Characteristics of functional impairment in patients with long-standing rheumatoid arthritis based on range of motion of joints: Baseline data from a multicenter prospective observational cohort study to evaluate the effectiveness of joint surgery in the treat-to-target era

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Abstract

Objective: To explore the characteristics of functional impairment in patients with established rheumatoid arthritis (RA) based on the range of motion (ROM) of joints in a prospective observational study of RA patients undergoing joint surgery.

Methods: We collected data on demographics, HAQ-DI, and the ROM of large joints including the shoulder, elbow, wrist, hip, knee, and ankle. Associations between the ROM of each joint and disability in the eight HAQ-DI categories were determined using receiver operating characteristic (ROC) and logistic regression analyses. ROM cut-off values of each joint for the absence of disability in each HAQ-DI category were determined using ROC curves.

Results: A total of 460 patients were enrolled and analyzed in this study. Based on ROC analysis, the ROM of each joint was significantly associated with disability in each category. After adjusting for disease activity, age, and sex, shoulder abduction had the highest independent impact on disability in activity [cut-off: 139 degrees (OR: 5.26)], elbow flexion-extension in dressing [121 degrees (OR: 2.22)], wrist flexion-extension in reach [86 degrees (OR: 2.71)], hip flexion-extension in walking [126 degrees (OR: 3.42)], and knee flexion-extension in walking [134 degrees (OR: 2.97)].

Conclusion: Limited ROM of multiple joints was significantly associated with functional impairment in patients with long-standing RA. Motion in daily activity involves multiple joints,

and at least two joints were independently involved in disability.

INTRODUCTION

Rheumatoid arthritis (RA) is a chronic disease that affects multiple joints and causes physical disability. Remarkable progress has been made in the past decade with respect to drug therapies for RA. At present, aggressive and early therapy is recommended [1, 2]. However, as shown in post-marketing surveillance studies, the mean disease duration of patients treated with biologics in clinical practice is about 8-10 years [3-7]. Many RA patients have long-standing disease and irreversible structural damage to their joints (both small and large joints), and as a result experience disability in daily life [8] and often must resign from their jobs [9]. These patients require reconstructive joint surgery to improve physical function and quality of life, as well as to control inflammation.

Range of motion (ROM) is widely used to assess joint function in daily practice. The treat-to-target strategy for RA clearly shows a benefit in terms of clinical outcome. ROM targets should be set in order to guide surgery and rehabilitation, but no such target values currently exist. In this context, it would be informative to understand how much improvement in ROM corresponds to an improvement in physical function in RA patients with joint damage.

This study aimed to explore the characteristics of functional impairment in RA patients with long-standing disease with joint damage based on ROM of joints using a multicenter prospective observational cohort.

PATIENTS AND METHODS

We conducted a multicenter prospective observational cohort study with patients who underwent elective joint surgery for RA from April 2012 to March 2016 (UMIN000012649) with/without a history of joint surgery, in order to evaluate the effectiveness of joint reconstructive surgery on improving physical function and patient-reported outcomes.

A total of ten institutes throughout Japan have joined this project. Baseline data were collected before the time of elective joint surgery. Documented variables at baseline included sex, age, disease duration, disease activity assessed by the 28-joint disease activity score using CRP (DAS28-CRP), and drug therapy [methotrexate (MTX), glucocorticoid (GC), and biologics]. With respect to the assessment of physical function, we used a validated Japanese version of the Health Assessment Questionnaire Disability Index (HAQ-DI) [10], ROMs of joints (shoulder, elbow, wrist, hip, knee, and ankle), and the Timed Up and Go test. Measured ROMs were as follows: shoulder: abduction, elbow: flexion-extension, wrist: supination-pronation and flexion-extension, hip: flexion-extension, knee: flexion-extension, and ankle: flexion-extension. These ROMs were measured by a well-trained orthopedic surgeon or physiotherapist using a manual goniometer.

Registered patients were followed for one year. At 6 months and 1 year after surgery, data on physical function and patient-reported outcomes were collected. If another operation

was performed within one year, the follow-up was censored at that time point.

The registry and study design were approved by the Ethics Committee of Nagoya University, School of Medicine. Patients provided written informed consent prior to participation. Patient anonymity was maintained during data collection, and the security of personal information was strictly controlled.

