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Postoperative Changes in Knee Joint Function of Total Knee Arthroplasty Patients

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Abstract. [Purpose] We investigated postoperative improvements in the knee joint function of 121 patients (17 males, 104 females) who received total knee arthroplasty (TKA). [Subjects and Methods] The evaluation criteria were: knee joint flexion range of motion, knee joint extension strength and flexion strength, pain in the knee joint, score on The Japanese Orthopedic Association knee criteria of "pain" and "ability to ascend and descend stairs", and 6-minute walking distance. The time points for the evaluations were: prior to surgery, at the time of discharge, 3 months postoperative, 6 months postoperative, and 1 year postoperative. In addition, the level of satisfaction 1 year after the operation was also assessed. [Results] In the results, 6-minute walking distance and ability to ascend and descend stairs were significantly better at 3 months postoperative than before surgery. Knee joint range of motion at 3 months postoperative had improved to its preoperative status, and was significantly improved at 1 year postoperative. Knee joint extension strength at 3 months postoperative had recovered to its preoperative status, and was significantly improved at 6 months postoperative. Knee joint pain was significantly ameliorated at the time of discharge compared to before surgery. Knee joint pain had completely disappeared in approximately 30% of patients by 1 year after surgery, and 90% of patients were satisfied with the results of their surgery. Nevertheless, many of the patients still complained of knee discomfort from TKA. [Conclusion] The results of this study show that knee joint pain was reduced at the time of discharge, and that 6-minute walking distance and ability to ascend and descend stairs were significantly improved at 3 months postoperative. Moreover, these results suggest that there are improvements in knee joint extension strength after 6 months, and in knee joint range of motion at 1 year postoperative. The results show that knee joint function after TKA improves over the year after surgery.
Key words: Total knee arthroplasty, Knee joint function, Postoperative changes

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INTRODUCTION

Along with dramatically extended mean life spans due to improvements in the development of medical science and lifestyle, there has also been a significant increase in the number middle-aged persons who have knee osteoarthritis ("knee OA") patients. The number of such patients in Japan is estimated to be 25 million[1)].

Knee OA is a disease in which pain and deformity develops with the degeneration and abrasion of the joint cartilage and meniscus with advancing age. This results in functional impairments such as limitation in the joint range of motion (ROM) and reduced quadriceps strength, and reduced ability to get up out of a chair, to walk and to ascend and descend stairs[2,3)].

Replacement of the damaged knee with an artificial joint is said to be effective in bringing pain relief, functional improvement and correction of the deformity[4–6)], and approximately 50,000 cases of total knee arthroplasty (TKA) are performed every year[7)]. It is extremely important to undergo physiotherapy to recover knee joint function and physical function after surgery. The main components of the postoperative physiotherapy are physical therapy for pain relief, knee ROM exercises, knee joint muscle exercises, and practice of activities of daily living (ADL) such as standing up, walking, and ascending and descending stairs. The ROM of recent knee prostheses, which are constructed with greater flexion is extremely good. ROM of the knee is

critical for descending stairs, getting into and out of cars, and stepping into a bathtub, and promptly regaining ROM is important for ADL. In addition, knee extension strength is known to affect physical function such as ascending and descending stairs and the timed up-and-go test[8], and knee strengthening exercises are important.

However, by shortening the length of the hospital stay, the patient is discharged before the ROM, extension strength and flexional strength of the operated knee have recovered to their preoperative levels. Moreover, postoperative knee pain is reduced, but some pain remains. Furthermore, the 6-minute walking distance is shortened compared to before surgery. Consequently, the physical activities at discharge from hospital after TKA are not fully recovered. It is generally considered that the majority of strength and ROM is regained by the third month[9]. Thus, we followed the changes in knee joint function over time and investigated the improvements in physical function.

