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Original Article

Factors influencing life-space mobility change after total knee arthroplasty in patients with severe knee osteoarthritis

Takashi Tobinaga, RPT, MS[1)]*, Shigeru Obayashi, MD, PhD[1)], Ryuhei Miyamoto, RPT[1)], Kodai Oba, RPT[1)], Namiko Abe, RPT[1)], Shiori Tsukamoto, RPT[1)], Masato Ogawa, MD[2)], Yuki Tochigi, MD, PhD[2)], Koichiro Oka, PhD[3)], Satoru Ozeki, MD, PhD[2)]

1) Department of Rehabilitation Medicine, Dokkyo Medical University Saitama Medical Center: 2-1-50 Minamikoshigaya, Koshigaya-city, Saitama 343-8555, Japan
2) First Department of Orthopaedic Surgery, Dokkyo Medical University Saitama Medical Center, Japan
3) Faculty of Sport Science, Waseda University, Japan

Abstract. [Purpose] The purpose of this study was to identify the factors influencing change in life-space mobility after total knee arthroplasty (TKA) in patients with severe knee osteoarthritis (knee OA). [Participants and Methods] Overall, 58 primary unilateral TKA recipients (9 males and 49 females; age ± SD 74.6 ± 6.5 years) were enrolled. We evaluated Life-Space Assessment (LSA) scores, knee extensor strength, Timed Up and Go test (TUG), one-leg standing time (OLS), Western Ontario and McMaster Universities osteoarthritis Index, and physical activity self-efficacy (SE) before surgery and at 3 months post-operation. [Results] Life space mobility significantly expanded 3 months after surgery compared with preoperative baseline. Preoperatively, walking SE and knee extensor muscle strength on the operative side were found to have strong correlation with LSA scores, while stairs SE and knee extensor muscle strength of the operative side were correlated at 3 months post-operation. [Conclusion] These findings suggest that to expand the life-space mobility of TKA recipients, it is important to enhance self-efficacy for general physical activity in addition to strengthening the quadriceps muscles.

Key words: Total knee arthroplasty, Life space mobility, Self-efficacy

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INTRODUCTION

Joint disorders are the number one cause of certified need for assistance among the elderly in Japan, constituting 17.2% of the whole[1)]. Consequently, in the overall management of ambulatory disorders toward forestalling certification for assistance, joint disorder management is of utmost importance. Among joint disorders, osteoarthritis of the knee (knee OA) is estimated to be symptomatic in 10 million people with 30 million more in the candidate pool[2)]. Symptoms include deformation of the joint, pain and limited range of motion (ROM) during exercise, which symptoms impact the Activities of Daily Living (ADL), reducing Health-Related Quality of life (HRQOL). As a surgical treatment of end stage knee OA, Total Knee Arthroplasty (TKA) along with post-operative rehabilitation has been shown to improve physical function and HRQOL[3, 4)]. On the other hand, approximately 20% of TKA recipients report dissatisfaction[5)].

Among the general elderly population physical activity has been reported to be a factor influencing HRQOL[6)]. Among knee OA patients who are TKA candidates, knee pain and reduced physical function result in reduced physical activity levels[7)]. However, although physical activity is objectively measurable, in recent decades the need for a more comprehensive

*Corresponding author. Takashi Tobinaga (E-mail: tobinaga@dokkyomed.ac.jp)

description of mobility and societal participation in the evaluation of HRQOL has spurred the use of life space mobility assessment[8]. Life space refers to the area where one gets out and about and lives an active life. Life space assessment quantifies the area and independence of movement while conducting the activities of daily life over a specified time period[9]. Life space has been reported to reflect the physical activity of the community-dwelling elderly and has been shown to relate to HRQOL[10]. End stage knee OA patients have a more restricted life space compared to the general elderly population[11]. However, of the few reports on life space after knee arthroplasty, recipients of unicompartmental knee arthroplasty (UKA) were reported to have life space improvement[12] while TKA recipients did not[13], resulting in a lack of certainty regarding factors determining HRQOL outcomes after arthroplasty. Clarification of factors affecting the life space of TKA recipients has become an essential prerequisite to the consideration of rehabilitative intervention aimed at improving physical activity and HRQOL. To that end we studied the pre and post TKA life space, looking for factors most directly exerting an influence on life space change.

