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ORIGINAL ARTICLE

Improvement in Gait Speed Affects Short-term Improvement in Activities of Daily Living in Patients with Moderate and Severe Knee Osteoarthritis

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Objectives: It is unclear whether improvements in knee pain or physical function lead to improvements in activities of daily living (ADL) and quality of life (QOL) in patients with moderate to severe knee osteoarthritis (KOA). This study aimed to investigate whether improvements in knee pain and physical function, achieved through exercise therapy, lead to improvements in ADL and QOL in patients with moderate to severe KOA. **Methods:** This case–control study included 18 patients with KOA. We evaluated knee range of motion, knee extension muscle strength (KEM), gait speed, knee pain, Knee Injury and Osteoarthritis Outcome Score (KOOS)-ADL, and KOOS-QOL at the first visit and after 3 months of exercise therapy. Patients were classified into the ADL and QOL improvement or no-improvement groups. Statistical analysis used split factorial analysis of variance with time and group as the main effects. When interactions were observed, post-hoc analysis was performed with two-sample *t*-tests. **Results:** For ADL improvement, the improvements in KEM of the affected side and gait speed were statistically significant. At 3 months, the gait speed of the improvement group was significantly higher than that of the no-improvement group. For QOL improvement, there was no significant interaction for any of the factors evaluated. **Conclusions:** No factor showed significant contribution to improved QOL in patients with moderate to severe KOA. However, increased gait speed may improve ADL and contribute to the development of efficient rehabilitation programs for patients with moderate to severe KOA.

Key Words: exercise therapy; knee injury; patient outcome assessment; quality of life

INTRODUCTION

Knee osteoarthritis (KOA) is a chronic degenerative joint disorder that affects a large population worldwide, particularly the elderly.[1)] According to a 2009 report,[2)] the prevalence of KOA in Japan in individuals over 60 years of age was 61.9% with a Kellgren-Lawrence scale (KL) rating of II or greater (mild to severe) and 20.6% with a KL rating of III or greater (moderate to severe). KOA causes knee pain and various physical functional declines, such as increased knee pain, decreased knee range of motion, decreased muscle strength of the knee, and decreased gait speed.[1–4)] Consequently, it leads to declines in activities of daily living (ADL) and quality of life (QOL).[5–7)] Therefore, patients with KOA are treated with conservative therapy or surgery to improve their ADL and QOL. Arthroplasty is commonly offered to patients with moderate or severe KOA because it is a cost-effective treatment with good results.[8,9)] However, a previous

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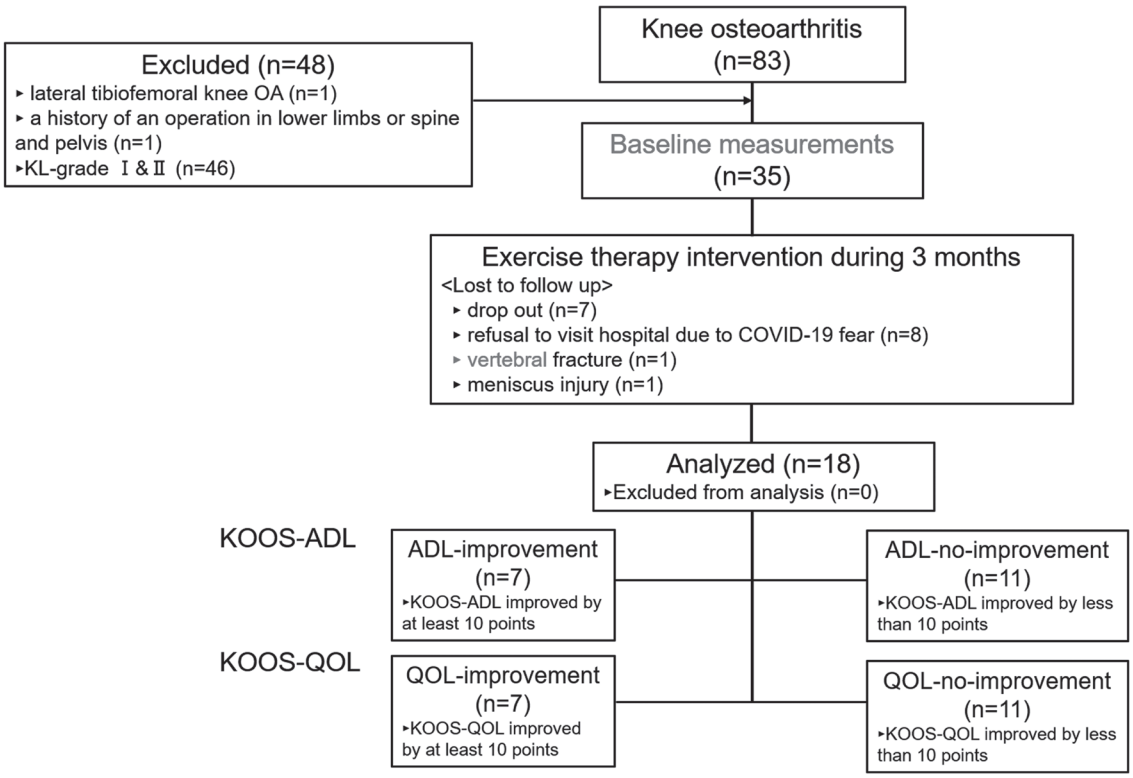