SUBJECTS AND METHODS

The study subjects were 132 patients treated at the Kobe University Hospital who were diagnosed with knee OA and underwent a TKA operation between September, 2003, to February, 2008. Patients with revision TKA and who underwent unicompartmental knee arthroplasty (UKA) and bilateral TKA were excluded. Patients who had contralateral knee OA but were asymptomatic or who experienced mild pain were included in this study. Moreover, patients with systemic disease, cerebrovascular disorders, RA, or who could not be evaluated later were also excluded. Of the 132 initial subjects, there were 121 patients who could be evaluated for up to one year after surgery. Twenty-nine patients had concomitant illness of diabetes, and 54 patients had hypertension.

The study group consisted of 17 males and 104 females, and surgery was performed on the right knee in 55 cases, and on the left knee in 66 cases. Subjects' mean age was 73.2 ± 5.6 years, their mean height was 150.8 ± 7.1 cm, their mean weight was 58.5 ± 10.0 kg, and their mean body mass index (BMI) was 25.7 ± 3.8 kg/m^2. Patients who underwent the TKA operation at our hospital received physiotherapy in the Rehabilitation Ward after surgery, and all offered their cooperation with our study. Over the 3–4 weeks after surgery, each of the subjects received the same physiotherapy regimen from a physical therapist (PT) 5 days per week, and their mean hospital stay from operation to discharge was 28.4 ± 8.1 days (Table 1). The subjects were informed of the goals and methods of the research beforehand, and their consent was obtained. Approval for this study was obtained from the Ethical Committee of the Kobe University School Hospital. Physiotherapy was begun on the 2nd-3rd day after surgery. A femoral nerve block was employed for the 1st week after the operation, after which a suppository was administered, to reduce pain in the operated knee while conducting the physiotherapy. Details of the rehabilitation program included the use of an ice pack for the knee pain during the acute phase, and later a hot pack was used to facilitate extensibility in the operated femur. The exercise therapy included patella setting, straight leg raising exercises, and quadriceps exercises. Moreover, trunk and leg mobilization, manual knee ROM exercises done with the PT and self-exercises were performed by the patients in a sitting or a standing position.

Table 1. Patient characteristics

Number	121 (17 males and 104 females)
Mean age	73.2 ± 5.6 years (mean ± SD)
Mean height	150.8 ± 7.1 cm (mean ± SD)
Mean body weight	58.5 ± 10.0 kg (mean ± SD)
Mean Body Mass Index	25.7 ± 3.8 kg/m^2 (mean ± SD)
Side operated	Right knee: 55 Left knee: 66
Mean hospital stay	28.4 ± 8.1 days

SD ; standard deviation

Table 2. Home exercise program

1.	Knee ROM exercises done by the patient
2.	Quadriceps exercises and squatting exercises
3.	Standing on one leg exercises
4.	ADL exercises such as walking with a crutch, ascending and descending stairs, getting up from a chair or floor, etc.

Several days after surgery, patients were asked to exercise by walking between parallel bars, using both their hands to maintain a load that was within a tolerable pain range. In addition, in the 1st and 2nd weeks after surgery, exercises including walking with a walker and gradually proceeding to walking with a cane, ascending and descending stairs, and ergometer exercise, were performed with the goal of discharging the patient at approximately the 4th week. At the time the patients were discharged, a physical therapist provided them with instructions for at-home therapeutic exercises.

After discharge, some patients visited their neighborhood clinic 1–2 times per week for the first 1-2 months, but all patients exercised by themselves at home guided by exercise therapy principles. The exercise therapy done at home consisted of ADL exercises, all of which are listed in Table 2.

Clinical evaluations were carried out of knee ROM, knee extension strength and flexion strength, knee pain, 6-minute walking distance, and score (with 25 points being a perfect score) on The Japanese Orthopaedic Association knee evaluation criteria of ability to ascend and descend stairs (JOA score). The time points for making the measurements were: prior to surgery, at the time of discharge, 3 months after surgery, 6 months after surgery, and 1 year after surgery. Improvements seen at the different time points were compared and studied. Patients' level of satisfaction 1 year after the operation was also assessed. For the 6-minute walking distance, cones were placed at either end of a 10-meter course, and the distance walked by the patient at the most rapid speed possible was measured. For the measurement of knee ROM, the patient lay in a supine position with the leg on the side to be measured being held at a 90-degree angle to the hip. The examiner applied