Statistical analysis

The ROM of each joint was defined as the mean ROM value of bilateral joints. To evaluate physical function, we calculated the HAQ-DI score using each score of eight categories (dressing, arising, eating, walking, hygiene, reach, grip, and activity). To clarify differences in patients with/without a history of joint surgery, we compared differences in their characteristics using the unpaired t-test for continuous values and the chi-square test for the categorical value.

Receiver operating characteristic (ROC) curves were generated to assess associations between the ROM in each joint and the presence of disability in each HAQ-DI category (score $\geq$1). These curves were also used to determine ROM cut-off points of each joint for the presence of disability in each HAQ-DI category. The best cut-off point was identified as the maximum point of the Youden index, which was calculated using the following formula: [Youden index

=sensitivity+specificity-1]. These analyses were performed for the entire study population as well as for patients with/without a history of joint surgery.

Multivariate logistic regression analysis was performed to examine the independent impact of the ROM of each joint (arc of motion) on disability in daily activities by HAQ-DI category. The ROM of each joint (arc of motion) was dichotomized using the cut-off values described above. The model was adjusted for age, sex, and disease activity (DAS28-CRP). All data were analyzed using SPSS version 22.0 (IBM Corporation, Armonk, NY). $P<0.05$ was considered statistically significant.

RESULTS

In total, 700 patients were registered during the study period, of whom 460 with data on age, sex, HAQ-DI, and any ROM of seven joints were identified and enrolled for analysis. Characteristics of all patients are summarized in Table 1. Mean age and disease duration were 64.5 years and 16.7 years, respectively. Most patients had long-standing RA. However, median values of CRP and DAS28-CRP were 0.2 mg/dl (within the normal limit) and 3.1 (low disease activity based on DAS category), respectively. About 25% of patients were treated with biologics.

Associations between the ROM of each joint and disability by HAQ-DI category differed based on analyses of areas under the ROC curve (Table 2A). With respect to dressing and eating, the ROM in the upper limbs was more strongly associated with disability than the ROM in the lower limbs. Conversely, for arising and walking, the ROM in the lower limbs was more strongly associated with disability than the ROM in the upper limbs. Finally, with respect to hygiene and reach, ROMs in both upper and lower limbs were associated with disability to about the same degree. Cut-off values and their sensitivities and specificities for disability are shown in Table 2B. Cut-offs for the absence of disability based on HAQ-DI (score=0) were as follows: shoulder abduction, 133–151 degrees; elbow extension, -19–-10 degrees; flexion, 139–142 degrees; flexion-extension, 114–141 degrees; wrist supination-pronation, 150–156 degrees; wrist flexion-extension, 70–89 degrees; knee flexion-extension, 124–134 degrees; hip

flexion-extension, 114–131 degrees; and ankle flexion-extension, 54–61 degrees.

The independent impact of ROM of each joint on disability for each category was determined by multivariate logistic regression analysis, after adjusting for age, sex, and DAS28-CRP in both patients with/without a history of joint surgery (Table 3). Odds ratios (ORs) of limited ROM dichotomized by cut-off values for disability are also shown. For each category, limited ROM in more than two joints was an independent factor associated with disability, except for disability in eating (only wrist flexion-extension was an independent factor).

Limited ROM of shoulder abduction was an independent factor even after adjusting for age, sex and DAS28-CRP for the following categories (Table 3): dressing [OR: 4.80, 95% confidence interval (95%CI): 2.32–9.91], arising (OR: 1.95, 95%CI: 1.14–3.35), hygiene (OR: 3.79, 95%CI: 2.1–6.85), reach (OR: 3.53, 95%CI: 1.31–9.53), and activity (OR: 5.26, 95%CI: 2.27–12.2). Limited ROM of elbow flexion-extension was an independent factor for the dressing category (OR: 2.22, 95%CI: 1.13–4.37). Limited ROM of wrist flexion-extension was an independent factor for the following categories: eating (OR: 2.20, 95%CI: 1.21–3.99), hygiene (OR: 2.25, 95%CI: 1.27–4.01), reach (OR: 2.71, 95%CI: 1.36–5.39), and grip (OR: 2.56, 95%CI: 1.32–4.97). Limited ROM of hip flexion-extension was an independent factor for the following categories: dressing (OR: 2.11, 95%CI: 1.14–3.92), walking (OR: 3.42, 95%CI:

1.92–6.12), reach (OR: 2.52, 95%CI: 1.14–5.56), grip (OR: 2.39, 95%CI: 1.18–4.85), and activity (OR: 3.26, 95%CI: 1.65–6.46). Finally, limited ROM of knee flexion-extension was an independent factor for the following categories: arising (OR: 1.75, 95%CI: 1.00–3.06), walking (OR: 2.97, 95%CI: 1.73–5.11), and hygiene (OR: 1.90, 95%CI: 1.08–3.32). Limited ROMs of wrist supination and pronation and ankle flexion-extension were not significant factors for any category by multivariate analysis.

In this study, all patients were registered regardless of whether or not they had a history of joint surgery. Thus, in order to clarify differences in patients with/without a history of joint surgery, we compared patient characteristics (Table 3) and analyzed the association of ROM with disability according to with or without joint surgery (Tables 5 and 6).

Patients without a history of joint surgery had better physical function and ROM than those with a history of joint surgery (Table 3). ROC analyses revealed that the association of ROM with disability and cut-off values for disability in HAQ-DI categories were almost the same in patients with and without a history of joint surgery (Tables 5A, B and 6A, B).

DISCUSSION

In this study, we revealed a relationship between the ROM of each joint and disability based on HAQ-DI categories in patients with long-standing RA who underwent elective joint reconstructive surgery under drug therapy. More than half of the patients enrolled in this study had normal levels of CRP and low disease activity. To our knowledge, this is the first study to report cut-off values of ROM for the evaluation of disability in daily life based on data from RA patients in real world practice who have damage to multiple joints.

Although only a few reports exist on the efficacy of rehabilitation including occupational therapy [11] and exercise [12] in patients undergoing drug therapy, the efficacy of exercise for improving the function of rheumatic hand was recently reported [13]. The ROM cut-offs reported in our study could serve as a useful tool to guide rehabilitation.

Interestingly, ROMs of a number of large joints were significantly associated with physical function in daily life. Motion in daily activity involves multiple joints and, in fact, at least two joints were involved in disability for each HAQ-DI category except for eating (only wrist flexion-extension was an independent factor) independently as shown in results of multivariate analysis. These results suggest that the assessment of only one targeted joint for elective joint surgery is insufficient for RA patients who suffer from damage to multiple joints.

Cut-off values of not only total ROM but also ROM in each direction (i.e., wrist pronation-supination, pronation, and supination) are related to disability in most daily activities

and provide important information for evaluating disability in long-standing RA patients. Notably, limied ROM of the shoulder had a significant impact on disability in all categories of HAQ-DI, with at least 130 degrees needed for reducing disability in daily life. Exercise and rehabilitation aimed at increasing ROM in the shoulder joint could be very important for daily management of long-standing RA patients. Patients with arthritis in the shoulder could be targets for intensive drug therapy.

In this study, all patients were registered regardless of a history of joint surgery. The comparison between patients with and without a history of joint surgery revealed that the association of ROM with disability was almost the same in patients with or without a history of joint surgery (Tables 5A and 6A, 5B and 6B), although patient characteristics significantly differed (Table 3). These results support the reliability of ROM.

Most patients showed improvements in ROM and pain after joint surgery. However, even after joint surgery, such as prosthesis implantation and especially joint fixation, limited ROM could remain without pain. Ishikawa et al. reported that patients who underwent partial joint fixation of the wrist (radiocarpal joint) had improved ROM in supination-pronation but not in flexion-extension [14]. Momohara et al. reported that improvement of physical function based on HAQ-DI after joint surgery was limited in spite of decreased pain [15]. This could be related to limited ROM in some patients. Limited ROM of joints that are not targeted in surgery

might also have a critical impact on disability after surgery. These information including cut-off of ROMs shown in this study, could be provided to the patients before operation.

A major limitation of this study was its cross-sectional observational design. The number of cases is still limited to explore the physical dysfunction in established RA patients with many factors. It is difficult for multivariate analysis to indicate the range of motion in each direction as independent factors in this study. We could not fully assess the ROM of the shoulder (flexion, extension, adduction, and external and internal rotation) and of the hip (abduction, adduction, and external and internal rotation).

