. The highest value of 3 maximal attempts in both directions was taken for analysis. The strength of the non-operative limb was measured first. Intensity of knee pain experienced both during the strength testing and during the previous week were assessed using a visual analogue scale (VAS; 0–100 mm) (23).

The initial measurements were performed at the orthopaedic outpatient clinic on the same day as the surgery assessment decision was made.

Table I. Baseline demographics and clinical data of knee replacement patients

Variables	Complete cases n=43	Drop-out cases n=8	All n=51
Females, n (%)	37 (86)	4 (50)	41 (80)
Age, years, mean (SD)	70 (5)	71 (3)	70 (5)
Body mass index, kg/cm ² , mean (SD)	31 (5)	30 (4)	31 (5)
Duration of knee pain, months, median (IQR)	45 (20, 61)	13 (10, 36)	36 (14, 60)
Knee pain in VAS, mm, median (IQR)	56 (45, 72)	61 (55, 69)	60 (50, 70)
Arthrosis			
Grade III, (%)	9 (21)	3 (38)	12 (24)
Grade IV, (%)	34 (79)	5 (62)	39 (76)
Duration of waiting list, months, median (IQR)	8 (4, 14)	19 (10, 23)	8 (5, 17)

SD: standard deviation; IQR: interquartile range; VAS: visual analogue scale.

The follow-up measurements were performed on the day before surgery and at 3 months after surgery. Two experienced physiotherapists jointly performed all the measurements. The same physiotherapist made the initial and follow-up measurements for each patient.

Surgical procedure. Surgery was performed under spinal or general anaesthesia. A mid-sagittal incision of the knee was performed and the medial parapatellar opening of the joint was used. The anterior cruciate ligament, meniscae and possible osteophytes were removed. The femoral and tibial bone cuts were performed with the help of appropriate jigs, and fitting with a trial prosthesis was performed before fixation of

Table II. Scoring of functional assessment system (FAS) of low extremity dysfunction

Variable	0	1	2	3	4
Hip flexion	>100°	85–95°	70–80°	50–65°	<50°
Extension deficit, hip	No deficit	5°	10°	15°	>15°
Abduction, hip	>15°	15°	10°	5°	0°
Adduction, hip	>15°	15°	10°	5°	0°
Knee flexion	>115°	100–110°	85–95°	70–80°	<65°
Extension deficit, knee	No deficit	5°	10°	15°	>15°
Raising up from half-standing, cm	>25	15–25	10–14	5–9	<5
Raising up/sitting down, cm	35	40	45 (ordinary chair)	50	>55
Step height, cm	45 (tractor)	40 (ordinary car)	23 (bus, train)	17 (stairs)	<10
Standing on one leg, sec	40–60	25–39	15–24	5–14	<5
Stair climbing	Full performance	One support, healthy leg first	2 support, healthy leg first	Personal solution, backwards	Unable
Gait speeds, m/sec	>1.4	1.0–1.3	0.7–0.9	0.5–0.6	<0.5
Walking aid	0	2 sticks or crutches	Rolling walker	Gait chair	Unable to walk
Communication/transport	No restriction	Can drive a car, difficulties with bus, train	In car, cannot use anything else	In car with company	Handicap transportation
Work/housekeeping	No restriction	Can perform everything, but with pain	Work half-time, some help at home	Cannot work, some help at home	Help with everything
ADL-functions, other	No restriction	Needs to sit in all ADL-functions	Needs aids for stockings and shoes, cannot manage pedicure	Needs external help with stockings and shoes	Help with everything
Leisure time/hobbies	No restriction	Can do everything but with more pain	Can do 50% activities	Serious reduction of activities	Total reduction in activities
Pain	No pain	Pain in load situation	Pain at rest	Pain at load and at rest	Permanent pain

Score 0–4: 0=no difficulty, 4=significant difficulty, inability to complete.

ADL: activities of daily living.

the final prosthesis components (AGC® Biomet, Warsaw, IL, USA) with cement. The same 2 surgeons performed all the operations.

Physiotherapy. When the decision in favour of operative treatment had been made, the patients received written instructions advising them to maintain themselves in good general condition and to maintain a good range of knee motion. In the surgical department on the day before surgery the patients were instructed on exercises to stimulate lower limb circulation, rising from bed and the use of crutches. Postoperatively, in the orthopaedic ward, a continuous passive motion (CPM) machine was used 2–3 times per day for 0.5–1 h (24) at a time during the patients' hospital stay, which varied between 5 and 7 days.