Table 3. Changes in various parameters

	preoperative	discharge	3 months	6 months	1 year
Knee flexion angle (degree)	127.9 ± 14.7	126.8 ± 11.6	128.5 ± 11.1	130.1 ± 10.2††	131.1 ± 9.9*†
Knee extension strength (%)					
Isokinetic	55.2 ± 24.4	45.7 ± 14.5*	61.9 ± 18.0†	72.3 ± 22.0*†‡	81.4 ± 20.2*†‡¶
Isometric	83.8 ± 33.4	64.2 ± 23.5*	88.0 ± 25.5†	100.0 ± 26.9*†‡	115.6 ± 44.0*†‡¶
Knee flexion strength (%)					
Isokinetic	29.8 ± 13.9	26.5 ± 12.3	34.2 ± 14.4**†	37.7 ± 15.1*†	40.0 ± 14.6*†‡
Isometric	37.0 ± 15.3	33.9 ± 12.0	39.8 ± 11.9†	42.1 ± 12.0*†	44.8 ± 13.5*†‡

Values are presented as the average ± SD. Each symbol is as shown below.
[p<0.01 ; compared with *) preoperative, †) discharge,‡) 3 months,¶) 6 months.]
[p<0.05 ; compared with **) preoperative, ††) discharge.]

Table 4. Changes in various parameters

	preoperative	discharge	3 months	6 months	1 year
Pain (score)	5.9 ± 1.7	3.3 ± 1.4*	2.8 ± 1.4*	2.0 ± 1.2*†	1.5 ± 1.3*†‡
6-minute walking distance (m)	267.0 ± 95.2	266.7 ± 70.7	319.4 ± 69.6*†	328.9 ± 76.8*†	355.0 ± 74.3*†‡¶
Ascending and descending stairs (score)	13.4 ± 5.4	16.4 ± 4.0*	19.2 ± 4.5*†	21.0 ± 4.0*†‡	22.6 ± 3.4*†‡¶

Values are presented as the average ± SD. Each symbol is as shown below.
[p<0.01 ; compared with *) preoperative, †) discharge,‡) 3 months and ¶) 6 months.]

pressure to the leg, and the flexion angle was measured at the position where pain occurred. Another PT also participated in the angle measurement. Evaluation of pain employed a numerical rating scale (NRS). Muscle strength was assessed on a Biodex System 3 (Biodex Medical System, Inc.) multi-functional evaluation and exercise unit that measures the isokinetic maximum torque of concentric contraction at an angular velocity of 60 degrees/sec, and isometric maximum torque of 60-degree knee flexion. These torque values were divided by body weight and multiplied by 100% to give the maximum torque/body weight ratio (%) as a measure of muscle strength. The evaluation of pain employed a numerical rating scale (NRS). Satisfaction with the surgery and pain were surveyed with a questionnaire, and follow-up for 1 year after surgery was possible in 85 cases. Satisfaction with the surgery was surveyed by having the patient select one of the following 5 choices: highly satisfied; satisfied enough to recommend it to others; satisfied, but not enough to recommend it to others; cannot judge; would have been better off not to have it done. The commercial software program StatFlex 5.0 (Artech Co.,Ltd.) was used for statistical processing. One-way analysis of variance and the Tukey test were used for the comparisons of the 6-minute walking distance, knee flexion angle, knee extension strength and the flexion strength. Dunnett's test was used in the comparisons of ability to ascend and descend stairs and the pain scores.

RESULTS

The ROM of the knee flexion angle was 127.9 ± 14.7 degrees before surgery, 126.8 ± 11.6 degrees at the time of discharge, 128.5 ± 11.1 degrees at 3 months after surgery 130.1 ± 10.2 degrees at 6 months after surgery, and 131.1 ± 9.9 degrees at 1 year after surgery. Compared to preoperative, the knee flexion angle was reduced at the time of discharge, but increases were observed at 3 months, 6 months and 1 year after surgery, and the knee flexion angle at 1 year after surgery was significantly increased compared to preoperative ($p<0.01$). Moreover, significant increases in the knee flexion angle were observed at 6 months and 1 year after surgery when compared to at the time of discharge ($p<0.01$) (Table 3).