The joints in the hands and feet were also not evaluated. Moreover, while instability and pain, as well as ROM, are very important, we could not fully assess each joint in terms of instability, pain, or inflammation. Given that the same trend was observed when the results of multivariate analysis with/without adjustment of disease activity were compared, only ROM might serve as a useful index for assessing physical function in long-standing RA patients.

In conclusion, joint ROM was significantly associated with functional impairment. The cut-offs of ROM reported here should be informative for assessing disability in patients with long-standing RA. The data presented here could guide the selection of surgical procedures under the background of aggressive drug therapy, and should be validated by further analyses of longitudinal data.

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CONTRIBUTORS

Each author has contributed to one or more of the following aspects of the manuscript; literature search, access to registry data, analysis and interpretation of data, drafting the article. All authors approved the final version.

COMPETING INTERESTS

There is no competing interest for this study in all authors.

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Table 1: Patient characteristics (N=460)

Variables			Unit	Mean	SD	Median
Age			(year)	64.5	(11.6)	65.0
Female			(%)	86.8		
Disease duration			(year)	16.7	(10.9)	16.0
HAQ-DI				1.14	(0.79)	1.00
DAS28-CRP				3.14	(0.98)	3.10
CRP			(mg/dl)	1.0	(3.5)	0.2
MTX use			(%)	58.1		
Dose of MTX			(mg/week)	7.9	(3.0)	8.0
GC use			(%)	55.5		
Dose of GC			(mg/day)	4.3	(2.4)	4.0
Biologics use			(%)	24.1		
Previous joint surgery			(%)	58.9		
Elective joint surgery						
prosthesis			(%)	51.5		
arthroplasty/desis			(%)	39.5		
synovectomy			(%)	9.0		
upper/lower limbs			(%)	45.5	/ 55	
ROM						
shoulder	abduction	n=395	(degrees)	141	(31.1)	150
elbow	flexion-extension	n=403	(degrees)	123	(21.6)	130
wrist	supination-pronatior	n=400	(degrees)	149	(24.8)	153
wrist	flexion-extension	n=364	(degrees)	63	(37.2)	63
hip	flexion-extension	n=397	(degrees)	126	(19.9)	130
knee	flexion-extension	n=415	(degrees)	127	(20.3)	133
ankle	flexion-extension	n=399	(degrees)	55	(17.5)	58

HAQ-DI: Health Assessment Questionnaire Disability Index
CRP: C-reactive protein
MTX: methotrexate, GC: glucocorticoid, ROM: range of motion

Table 2: Association between range of motion of each joint and disability in daily activity based on HAQ-DI category using ROC analysis

A: Assessment by area under the ROC curve

		HAQ-DI category							
		Dressing	Arising	Eating	Walking	Hygiene	reach	Grip	Activity
shoulder	abduction	0.70 **	0.64 **	0.70 **	0.63 **	0.71 **	0.67 **	0.66 **	0.70 **
elbow	extension	0.67 **	0.57 *	0.65 **	0.52	0.63 **	0.61 **	0.63 **	0.58 *
	flexion	0.62 **	0.56 *	0.54	0.55	0.58 *	0.53	0.54	0.55
	flexion-extension	0.68 **	0.58 **	0.61 **	0.55	0.63 **	0.59 *	0.60 **	0.59 *
wrist	pronation	0.67 **	0.59 **	0.71 **	0.54	0.64 **	0.67 **	0.65 **	0.59 *
	supination	0.61 **	0.55	0.66 **	0.51	0.61 **	0.60 *	0.62 **	0.54
	supination-pronatio	0.65 **	0.57 *	0.70 **	0.52	0.64 **	0.64 **	0.64 **	0.57
wrist	extension	0.64 **	0.51	0.62 **	0.51	0.59 **	0.57 *	0.56	0.58 *
	flextion	0.64 **	0.52	0.58 *	0.51	0.61 **	0.56	0.55	0.58 *
	flexion-extension	0.67 **	0.52	0.62 **	0.51	0.61 **	0.58 *	0.57 *	0.59 *
hip	extension	0.64 **	0.64 **	0.55	0.68 **	0.59 **	0.61 **	0.58 *	0.64 **
	flextion	0.65 **	0.71 **	0.56	0.72 **	0.63 **	0.65 **	0.62 **	0.65 **
	flexion-extension	0.67 **	0.71 **	0.56	0.74 **	0.63 **	0.65 **	0.62 **	0.67 **
knee	extension	0.50	0.59	0.49	0.63 **	0.53	0.50	0.52	0.54
	flextion	0.59 **	0.68 **	0.51	0.74 **	0.61 **	0.58 *	0.59 *	0.60 **
	flexion-extension	0.59 **	0.69 **	0.50	0.74 **	0.61 **	0.57 *	0.58 *	0.61 **
ankle	extension	0.56 *	0.58 *	0.55 *	0.60 *	0.59 **	0.53	0.54	0.54
	flextion	0.60 **	0.59 **	0.58 *	0.64 **	0.56 *	0.58 *	0.60 **	0.57 *
	flexion-extension	0.65 **	0.63 **	0.62 **	0.68 **	0.61 **	0.61 **	0.62 **	0.60 **