Isometric thigh exercises in sitting and prone lying, the straight leg raise exercise, gait re-education and cold treatment were started on the day after surgery. Patients received individual physiotherapy sessions 2–3 times per day, depending on need. On discharge home or to the ward of a local health centre, the patients received a written exercise programme. This included knee motion exercises and exercises to increase/maintain muscle activation using the weight of the leg as the resistance, knee flexion exercise, passive extension and knee extensor exercises as well as hip abduction and extension exercises in standing. These were recommended to be performed with 10–15 repetitions, 1–2 times per day. Patients were allowed to take a full weight-bearing or as much as tolerated on the operated leg, but for personal safety were recommended to use crutches after the operation for up to 6 weeks.

Statistical methods

The results are expressed as means or medians with SD, interquartile ranges (IQR), or 95% confidence intervals (95% CI). CI for the items of FAS index means were obtained by bootstrapping (1000 replications) method. The normality of variables was evaluated with the Shapiro-Wilk statistic. Statistical comparison between the operated and non-operated sides was made using the Mann-Whitney *U* test, analysis of variance (ANOVA) and Permutation test with Hommel's adjustment. Correlation coefficients were calculated by the Pearson method. The α level was set at 0.05 for all tests.

RESULTS

Mean waiting time from decision to time of surgery was 10 (SD 8) months (Table I). Knee pain on the operated side was 58 (SD 18) mm and did not change between the initial and pre-operative assessments. Postoperatively, pain decreased significantly to 29 (SD 28) mm ($p < 0.001$). No correlation was observed between degree of diagnosed OA and pain experienced at the different follow-ups (Fig. 1).

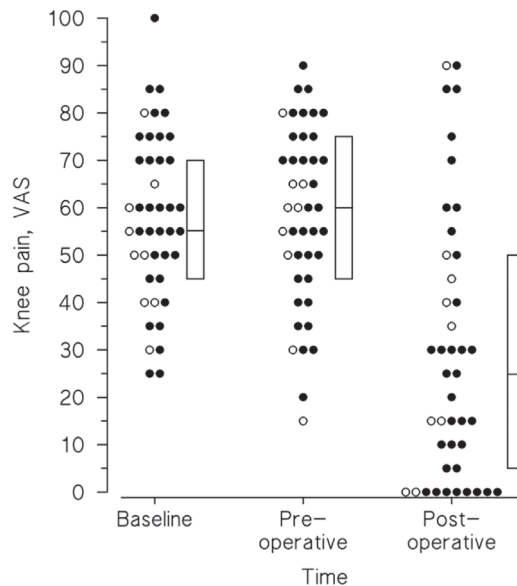


Fig. 1. Median (interquartile range) knee pain during the week before check-up time in grade III and IV of arthrosis (open dots = grade III, filled dots = grade IV). VAS: visual analogue scale.

At the initial assessment the extension strength of the operative knee was 19% weaker than that of the non-operative knee ($p > 0.001$). Knee flexion strength did not show side differences (Table III). Three months after surgery the extension strength of the operated knee was 26% ($p = 0.001$) weaker than at the initial assessment and 42% weaker than that of the non-operated knee ($p < 0.001$). The flexion strength of the operated knee had weakened by 12% ($p = 0.037$) from the initial assessment. At the initial assessment during the extension strength testing, the pain experienced in the operative knee was significantly higher than that in the non-operative knee (Table III). The pain experienced during testing at 3 months after surgery was clearly lower, but was still greater on the operated than non-operated side in both extension and flexion strength. Pain during testing was inversely correlated with extension strength ($r = -0.37$; 95% CI -0.61 to -0.07) and flexion strength ($r = -0.44$; 95% CI -0.66 to -0.15) at 3 months post-operatively.

Table III. Isometric knee strength and pain during the strength measurements

	Baseline		Change from baseline to preoperative check-up		Change from baseline to 3 months postoperative check-up		Difference between the legs at 3 months <i>p</i> -value
	Operative knee Mean (SD)	Non-operative knee Mean (SD)	Operative knee Mean (95% CI)	Non-operative knee Mean (95% CI)	Operated knee Mean (95% CI)	Non-operated knee Mean (95% CI)	
Isometric knee strength (N)							
Extension	186 (90)	231 (119)	-5 (-18 to 8)	1 (-9 to 10)	-48 (-66 to -30)	5 (-13 to 24)	0.001
Flexion	90 (36)	96 (44)	0 (-8 to 8)	1 (-7 to 8)	-10 (-20 to -1)	1 (-9 to 10)	<0.001
Pain during the trial (VAS, mm)							
Extension	34 (24)*	19 (22)*	1 (-6 to 8)	5 (-10 to 2)	-7 (-16 to 2)	-8 (-16 to -2)	0.003
Flexion	21 (24)	17 (20)	-11 (-20 to -0)	-5 (-10 to 0)	-5 (-13 to -3)	-8 (-16 to 1)	<0.001

*Difference between the legs at baseline ($p = 0.001$).