Fig. 1. Flowchart of patient registration and classification of subjects for analysis.

study reported that 20% of patients were not satisfied with functional improvement after arthroplasty.[10] Furthermore, arthroplasty causes more adverse events than conservative therapy.[11] In addition, there is a subset of patients who decline surgery because of concerns about surgical risks and other reasons.[12]

Conservative therapy, especially exercise therapy, is recommended as a treatment method for KOA according to the Osteoarthritis Research Society International guidelines.[13] A previous study showed that exercise therapy is effective in reducing knee pain and improving physical functions in patients with KOA when compared with usual care (i.e., regular follow-up by a doctor).[14] Furthermore, exercise therapy has been shown to be effective in patients with moderate to severe KOA.[15–17] However, it is unclear whether exercise therapy improves ADL and QOL in patients with moderate to severe KOA.

Identifying a connection between improvements in pain and physical function and enhanced ADL or QOL in patients with moderate to severe osteoarthritis could aid the design of effective rehabilitation programs for those who opt not to undergo surgery. This study aimed to investigate whether improvements in knee pain and physical function, obtained through exercise therapy, lead to improvements in ADL and QOL in patients with moderate to severe KOA.

MATERIAL AND METHODS

Participants and Design

This was a case–control study. The participants were patients with KOA who visited Shimada Hospital between June 2019 and March 2021 with a chief complaint of knee pain. The inclusion criteria were as follows: 1) aged 50 years or over, 2) moderate or severe OA. Patients were excluded on the basis of the following criteria: 1) lateral tibiofemoral KOA, 2) history of surgery in the lower limbs, spine, or pelvis (**Fig. 1**). The patients who were included had medial tibiofemoral KOA in one or both knees. If symptoms were found to be bilateral, the side with the more severe symptoms was defined as the affected side. Measurements were taken at the first visit (baseline) and at follow-up (3 months). This study was approved by the Shimada Hospital Ethics Committee (2021–013) and was conducted in accordance with the Declaration of Helsinki. The purpose of the study was explained to participants, and written consent for participation was obtained from all patients.

Basic Information

Demographic data were obtained using self-reported questionnaires (i.e., age and sex). Body height and weight were measured using a height meter and weight scale, respectively. Information on the use of oral drugs, topical drugs, and intra-articular injections was obtained from medical records. In addition, medical records were used to establish the number of rehabilitation sessions with a physical therapist in this study, the number of subjects with previous experience in rehabilitation for KOA (experience in rehabilitation), the use of walking aids, and the presence of coexisting orthopedic diseases.

Radiography

Weight-bearing anteroposterior and lateral semi-flexed radiographs were recorded for both knees of each subject. They were radiologically graded according to the KL.[18] KL uses ratings from 0 to IV, where 0=normal radiograph; I=doubtful pathology; II=minimal osteophytes, possible narrowing, cysts, and sclerosis; III=moderate, definite osteophytes with moderate joint space narrowing; and IV=severe, large osteophytes and definite joint space narrowing. Experienced doctors evaluated each radiograph.

Physical Function

Physical function was measured in terms of knee extension and flexion range of motion, knee extension muscle strength of the affected and opposite sides, and gait speed. Range of motion was measured in the supine position using a long-arm goniometer (Sakai Medical, Tokyo, Japan).[3]

Knee extension muscle strength of the affected and opposite sides was measured using a handheld dynamometer (Sakai Medical, Tokyo, Japan). Patients were seated with crossed arms and with their knees flexed to 90°. The handheld dynamometer was secured using a belt to the distal lower leg. This test was performed twice, and the highest value was recorded for each side. Knee extension strength was normalized according to the patient's body weight.[19]

Gait speed was measured by instructing the participants to walk 10 m at their usual pace. To account for acceleration and deceleration, a spare path of 3 m was provided before and after the measured section. This test was performed twice, and the value for the faster performance was recorded.