The maximum torque/body weight ratio obtained from the maximum muscle strength of isokinetic knee extension in concentric contraction at 60 degrees/sec was 55.2 ± 24.4% before the surgery, 45.7 ± 14.5% at the time of discharge, 61.9 ± 18.0% at 3 months after surgery, 72.3 ± 22.0% at 6 months after surgery, and 81.4 ± 20.2% at 1 year after surgery. Compared to before surgery, the maximum torque had significantly decreased at the time of discharge ($p<0.01$), while an increase was observed in the maximum extension strength from 3 months after surgery. A significant increase in the maximum extension strength was observed at 6 months and 1 year after surgery compared to preoperative ($p<0.01$). A significant increase in the maximum extension strength was observed at 3 months, 6 months, and 1 year after surgery compared to the time of discharge ($p<0.01$). Furthermore, a significant increase in the maximum extension strength was observed when comparing 1 year with 3 months after surgery ($p<0.01$). Moreover, significant increases in the maximum extension strength were also observed in the comparisons between 3 months and 6 months after surgery, and between 6 months and 1 year after surgery ($p<0.01$) (Table 3).

The maximum strength of isokinetic knee flexion was 29.8 ± 13.9% before surgery, 26.5 ± 12.3% at the time of discharge, 34.2 ± 14.4% at 3 months after surgery, 37.7 ± 15.1% at 6 months after surgery, and 40.0 ± 14.6% at 1 year after surgery. Thus, a decrease was observed in the maximum flexion strength at the time of discharge, while

an increase was observed at 3 months after surgery. A significant increase in the maximum flexion strength was observed at 3 months ($p<0.05$), 6 months, and 1 year ($p<0.01$) after surgery compared to preoperative. In addition, a significant increase in the maximum flexion strength was observed at 3 months, 6 months, and 1 year after surgery compared to the time of discharge ($p<0.01$). Furthermore, a significant increase in the maximum flexion strength was observed when comparing 1 year with 3 months after surgery ($p<0.01$) (Table 3).

The maximum torque/body weight ratio of the maximum isometric knee muscle extension strength in 60-degree knee flexion was 83.8 ± 33.4% before the surgery, 64.2 ± 23.5% at the time of discharge, 88.0 ± 25.5 at 3 months after surgery, 100.0 ± 26.9% at 6 months after surgery, and 115.6 ± 44.0% at 1 year after surgery. Isometric maximum extension strength and the isokinetic knee extension strength were similar before surgery. The maximum torque had significantly decreased at the time of discharge ($p<0.01$), while an increase was observed in the maximum extension strength from 3 months after surgery. Compared with before surgery, at 6 months after surgery, a significant increase in maximum extension strength was observed ($p<0.05$), and a significant increase was observed at 1 year after surgery ($p<0.01$). A significant increase in the maximum extension strength was observed at 3 months, 6 months, and 1 year after surgery compared to at the time of discharge ($p<0.01$). Furthermore, a significant increase in the maximum extension strength was observed in comparisons of 3 months vs. 6 months after surgery, 3 months vs. 1 year, and 6 months vs. 1 year ($p<0.01$) (Table 3).

The maximum strength of isometric knee flexion was 37.0 ± 15.3% before surgery, 33.9 ± 12.0% at the time of discharge, 39.8 ± 11.9% at 3 months after surgery, 42.1 ± 12.0% at 6 months after surgery, and 44.8 ± 13.5% at 1 year after surgery. There was a decrease in the maximum flexion strength at the time of discharge, but an increase was observed from 3 months after surgery, while there were significant increases in the maximum flexion strength at 6 months and 1 year after surgery compared with that before surgery ($p<0.01$). A significant increase in the maximum flexion strength was observed at 3 months, 6 months, and 1 year after surgery compared with that at the time of discharge ($p<0.01$). Furthermore, a significant increase in the maximum flexion strength was observed from 3 months to 1 year after surgery ($p<0.01$). There was an increase in the maximum flexion at 1 year after surgery compared with at 6 months, but the difference was not significant (Table 3).