SD: standard deviation; 95% CI: 95% confidence interval; VAS: visual analogue scale.

Gait speed did not change at follow-up: at the initial assessment it was 1.1 (SD 0.4) m/sec and at 3 months postoperatively 1.2 (SD 0.4) m/sec. On the operated side mean single leg stance time was 5.6 (SD 6.6) sec preoperatively and 10.3 (SD 14.7) sec postoperatively ($p=0.013$). The extension strength of the operated knee correlated with measured gait speed ($r=0.48-0.70$, $p=0.002-0.001$), single leg stance time ($r=0.35-0.39$, $p=0.029-0.013$) and stride height ($r=0.45-0.64$, $p=0.004-0.001$) at each check-up.

According to the FAS, the greatest problem experienced at the baseline assessment was maintaining balance (Fig. 2). At follow-up the changes in functional abilities were small (mean change < 1). Three months postoperatively, pain on the FAS scale was lower, while mean knee flexion movement had decreased from 112 (SD 12)° to 103 (SD 13)° ($p=0.031$). Knee extension deficit at the initial assessment was 10 (SD 7)° and this did not change at follow-up.

DISCUSSION

During the prolonged preoperative waiting period no significant changes took place in pain or in the objective functional measurements of knee muscle strength and mobility, showing that the delay in receiving surgery did not further reduce knee function in these patients. Previous studies have found that a preoperative waiting period of 2.5–4.5 months did not decrease subjectively perceived physical function or health-related quality of life in joint replacement patients (15–17, 25). The patients in the present study had had symptoms for almost 4 years before the decision to operate was made. These patients might have postponed surgery for personal reasons. They may have had deficits in function and muscle strength for a long time before the orthopaedic assessment, as some studies have shown (4, 6, 8).

Three months postoperatively average pain during the previous week was 50% less than at baseline, which result is consistent with earlier findings (26–30). A pain level of above 30 mm on

the VAS is classified as moderate pain, and in some cases such patients need pain killers, while a pain level of under 30 mm is classified as mild pain, i.e. pain that does not interfere with the ability to perform ADLs (31). In 58% of the patients mild pain was reported and 23% of patients reported no pain at all. Nevertheless, moderate or severe pain was reported in 20% of the cases.

The changes in functional activities measured on the FAS at follow-up were minor. The inter-tester reliability of the FAS has been reported to be good (0.99–1.00) and its content and face validity have been shown to be excellent (20). The responsiveness of the FAS has not been studied. As seen in Fig. 2, the majority of patients score were 0 or 1 on the FAS in baseline. We do not know if the patients improved their function between baseline/pre-operative to 3 months post-operative, because our method (the FAS) seems insensitive to improvements in our population of patients.

We chose follow-up-time of 3 months to allow healing of the wound and soft-tissue. Earlier studies have shown that most of the improvement occurs within the first 3 months after the operation (15, 32, 33).

People may estimate their mobility higher by self-reported questionnaires than has been found by objective physical function tests (34). In these patients positive self-report may be an effect of the pain relief experienced after the knee arthroplasty. Thus, it is important to include objective measurements in follow-up studies and not self-reported questionnaires alone. Knee ROM, both toward flexion and extension at 3 months postoperatively was lower than the preoperative level. Previous studies have also reported a 5–15° decrease in knee flexion at follow-up during 2–6 months after surgery (28–30, 35–37). Conservatively treated individuals with OA have been shown to use a smaller knee angle in ADL performance than healthy controls due to pain and stiffness (38–39). Different ADLs require a wide ROM of the knee joint. Knee flexion needs in humans are: for walking 65–70°, for ascending stairs 84°, for descending stairs 90°, and for sitting 90°. Tying shoelaces and