Knee Pain

The intensity of knee pain on the affected side during rest, motion, and gait was assessed using the Visual Analog Scale (VAS). Rest pain was defined as pain during non-weight-bearing (supine or sitting) posture. Gait pain was defined as the pain during walking. Motion pain was defined as the intensity of pain during the most painful movements, such as climbing stairs or standing up from the floor, other than gait pain.

Function in ADL and QOL Scores

ADL and QOL scores were assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS)-ADL and KOOS-QOL, respectively. A level of 10 points or more of improvement or decline was suggested as the cut-off representing a clinically significant difference in KOOS.[20]

Exercise Therapy Intervention

All patients underwent exercise therapy for one 40-min session every 2 weeks under the supervision of one of two physiotherapists (17 or 14 years of clinical experience). Exercise therapy consisted of stretching (hamstrings, gastrocnemius, and soleus), strength training (quadriceps, hamstrings, gluteus medius, and gluteus maximus), manual therapy of the knee joint, and instruction for home exercises. The home exercises were land-based exercises that could be performed once a day for 20 min.

Classification

The participants were classified based on two sets of data. First, patients were categorized into two groups according to their KOOS-ADL scores: those with improvements of 10 or more points (ADL-improvement group) and those with less than a 10-point improvement (ADL-no-improvement group). Second, the patients were also divided into two groups based on KOOS-QOL scores: those with improvements of 10 or more points (QOL-improvement group) and those with less than a 10-point improvement (QOL-no-improvement group; **Fig. 1**).

Statistical Analysis

All patient characteristics and confounding factors were compared between the ADL-improvement group and the ADL-no-improvement group, and between the QOL-improvement group and the QOL-no-improvement group using Fisher's exact test and the Mann–Whitney U test. The normal distribution of knee pain and physical function was assessed using the Shapiro–Wilk test. Main effects for knee pain and physical function were analyzed with factors of time and group, and interactions were explored using analysis of variance for a split-plot factorial design. If an interaction was observed for any physical function or knee

Table 1. Patient characteristics

Variable	KOOS-ADL (n=18)			KOOS-QOL (n=18)		
	Improvement (n=7)	No-improvement (n=11)	P value	Improvement (n=7)	No-improvement (n=11)	P value
Age (years)	73.0±6.3	74.1±7.6	0.76	70.1±8.0	76.1±5.1	0.08
Sex (male/female), n	0/7	2/9	0.50	0/7	2/9	0.50
Height (cm)	157.9±5.3	155.6±8.6	0.55	156.9±5.5	156.3±8.6	0.88
Body mass (kg)	62.2±7.9	62.1±13.6	0.98	62.5±8.1	61.9±13.5	0.92
Walking aid, n	0	0		0	0	
KL grade (affected side), n						
Grade III/IV	3/4	5/6	1.00	4/3	4/7	1.00

Data given as mean ± standard deviation or as number.

Table 2. Confounding factors

Variable	KOOS-ADL (n=18)			KOOS-QOL (n=18)		
	Improvement (n=7)	No-improvement (n=11)	P value	Improvement (n=7)	No-improvement (n=11)	P value
Intra-articular injection, n (%)	3 (42)	3 (27)	0.63	3 (42)	3 (27)	0.62
NSAIDs, n (%)	4 (57)	3 (27)	0.33	4 (57)	3 (27)	0.33
Topical medications, n (%)	2 (29)	3 (27)	1.00	1 (14)	4 (36)	0.60
No. of rehabilitation sessions, n	7 [6–9]	6 [5–8]	0.29	8 [7–9]	6 [5–8]	0.06
Experience in rehabilitation, n (%)	2 (29)	3 (27)	1.00	2 (29)	3 (27)	1.00
Coexisting orthopedic diseases, n (%)	1 (14)	2 (18)	1.00	1 (14)	2 (18)	1.00

Data given as number (percentage) or median [interquartile range].
NSAIDs, nonsteroidal anti-inflammatory drugs.

pain, as a post-hoc analysis, we used a two-sample *t*-test to analyze the difference between the improvement and no-improvement groups at 3 months. The significance level was 5%. Statistical analysis was performed using SPSS ver. 27.0 (IBM, Armonk, NY, USA).

Sample Size

The sample size was calculated using G*Power v3.1.[21] The interaction effect size was set to 0.14 with reference to a previous study.[22] To achieve 80% power to detect meaningful differences at the 5% level, 13 participants were required for each group. We included 35 participants, predicting a follow-up rate of 80%.