The NRS pain score was 5.9 ± 1.7 before surgery, 3.3 ± 1.4 at the time of discharge, 2.8 ± 1.4 at 3 months after surgery, 2.0 ± 1.2 at 6 months after surgery, and 1.5 ± 1.3 at 1 year after surgery. A reduction in pain was observed from the time of discharge, and significant amelioration of pain was observed at 3 months, 6 months, and 1 year after surgery as compared to before the surgery ($p<0.01$). Moreover, significant improvements in pain were observed at 6 months and 1 year after surgery compared to at the time of discharge ($p<0.01$). Furthermore, a significant improvement in pain was observed from 3 months to 1 year after surgery ($p<0.01$). There was an improvement in the pain from 6 months to 1 year after surgery but the difference was not significant (Table 4).

The results for the 6-minute walking distance were 267.0 ± 95.2 m before surgery, 266.7 ± 70.7 m at the time of discharge, 319.4 ± 69.6 m at 3 months after surgery, 328.9 ± 76.8 m at 6 months after surgery, and 355.0 ± 74.3 m at 1 year after surgery. There was no change in the 6-minute walking distance at the time of discharge as compared with before surgery, but it gradually became longer at 3 months, 6 months, and 1 year after surgery, and the distances at 3 months, 6 months, and 1 year after surgery were significantly longer than before surgery ($p<0.01$). Moreover, a significant lengthening of distance was observed at 3 months, 6 months, and 1 year after surgery when compared with at the time of discharge ($p<0.01$). Furthermore, a significant increase in the distance was observed from 3 months to 1 year after surgery ($p<0.01$), and a significant lengthening in the walking distance was observed from 6 months to 1 year after surgery ($p<0.01$) (Table 4).

The JOA score for the ability to ascend and descend stairs was 13.4 ± 5.4 before surgery, 16.4 ± 4.0 at the time of discharge, 19.2 ± 4.5 at 3 months after surgery, 21.0 ± 4.0 at 6 months after surgery, and 22.6 ± 3.4 at 1 year after surgery. Compared to before surgery, improvements over time in the ability to ascend and descend stairs were observed at 3 months, 6 months, and 1 year after surgery ($p<0.01$). Moreover, significant improvements in the ability to ascend and descend stairs were observed at 3 months, 6 months, and 1 year after surgery when compared with at the time of discharge ($p<0.01$). Furthermore, a significant improvement in the ability to ascend and descend stairs was observed in comparisons of 3 months vs. 6 months after surgery, 3 months vs. 1 year, and 6 months vs. 1 year ($p<0.01$) (Table 4).

Eighty-five subjects were surveyed regarding their satisfaction with the surgery after 1 year. The results of the survey were as follows: 47/85 (55%) of patients were satisfied enough to recommend it to others, 33/85 (39%) were highly satisfied, 3/85 (4%) were satisfied, but not enough to recommend it to others, 1/85 (1%) could not judge, and 1/85 (1%) thought they would have been better off not to have it done. Combining the patients who responded that they were satisfied enough to recommend it to others with those who responded that they were highly satisfied gives somewhat more than 90% who were positive about TKA. A point of dissatisfaction was residual pain in the knee. In particular, since squatting is a common action in Japanese daily life, many felt they had knee pain when their knee was touching the floor. Moreover, there were many patients who complained of discomfort and that "it didn't feel like their own knee".

DISCUSSION

We surveyed patients following TKA surgery and studied their knee function and physical function over time. The parameters selected for this were: knee ROM, knee extension strength and flexion strength, knee pain (NRS), scores on The Japanese Orthopaedic Association knee evaluation criteria of "pain" and "ability to ascend and

descend stairs" (JOA score), and 6-minute walking distance. These were measured at the time points of: before surgery, at the time of discharge, 3 months after surgery, 6 months after surgery, and 1 year after surgery. Our study made observations of physical function at these time points. In addition, the level of satisfaction 1 year after the operation was also assessed.