**p<0.01, *p<0.05

B1 Cut-off value of ROM of each joint

		Dressing	Arising	Eating	Walking	Hygiene	Reach	Grip	Activity
					Cut-off				
					sensitivity	specificity			
shoulder	abduction	133	143	149	148	141	134	151	139
		0.91 0.47	0.75 0.54	0.74 0.57	0.68 0.58	0.82 0.55	0.91 0.39	0.69 0.57	0.91 0.46
elbow	extension	-19	-14	-16		-13	-16	-10	-19
		0.91 0.40	0.72 0.43	0.86 0.39		0.78 0.48	0.86 0.37	0.69 0.55	0.86 0.33
	flexion	141	139			142			
		0.49 0.76	0.54 0.61			0.42 0.76			
	flexion-extension	121	122	114		142	121	121	114
		0.84 0.48	0.73 0.44	0.87 0.36		0.42 0.76	0.80 0.40	0.82 0.41	0.81 0.33
wrist	pronation	73		69		72	79		73
		0.64 0.61		0.74 0.44		0.64 0.55	0.47 0.68		0.61 0.56
	supination	79		82		79			76
		0.74 0.52		0.62 0.54		0.70 0.51			0.75 0.43
	supination-pronation	150		151		153	156	151	152
		0.71 0.60		0.68 0.54		0.60 0.61	0.58 0.59	0.64 0.52	0.66 0.53
wrist	extension	25	43	37		46	47	47	47
		0.85 0.40	0.42 0.75	0.71 0.60		0.39 0.83	0.49 0.79	0.47 0.79	0.38 0.78
	flexion	34		29		35	47	48	
		0.54 0.64		0.71 0.58		0.52 0.66	0.42 0.80	0.39 0.84	
	flexion-extension	79	70	76		79	86	89	
		0.49 0.73	0.50 0.63	0.62 0.71		0.48 0.75	0.51 0.77	0.47 0.79	
hip	extension	14	14		14	11	14	14	14
		0.69 0.55	0.69 0.58		0.74 0.58	0.71 0.49	0.75 0.51	0.67 0.49	0.74 0.52
	flexion	114	114		111	109	111	119	111
		0.67 0.58	0.71 0.64		0.79 0.56	0.79 0.43	0.78 0.48	0.54 0.68	0.76 0.49
	flexion-extension	126	131		126	126	126	131	126
		0.73 0.55	0.61 0.72		0.79 0.59	0.68 0.55	0.75 0.49	0.62 0.63	0.78 0.52
knee	extension		-1		-1				
			0.72 0.45		0.79 0.46				
	flexion	139	139		134	131	119	116	139
		0.49 0.67	0.57 0.75		0.74 0.64	0.65 0.53	0.88 0.26	0.91 0.24	0.54 0.65
	flexion-extension	136	136		134	131	124	124	131
		0.50 0.67	0.57 0.75		0.68 0.70	0.61 0.59	0.74 0.40	0.75 0.40	0.66 0.55
ankle	extension	16	16		19	19			
		0.72 0.42	0.74 0.46		0.68 0.52	0.68 0.52			
	flexion	39	34	39	39	39	39	39	39
		0.61 0.57	0.69 0.48	0.64 0.55	0.66 0.59	0.66 0.59	0.65 0.53	0.70 0.55	0.64 0.54
	flexion-extension	54	61	56	59	59	54	54	56
		0.74 0.50	0.52 0.70	0.73 0.52	0.66 0.62	0.66 0.62	0.78 0.45	0.79 0.46	0.70 0.50

Cut-off values were determined using ROC curves when a significant association (p<0.05) was found
Sensitivity and specificity of each cut-off value are shown.