RESULTS

Of 83 patients with KOA, 48 were excluded. Of the remaining 35 patients, 17 were lost to follow-up, leaving a total of 18 patients for follow-up analysis after 3 months (**Fig. 1**). **Table 1** and **Table 2** present patient characteristics and confounding factors by KOOS-ADL and KOOS-QOL score classification. Two patients had lumbar spinal stenosis and one had degenerative spondylosis as coexisting orthopedic diseases. The Shapiro–Wilk test revealed that data for the muscle strength of the affected side and opposite side, gait speed, gait pain, and motion pain were normally distributed (P>0.05). In contrast, data for range of motion and rest pain were not normally distributed (P<0.05).

The results of the KOOS-ADL score classification are shown in **Table 3**. There were significant time differences in muscle strength of the affected side, gait speed, gait pain, and motion pain. Time × group interaction was significant for muscle strength of the affected side and gait speed. Post-hoc test for these variables indicated that the gait speed was significantly faster in the improvement group than in the no-improvement group at 3 months (**Table 4**).

The results of the KOOS-QOL score classification are shown in **Table 5**. There were significant time differences in muscle strength of the affected side, gait speed, gait pain, and motion pain. The time × group interaction was not significant for any of the measurement variables (**Table 5**).

Table 3. Results of classification by KOOS-ADL

Measurement	ADL-improvement (n=7)		ADL-no-improvement (n=11)		P value		η_p^2	
	Baseline	At 3 months	Baseline	At 3 months	Time	Time×group	Time	Time×group
Range of motion (°)								
Knee extension	−12.1 (8.1)	−4.3 (3.5)	−5.0 (4.5)	−3.2 (3.4)	<0.01	0.04	0.44	0.24
Knee flexion	122.1 (7.6)	128.6 (7.5)	127.3 (9.3)	130.9 (10.0)	0.01	0.45	0.33	0.04
Muscle strength								
Affected side	0.32 (0.15)	0.42 (0.12)	0.31 (0.11)	0.32 (0.12)	0.01	0.04	0.34	0.24
Opposite side	0.39 (0.14)	0.43 (0.10)	0.35 (0.12)	0.35 (0.09)	0.3	0.24	0.07	0.09
Gait speed (m/s)	1.1 (0.2)	1.4 (0.2)	1.1 (0.2)	1.2 (0.1)	<0.01	0.03	0.47	0.25
Knee pain (VAS)								
Rest	0.4 (1.1)	0 (0)	10.2 (29.9)	2.1 (4.7)	0.48	0.53	0.03	0.03
Gait	52.3 (24.4)	17.9 (22.5)	51.5 (30.0)	32.6 (17.9)	<0.01	0.3	0.45	0.07
Motion	64.0 (24.4)	30.3 (24.9)	62.0 (23.1)	41.5 (25.5)	<0.01	0.42	0.43	0.04

Data given as mean (standard deviation).

Table 4. Results of the post-hoc test at 3 months after the exercise therapy intervention

Variable	ADL-improvement (n=7)	ADL-no-improvement (n=11)	P value	Cohen's d
Muscle strength (affected side)	0.42 (0.12)	0.31 (0.13)	0.13	0.77
Gait speed (m/s)	1.4 (0.2)	1.1 (0.1)	0.01	1.40

Data given as mean (standard deviation).

Table 5. Results of classification by KOOS-QOL

Measurement	QOL-improvement (n=7)		QOL-no-improvement (n=11)		P value		η_p^2	
	Baseline	At 3 months	Baseline	At 3 months	Time	Time×group	Time	Time×group
Range of motion (°)								
Knee extension	−9.3 (6.1)	−4.3 (3.5)	−6.8 (7.5)	−3.2 (3.4)	0.01	0.67	0.33	0.01
Knee flexion	122.9 (8.1)	130.0 (7.6)	126.8 (9.3)	130.0 (10.0)	0.01	0.28	0.35	0.07
Muscle strength								
Affected side	0.32 (0.15)	0.39 (0.15)	0.31 (0.11)	0.34 (0.11)	0.03	0.22	0.28	0.09
Opposite side	0.37 (0.14)	0.42 (0.13)	0.36 (0.11)	0.36 (0.08)	0.34	0.38	0.06	0.05
Gait speed (m/s)	1.2 (0.2)	1.4 (0.2)	1.1 (0.2)	1.2 (0.1)	<0.01	0.09	0.44	0.17
Knee pain (VAS)								
Rest	0.4 (1.1)	0 (0)	10.2 (29.9)	2.1 (4.7)	0.48	0.53	0.03	0.03
Gait	55.9 (25.3)	25.0 (23.8)	49.2 (29.3)	28.1 (19.3)	<0.01	0.52	0.43	0.03
Motion	64.0 (24.4)	37.0 (28.1)	62.0 (23.1)	37.2 (24.6)	<0.01	0.89	0.4	0.01

Data given as mean (standard deviation).