Generally, the main objective of rehabilitation after TKA is improvement in abilities such as walking and handling uneven surfaces such as stairs, while postoperative physiotherapy is intended to decrease pain, increase strength in the leg muscles, acquire a broader ROM, and facilitate smooth functioning of the knee joint with the aim that the patient will be able to move without pain.

Knee ROM was somewhat diminished at the time of discharge as compared to before surgery. There were improvements over time thereafter, at 3 months, 6 months, and 1 year after surgery, and significant improvements were observed at 1 year after surgery as compared to before surgery ($p<0.01$) . A decrease in ROM interferes with the ADL such as climbing stairs or squatting. The main factors that influence postoperative knee ROM include preoperative ROM, type of prosthesis, surgical technique, pain, swelling, patient's will power, and postoperative treatment. Among these, the preoperative ROM has been reported to have the most substantial effect on postoperative ROM[10–14]. In other words, a patient with a good preoperative knee ROM will also have good postoperative flexion. Anouchi et al.[15] reported substantial improvement when the preoperative flexion angle was small, and conversely this was balanced by a decrease in the postoperative flexion angle when the preoperative flexion angle was large. They also reported a correlation between the postoperative flexion angle and the preoperative mean flexion angle. The same trend was evident in the present study, however we consider the patients might, at least, up to 1 year after surgery.

Knee extension and flexion strength were reduced at the time of discharge compared to before surgery, but they had recovered to the preoperative state at 3 months after surgery, and increased further at 6 months and 1 year after surgery. The knee extension strength had significantly increased at 6 months after surgery compared to at the time of admission ($p<0.01$). Lorentzen et al.[16], like us, stated findings of recovery from the preoperative state after 3 months, and a 14–18% marked increase after six months. In our current study, we found that at 1 year after surgery, there were further improvements in muscle strength.

Stevens et al.[17], when discussing recovery of strength immediately after surgery, indicated that while improvements in pain and physical function are obtained following TKA, quadriceps strength decreases by up to 40% of the preoperative maximum strength[12]. In our present study, at the time of discharge approximately 4 weeks after surgery, there were decreases of 20% in isokinetic maximum extension strength and 25% in isometric maximum extension strength. In TKA, the most notable factor is the detachment of the soft tissue through direct invasion of the joint due to surgery, which suggests that time is required for recovery. At the time of discharge, both the isokinetic and isometric maximum knee flexion strength were reduced by only 10% compared to before surgery. After surgery, Miyazaki et al.[18] mentioned less invasion of the muscle and peripheral soft tissue during surgery resulted in more satisfactory improvements in muscle strength, particularly in the early period. Mizner et al.[19], reported that quadriceps strength at one month after TKA is correlated with improved functional performance. As such, quadriceps strength is an essential element of exercise therapy. Mizner et al.[19], reported that the influence of pain on muscle weakness is minimal at 1 month after TKA surgery, and that the cause is instead a reduction in voluntary neural firing. Therefore they recommended using methods such as biofeedback to promote neuromuscular unit firing rather than exercises to strengthen the quadriceps. On the other hand, when Silva et al.[20] compared a TKA group 2 or more years after surgery with a healthy control group, they observed that maximum isometric extension strength had decreased by 30%, and that obese women of at least 70 years of age experienced quadriceps weakness. However, in contrast to Silva's[20] subjects, who had an average BMI of 33, the subjects in our study had an average BMI of 25. In the future, subjects may need to be given instructions to maintain their body weight. The NRS pain score was significantly improved at the time of discharge as compared to before surgery ($p<0.01$). Improvements in early postoperative pain have been reported due to the replacement of worn knee joints with artificial knee joints, which provides a correction of the deformity in a painless and stable manner[9].