PARTICIPANTS AND METHODS

Participants included 58 recipients (9 males/49 females, age 74.6 ± 6.5 years) of unilateral TKA who had presented at our facility with severe knee OA (Table 1). Exclusion criterion included individuals with previous contralateral TKA, neurological or other conditions affecting the ability to walk, or who had difficulty visiting the outpatient clinic. Candidates for participation in this study provided written consent after receiving an oral explanation along with an explanatory document of research contents. This study was carried out under the approval of the Dokkyo Medical University Saitama Medical Center Bioethics Committee (0826).

Table 1. Preoperative characteristics

Age (years)	74.6 ± 6.5
Gender (Male/Female)	9/49
Height (cm)	150.5 ± 7.4
Weight (kg)	59.6 ±10.4
BMI (kg/m^2)	26.3 ± 4.2
Post-op hospital days (d)	26.2 ±14.3

BMI: Body Mass Index. Data are the mean and standard deviation except for Gender.

For evaluation of life space mobility, the Life Space Assessment (LSA)[8] developed by Baker et al. was used. A maximum of 120 points were assigned based on the existence or absence of activity as well as the frequency and the degree of independence in each life space level during the month prior to the assessment. Higher scores indicate the wider life space and/or greater independence.

Knee extension strength was measured using BIODEX system 3 (Biodex Medical Systems Inc., Shirley, NY, USA). Measurements were repeated five times on isokinetic contractions with an angular velocity of 60°/sec in the upright seated position, and the value obtained by dividing the knee extension maximum torque on the operative side and the non-operative side by the body weight was taken as the representative value of each case.

The 30-second Chair Stand test was carried out according to Jones' method[14]. Participants gave maximum effort to repeatedly standing up after being uniformly instructed to "Stand up as many times as possible in 30 seconds". The measurement was made only once, and any partial rise at the end of the 30 seconds was counted as one rise.

The One leg standing time (OLS) test was carried out according to the method used in the Japan fitness test[15]. Standing barefoot with both hands on the hips, the length of time a patient could stand on one leg was measured, ending when the lifted foot touched the floor surface. The maximum value of three attempts was taken as the representative value.

For the 5 m maximum walking speed test (5MWS) patients were uniformly instructed to walk as fast as they can for 5 m, using 3 m before and 3 m after for acceleration and deceleration, for a total of 11 m. Each patient was measured twice, and the faster value was taken as the representative value.

The timed up and go test (TUG) was conducted according to the Podsiadlo et al. original method[16]. To minimize the fluctuation of results due to variation of psychological state at the time of measurement and varied interpretation of instructions, the Japanese translation of "please go as fast as you can" was used uniformly. Measurement at maximum effort was carried out twice, and the faster value was used.

To evaluate the pain and function of the knee joint, a Japanese adaptation of the WOMAC (Western Ontario and McMaster Universities osteoarthritis Index) developed by Hashimoto et al.[17] was used (hereafter referred to as WOMAC-J). Results are scored from 0 to 100 points, with higher scores indicating less pain and better function of the knee joint.

For the evaluation of Self-Efficacy (SE), a scale was used that had been developed and published in Japanese by Inaba et al., with the English title Self-Efficacy of physical activity in frail elderly people[18]. This SE scale evaluates three physical activity items: walking, stair-climbing (hereafter stairs SE) and lifting a weight. Scores ranging from 5 to 25 points were assigned for five levels of activity varying by time and intensity from "cannot do at all" to "absolutely can do", where the higher value indicates higher physical activity and higher SE.

Postoperative physical therapy was performed according to our clinical pathway. From the next day following surgery, participants started full weight bearing walking, range of motion and muscle strengthening exercises. From 2 weeks postoperatively balance exercise and stair climbing exercise were added according to improvement of walking. The standard hospital stay was 3 weeks post-op and the goal of therapy was to achieve independence of walking and stair climbing prior to discharge. Outpatient physical therapy was continued 1 to 2 times weekly for 3 months after surgery to confirm the continuation and quality of home exercise and to monitor the improvement of bodily function and physical activity. Evaluations for each participant were performed before and 3 months after surgery.