DISCUSSION

In this study, conservative therapy, especially exercise therapy, improved muscle strength of knee extension on the affected side, gait speed, and knee pain (motion and gait) in patients with moderate to severe KOA. This study is the first to verify the relationship between improvement in knee pain and physical function, and improvement in ADL and QOL in patients with moderate to severe KOA. Our study findings indicated that improvement in gait speed contributed to improved ADL. We used the KOOS-ADL score, which is a comprehensive evaluation tool for various ADL, such as climbing stairs or rising from the floor. Given that gait speed has been reported to predict stair-climbing speed,[23] it may also predict various ADL abilities. Previous studies have reported that elderly people who walked at good speed tended to have high ADL scores when measured by the Barthel Index[24] or by self-report.[25] Therefore, in this study, we consider that improvement in gait speed contributed to improvements in various ADL in patients with moderate to severe KOA.

Conversely, improvements in muscle strength of knee extension on the affected side and knee pain (motion and gait) were not associated with improvement in ADL. Self-reported limitations of ADL in patients with KOA are not dependent on the knee range of joint motion or muscle strength of knee extension.[5] It is speculated that the physical functions required for various ADL are not limited to range of motion and extension muscle strength of the knee. A previous study reported that mechanical joint loading related to knee pain differs between activities.[26] Therefore, knee pain during different ADL should be assessed for each ADL.[27] In this study, we evaluated gait pain and pain during the most difficult movements (motion pain). However, we acknowledge that pain assessment during movements could have been subdivided into more categories. Nevertheless, we believe that this did not affect improvement in ADL.

In terms of QOL improvement, no contributions were observed from improvements in knee pain or physical functions. Exercise therapy was introduced as a safe and effective treatment for knee osteoarthritis in the guidelines of the International Osteoarthritis Research Society.[13] Exercise therapy has been reported to have a short-term benefit in improving knee pain, physical function, and QOL of patients with KOA.[28] Based on these findings, it was predicted that improvements in pain and physical function would be related to improvements in QOL. However, the participants in our study differed from those in previous studies. Specifically, a previous study[28] targeted patients with early and mild KOA, whereas our study included only patients with moderate and severe KOA. The differences in these participants may have affected the results. However, it was reported that an improvement in self-efficacy and behavior modification for pain improves the QOL of patients with KOA.[29] Therefore, to improve the QOL of patients with moderate to severe KOA, it may be necessary to focus not only on knee pain and physical function but also on self-efficacy and pain behavior. We hope to confirm the importance of self-efficacy and pain behavior in future studies.

In this study, although the same patients were classified according to KOOS-ADL and KOOS-QOL improvement/no-improvement (**Fig. 1**), the results were significantly different between the KOOS-ADL and KOOS-QOL classifications. In part, these differences were attributed to one patient who improved in KOOS-ADL but not in KOOS-QOL and to another patient who improved in KOOS-QOL but not in KOOS-ADL. It is generally believed that improved ADL leads to improved QOL in patients with KOA.[29] However, given that there are cases in which ADL and QOL improvements are not correlated, it may be necessary for improvements in ADL and QOL to be assessed separately.

This study has the following limitations: 1) small sample size, 2) low follow-up rate, 3) unclear implementation rate of home exercise. The first and second limitations were attributed to circumstances related to the COVID-19 pandemic. Fear of COVID-19 infection likely prevented some patients from visiting the hospital. Regarding the third limitation, the implementation rate was unclear because the patients did not keep daily exercise records. However, at each supervised session, physical therapists were able to confirm whether the patients were exercising at home.

CONCLUSION

This study investigated whether improvements in knee pain and physical function led to improved ADL and QOL in patients with moderate to severe KOA. We observed that improvement in gait speed contributed to the improvement in ADL. However, improvements in knee pain or physical function did not lead to significant improvement in QOL. Although further research is needed to determine whether exercise therapy improves gait speed and ADL in patients with moderate to severe KOA, the results of this study have the potential to contribute to the development of efficient rehabilitation programs for patients with moderate to severe KOA.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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