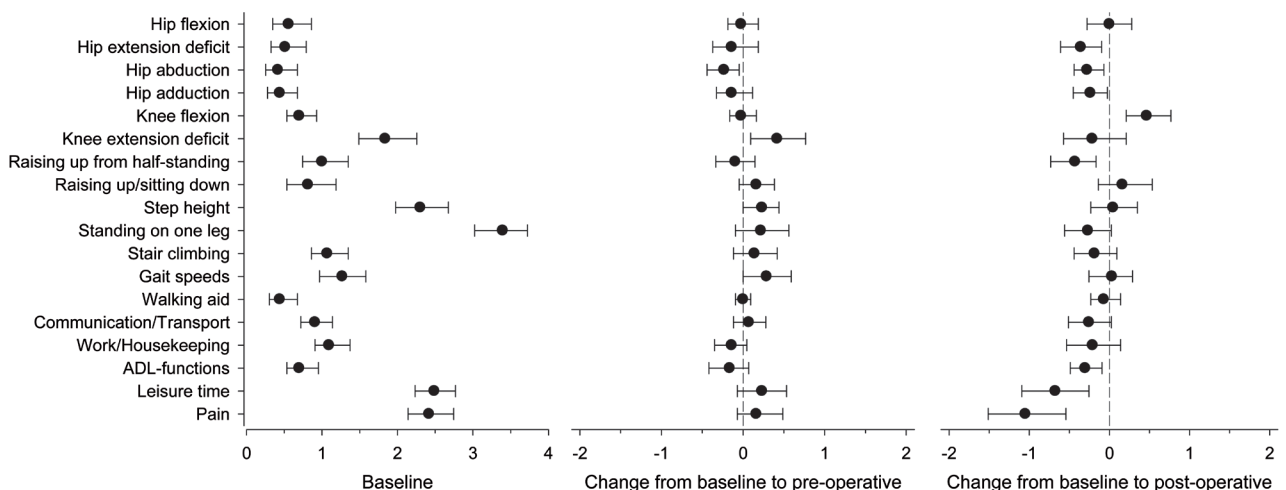


Fig. 2. Means of functional assessment system with 95% CI at the baseline and changes both from baseline to pre-operative (10-month) and to post-operative (3-month) follow-ups. ADL: activities of daily living; 95% CI: 95% confidence interval.

rising from a chair are possible with approximately 105° knee flexion (40). Changes in mobility may also lead to abnormal posture and cause compensatory hip movement. Therefore, owing to impaired knee mobility, our subjects would have been expected to encounter difficulties in some ADLs 3 months after surgery. However, the FAS assessment applied was not sensitive enough to detect these disabilities.

In this study preoperatively measured flexion and extension strength on the operative side were lower than on the non-operative side. Previous studies have demonstrated similar findings; flexion strength on the operated side has been 25–34% weaker and extension strength 24–41% weaker than on the non-operated side (33, 41). In the study by Lamb & Frost (42) lower limb leg press strength on the operative side was preoperatively 31% weaker than in the contra-lateral limb. However, preoperative physiotherapy or exercise has not been shown to improve recovery after surgery in studies with follow-up times of between 3 months and 2 years (26, 35, 43, 44).

The results of our study are consistent with earlier reports showing 26–40% lower knee extension and flexion strength levels 3 months post-surgery (27, 41, 42, 45–49). Pain may prevent optimal muscle activation (50). Also in the present study, pain experienced at the time of strength testing continued to be associated with thigh strength after surgery. As muscle strength weakens, much of the patient's strength reserve is used in performing ADLs. Even a minor additional disease or bed rest can reduce strength reserve to a level that prevents independent coping. Older persons may use up to 97% of their maximal strength when rising from a chair (51). Difficulties in rising from a chair have been reported when knee extension strength is less than 10 kg and hip flexor strength less than 15 kg (52). It is not possible to fully recover from the operation in 3 months. Retraining muscle strength after disuse takes long time and without specific training often remains incomplete (53–55).

Knee flexor and extensor strength levels affect gait speed and prosthesis loading (49, 50, 53, 54). It has been reported previously that arthroplasty patients' gait speed is reduced by 15–20%, and does not fully return within one year after surgery (39, 46, 56, 57). In this study gait speed was low preoperatively and no significant changes were found in gait speed or balance at follow-up. The risk of falling was probably still high, as a short single leg stance time correlates with an increased risk of falling (58). The risk of falling is also increased in instances where there is a need to walk at near maximal speeds, such as at traffic lights where the average gait speed required is 1.4 m/sec (59), which, on average, the present patients did not have.

On discharge from hospital patients received instructions on strengthening exercises, using their own leg weight as a resistance, and knee motion exercises, as well as advice to return to normal daily activities, which were not sufficient to restore knee function to the pre-operative level. To achieve this, progressive strength training would be needed. Studies with long-term follow-up are needed to determine the effectiveness of more active rehabilitation after knee arthroplasty.

In conclusion, patients had considerable pain and dysfunction at the time that the operation decision was made. Waiting time did not affect knee pain or isometric knee extension/flex-

ion strength. Three months post-operatively, knee pain had decreased significantly, but the strength of the operated knee was significantly lower than the pre-operative level.

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