The normality of the data was confirmed by Shapiro-Wilk's normality test, and measurement items other than the LSA before the operation and 3 months after the operation were not normally distributed at both measurement timings or at either measurement timing. Therefore, changes in LSA corresponded to the t-test, and changes in other measurement items were analyzed using Wilcoxon's signed rank test. After calculating change values from pre-op to 3 months post-op in LSA and all measurement categories, the relationship between each change value and its baseline value was analyzed using the Pearson correlation coefficient or its partial correlation coefficient adjusted for age. Furthermore, in order to clarify factors related to LSA at each measurement time, univariate analyses were performed between LSA and each measured item using Spearman correlation coefficients and a partial correlation coefficient adjusted for age. Each factor found to correlate to LSA was then used as an independent variable against LSA as the dependent variable in a stepwise regression analysis. For statistical analysis SPSS ver. 19.0 (IBM Inc., Japan) was used with significance set to 5%.

RESULTS

LSA scores increased from 59.6 ± 25.6 points before operation to 72.8 ± 25.1 points 3 months after the operation, indicating a significant expansion of life space mobility (Table 2). In addition, all measurement items relevant to physical function, such as the pain and function sections of the WOMAC-J and all items of physical activity SE, also had improved significantly at 3 months post-op, compared to pre-op (Table 2).

Significant negative correlation was found between LSA change and baseline values (Table 3). Of the other measured items using age-adjusted partial correlation coefficients, significant negative correlations were found in all categories except CS-30 and operative-side OLS (Table 3).

Table 2. Outcome measures

		Pre-op	Post-op 3 M
Life Space Assessment score (points)		59.6 ± 25.6	72.8 ± 25.1**
Quadriceps strength (N·m/kg)	Operative side	54.1 ± 25.3	58.7 ± 17.1*
	Non-operative side	75.5 ± 28.5	79.8 ± 27.9**
CS-30 (times standing)		13.1 ± 4.2	14.9 ± 5.2*
OLS (seconds)	Operative side	11.6 ± 17.2	25.0 ± 28.3**
	Non-operative side	12.7 ± 18.3	18.2 ± 22.8**
5MWS (seconds)		5.2 ± 2.3	4.1 ± 1.2**
TUG (seconds)		11.2 ± 4.1	9.5 ± 2.5**
WOMAC-J (points)	Operative side pain	50.0 ± 22.4	76.6 ± 16.9**
	Non-operative side pain	63.8 ± 24.5	77.6 ± 21.7**
	Function	61.8 ± 19.0	77.7 ± 16.2**
SEPAF	Walking	14.2 ± 5.2	17.4 ± 5.2**
	Stair-climbing	9.4 ± 4.7	12.0 ± 5.1**
	Lifting a weight	16.9 ± 5.5	18.4 ± 5.8*

**p<0.01, *p<0.05.
CS-30: 30-sec Chair Stand test; OLS: One Leg Standing time; 5MWS: 5 m Maximum Walking Speed test; TUG: Timed up and go test; WOMAC-J: Western Ontario and McMaster Universities Osteoarthritis Index; SEPAF: Self-Efficacy of Physical Activity in Frail Elderly People.

Table 3. Relationship between change amount of each measurement item and initial value

		Correlation coefficient	Partial correlation coefficient
Life Space Assessment		−0.476**	−0.479**
Quadriceps strength	Operative side	−0.753**	−0.746**
	Non-operative side	−0.361**	−0.371**
CS-30		−0.284*	−0.199
OLS	Operative side	0.226	0.190
	Non-operative side	0.124	−0.424**
5MWS		−0.762**	−0.878**
TUG		−0.602**	−0.799**
WOMAC-J	Operative side pain	−0.759**	−0.754**
	Non-operative side pain	−0.584**	−0.581**
	Function	−0.605**	−0.587**
SEPAF	Walking	−0.427**	−0.448**
	Stair-climbing	−0.540**	−0.670**
	Lifting a weight	−0.290*	−0.368**