Furthermore, significant improvements were observed from 3 months to 1 year after surgery ($p<0.01$), which confirmed that pain was reduced up to 1 year after surgery. In the present work, essentially all knee pain had disappeared in approximately 30% of patients, but many patients still felt some pain, such as when climbing stairs.

Dierick et al.[21] reported improvements in mobility at 6 months after surgery compared to before surgery. In our current study, the 6-minute walking distance measurements showed significant improvements in ability to walk at 3 months after surgery versus at the time of discharge ($p<0.01$). Furthermore, a significant lengthening of the walking distance was observed at 1 year after surgery versus 6 months after surgery ($p<0.05$). Specifically, we considered that significant improvements in walking ability were observed over the 1-year period after surgery. According to Kroll[22], the increase in walking speed after TKA surgery for knee OA is related to postoperative amelioration of knee joint pain. Moreover, Parent et al.[23] reported that the 6-minute walking distance criterion exhibits the earliest recovery, occurring at 2 months after TKA. They conjectured that the amelioration of pain due to surgery was sufficient to withstand the load and allow a lengthening of the walking distance, and it was thus easier to accomplish the actions associated with exercising the knee joint. In the present study as well, only knee joint pain showed improvement at 3 months after surgery compared to before the surgery, and we consider it plausible that there is a relationship between early improvements in walking ability and reduction in pain. Furthermore, regarding the improvements in walking ability after 6 months after

surgery, we consider that improvements in knee joint ROM and an increase in knee joint strength as well as pain reduction resulted in a faster walking speed and more improvement in the walking distance. Improvements were observed over time in the ascending and descending of stairs, and the preoperative ability to ascend and descend stairs had been regained at the time of discharge. Compared with before surgery, a significant improvement in the ability to ascend and descend stairs was observed at 3 months after surgery ($p<0.01$), and compared with 3 months after surgery, a further significant improvement in the ability to ascend and descend stairs was observed at 1 year after surgery ($p<0.01$). Specifically, we consider that there were improvements in the ability to ascend and descend stairs over the 1 year period after surgery. Mizner et al.[8] stated that preoperative quadriceps strength has the greatest effect on physical function such as ascending and descending stairs and the timed up-and-go test. Moreover, Rossi et al.[24] reported a significant correlation between knee extension strength and the timed up-and-go test following surgery, and Zeni et al.[25] mentioned the importance of muscle strength in the non-operated leg[19]. For ascending and descending stairs, knee joint strength and knee ROM improved, and a handrail was unnecessary. However, slight knee pain remained in descending stairs at 1 year after surgery.

The patients' satisfaction with their surgery at 1 year after surgery was surveyed with a questionnaire, and a majority of 90% of patients responded that they were quite pleased. The patients were not satisfied at the time of discharge since they unavoidably still had considerable knee pain; however their satisfaction with the surgery and with their leg function at 1 year after surgery was confirmed. Nevertheless, the residual knee pain was unsatisfactory, in particular since squatting is essential in the Japanese lifestyle, and many patients felt they had knee pain when their knee was touching the floor. Moreover, there were many patients who complained of discomfort in their knee compared to before surgery. Even though the pronounced pain before the operation had disappeared, they were still able to perceive the discomfort of the knee prosthesis and its inconvenience in the Japanese lifestyle in a manner that doesn't arise in Western countries.

In the present work, we evaluated knee function over time from before TKA to 1 year after surgery, and investigated satisfaction with the surgery at the 1-year point. From the results of the survey questionnaire, although 70% of patients had some residual knee pain, 90% expressed their satisfaction with TKA. Based on this study, pain at 1 month after surgery for knee joints that have undergone TKA improved compared to the preoperative condition, and at 3 months after surgery both walking ability and the ability to ascend and descend stairs had also improved compared to the preoperative conditions. In addition, since the musculature around the knee joint improved at 6 months after surgery as compared to prior to surgery, and the range of motion of the knee joint had improved at 1 year after surgery, we observed further improvements in walking ability and the ability to ascend and descend stairs from 6 months post-surgery. In conclusion, we demonstrated that knee joint function improves over 1 year post-surgery.

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