**p<0.01, *p<0.05. Abbreviations: See Table 2.

Table 4. Relationship between LSA and each measurement item at preoperative baseline

		Correlation coefficient	Partial correlation coefficient
Quadriceps strength	Operative side	0.43**	0.41**
	Non-operative side	0.23	0.12
CS-30		0.24	0.23
OLS	Operative side	0.43**	0.31*
	Non-operative side	0.19	0.10
5MWS		−0.39**	−0.32*
TUG		−0.38**	−0.32*
WOMAC-J	Operative side pain	0.10	0.10
	Non-operative side pain	0.19	0.02
	Function	0.36**	0.34*
SEPAF	Walking	0.52**	0.52**
	Stair-climbing	0.20	0.16
	Lifting a weight	0.32*	0.24

**p<0.01, *p<0.05. Abbreviations: See Table 2.

Table 5. Relationship between LSA and each measurement item at 3 months after surgery

		Correlation coefficient	Partial correlation coefficient
Quadriceps strength	Operative side	0.31*	0.39**
	Non-operative side	0.07	0.11
CS-30		0.16	0.21
OLS	Operative side	0.05	−0.11
	Non-operative side	0.01	−0.06
5MWS		−0.14	−0.15
TUG		0.06	−0.08
WOMAC-J	Operative side pain	0.24	0.23
	Non-operative side pain	−0.17	−0.12
	Function	0.18	0.23
SEPAF	Walking	0.19	0.26
	Stair-climbing	0.35**	0.40**
	Lifting a weight	0.11	0.20

**p<0.01, *p<0.05. Abbreviations: See Table 2.

Table 6. Factors influencing LSA preoperatively and at 3 months after surgery

Dependent variable	Independent variable	B	β	p	R	R^2
Preoperative LSA	(constant)	16.471		0.072	0.566	0.321
	Walking SE	2.056	0.422	0.001		
	Quadriceps strength ope. side	0.254	0.251	0.043		
3 mos Post-op LSA	(constant)	27.216		0.026	0.489	0.239
	Stair-climbing SE	1.615	0.325	0.011		
	Quadriceps strength ope. side	0.447	0.305	0.016		

B: Non-standard partial regression coefficient; β: standardized partial regression coefficients.
LSA: Life Space Assessment score; SE: Self-Efficacy.

Univariate analyses revealed significant correlations between preoperative LSA adjusted for age, and operative-side knee extension muscle strength, operative side OLS, 5MWS, TUG, WOMAC-J function, and walking SE (Table 4). LSA at 3 months postop was found to correlate with knee extensor muscle strength on the operative side and stairs SE (Table 5).

Multiple regression analysis identified pre-op walking SE and operative-side knee extension muscle strength as factors influencing preoperative baseline LSA scores (Table 6). Stairs SE and knee extension muscle strength on the operative side were identified as factors influencing LSA at 3 months post-op (Table 6).

DISCUSSION

This study found that for TKA recipients, at 3 months post-op, life space mobility had expanded compared to pre-op assessments. This differs from results reported by Hiyama et al. where post-TKA LSA scores did not improve at 3 months and 6 months postoperatively with respect to baseline[13]. The main reason for this variance may be the large difference in baseline values between the two groups. In their report the pre TKA LSA was 83.4 ± 24.1, whereas in this study it was markedly more restricted at 59.6 ± 25.6. In this study, not only were the pre-TKA LSA scores predictably lower than for the general population in the same age bracket in Japan at 91.6 ± 14.6[19], but as end-stage knee OA candidates for surgery, they were also lower than the 68.5 ± 28.0 reported to be typical for the severe knee OA patient[11].

The large difference in baseline LSA between the two groups is not attributable to a difference in average age, as both groups were mainly early old age (under 75) and no significant difference was found. It is more likely attributable to differences in criteria for selection and exclusion of participants. The former study excluded candidates from rural farming communities, including only those with urban transportation, whereas this study did not. Their study also excluded candidates with high blood pressure, diabetes, contralateral knee OA and other orthopedic ailments requiring surgery within 6 months[13]. It has been reported that the general health situation, motor function, and physical/human environment are directly involved in the life space mobility of general elderly people[19]. Thus, it is possible that the pre-TKA life space of participants in our study was markedly narrower than prior studies due to differences in residential environment and comorbidities.

Postoperatively at 3 months, LSA scores in this study were 72.8 ± 25.1, virtually the same as those in the Hiyama et al. study at 70.5 ± 27.9. A significant negative correlation was found in the relationship between the amount of change in LSA scores and the baseline LSA scores. From this it can be seen that the narrower the preoperative life space, the greater is the possibility of improvement in life space. On the other hand, patients with low preoperative LSA scores may be less likely to attain to the same postoperative LSA scores as those with high baseline LSA scores. An LSA score of 56 points is reported to be the cutoff point predicting an impact on instrumental ADL[20], so independence in instrumental ADL is presumed to have been preserved. However, the LSA scores of the general Japanese elderly population[19] were not attained. This aspect of postoperative LSA runs parallel to the observation that LSA reflects physical function, as it has been reported that patients with lower pre-TKA physical function, while having greater improvement range, do not improve to the level of patients with higher preoperative physical function[21].

Of physical function factors having an effect on LSA, operative-side knee extension strength was found to correlate with LSA scores both at the pre-operative baseline and at 3 months post-op. The LSA of community-dwelling elderly people is related to aging, health status, physical functions necessary for mobility, and instrumental daily living activities requiring high mobility functions[22]. Walking speed has also been mentioned as one of the factors that regulate the life space mobility of elderly people[23]. For both end-stage knee OA patients and TKA recipients at 6 months post-op, TUG scores (an index of mobility) confirmed mobility influences LSA scores[11, 13]. The results of this study differed slightly from that of earlier studies but for knee OA patients knee extension strength is seen to be related to walking speed[24] and physical activity[25]. This suggests that to expand the life space of TKA recipients, strength training is needed on the operative side to strengthen the quadriceps which are essential for mobility and physical activity.

As psychological factors affecting life space mobility, this study found walking SE to correlate with pre-TKA LSA scores, while stairs SE to correlated with LSA scores at 3 months post-op. In previous studies, for end-stage knee OA patients, self-confidence for getting out was found to be influential[11], and at 6 months post-op walking self-efficacy was found to be influential[13]. As both of these psychological factors have been reported to influence life space, the present study is in agreement with prior studies.

It has been reported that in order to improve life space after TKA, establishment of a program for the improvement of walking SE through self-directed mastery experience is important[26]. In this study pre-operative walking SE, and stairs SE at 3 months post-op, were found to be correlative, such that at each evaluation point there was a different correlating physical activity SE factor. The likely reason for this is that walking improves with the reduction of pain, and subsequent improvement in physical function leads to the higher activity levels required by stairs. To expand the life space of TKA recipients, it is necessary to raise physical activity through the guided mastery[27] of a graduating series of physical activity levels. Self-efficacy is thought to arise from subsequent self-directed mastery experiences involving walking and the navigation of stairs on the patient' own initiative[26, 27].

From the above it became clear that TKA recipients' life space can be significantly improved by 3 months post-op, and that the narrower a TKA recipient's preoperative life space the greater the range of improvement possible at the 3-month post-op point of evaluation. Since knee extension strength is seen to be factorial in walking speed[24], physical activity[25], and stairs SE (this study), it follows that intervention for the expansion of life space for TKA recipients would include exercises for strengthening the quadriceps, along with behavioral intervention designed to improve physical activity SE.

As a limitation to the scope of this study, while it was possible to clarify physical and psychological factors influencing the life space of TKA recipients, it should be pointed out that multiple factors in the social and physical environment were not examined here. Also, comorbidities were not fully examined, and, due to the lack of data beyond 3 months post-op, long-term changes in life space are unknown. Longitudinal studies are needed. Going forward, broadening the examination of factors influencing the life space of TKA recipients to include comorbidities as well as physical and psychological factors, should lead to the development of more wholistic approaches to expanding that life space after TKA.

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