1

2

Table 3: Impacts of limited ROM of each joint on disability in daily activity based on HAQ-DI category: multivariate logistic regression analysis

Age, sex and DAS28-CRP adjusted Model

		Dressing	Arising	Eating	Walking	Hygiene	Reach	Grip	Activity
		OR (95% CI)							
shoulder	abduction	4.80 ** (2.32 - 9.91)	1.95 * (1.14 - 3.35)	1.81 (0.95 - 3.47)	1.37 (0.79 - 2.37)	3.79 ** (2.10 - 6.85)	3.53 * (1.31 - 9.53)	1.40 (0.71 - 2.76)	5.26 ** (2.27 - 12.2)
elbow	flexion-extension	2.22 * (1.13 - 4.37)	1.51 (0.85 - 2.69)	2.26 (0.99 - 5.17)		0.84 (0.39 - 1.81)	1.35 (0.60 - 3.05)	1.80 (0.79 - 4.12)	1.57 (0.73 - 3.40)
wrist	supination-pronation	1.33 (0.73 - 2.41)		1.03 (0.54 - 1.96)		1.28 (0.73 - 2.25)	0.81 (0.40 - 1.65)	0.76 (0.37 - 1.55)	1.15 (0.62 - 2.12)
wrist	flexion-extension	1.56 (0.88 - 2.78)	1.26 (0.73 - 2.17)	2.20 * (1.21 - 3.99)		2.25 ** (1.27 - 4.01)	2.71 ** (1.36 - 5.39)	2.56 ** (1.32 - 4.97)	
hip	flexion-extension	2.11 * (1.14 - 3.92)	1.69 (0.97 - 2.92)		3.42 ** (1.92 - 6.12)	1.23 (0.69 - 2.19)	2.52 ** (1.14 - 5.56)	2.39 * (1.18 - 4.85)	3.26 * (1.65 - 6.46)
knee	flexion-extension	0.91 (0.50 - 1.67)	1.75 * (1.00 - 3.06)		2.97 ** (1.73 - 5.11)	1.90 ** (1.08 - 3.32)	0.96 (0.43 - 2.14)	1.20 (0.55 - 2.64)	1.26 (0.67 - 2.34)
ankle	flexion-extension	1.49 (0.81 - 2.75)	1.28 (0.73 - 2.22)	1.72 (0.91 - 3.26)	1.64 (0.95 - 2.85)	0.89 (0.50 - 1.59)	1.27 (0.59 - 2.73)	1.48 (0.71 - 3.08)	0.85 (0.46 - 1.60)

OR: Odds ratio, CI: Confidence interval

Cut-off values in Table 2B were used for dichotomization

**p<0.01, *p<0.05

Table 4: Differences in characteristics between patients with/without history of joint surgery

			Histroty of joint surgery		
			(-) (N=190)	(+) (N=270)	
variables		Unit	Mean (SD)	Mean (SD)	p-value
age		(year)	63.1 (12.7)	65.6 (10.2)	.018
Female		(%)	81.1	90.0	.008
disease duration		(year)	11.4 (8.5)	20.6 (10.9)	<0.001
DAS28-CRP			3.31 (0.99)	3.07 (1.01)	.019
HAQ-DI			.96 (.79)	1.26 (.77)	<0.001
ROM					
shoulder	abduction	(degrees)	148 (27.7)	136 (32.9)	<0.001
elbow	flexion-extension	(degrees)	128 (19.7)	119 (22.9)	<0.001
wrist	supination-pronation	(degrees)	153 (23.0)	147 (26.4)	.014
wrist	flexion-extension	(degrees)	77 (36.2)	55 (35.9)	<0.001
hip	flexion-extension	(degrees)	129 (20.0)	124 (19.7)	.018
knee	flexion-extension	(degrees)	129 (22.2)	124 (20.6)	.005
ankle	flexion-extension	(degrees)	58 (16.1)	52 (18.2)	.001

HAQ-DI: Health Assessment Questionnaire Disability Index
ROM: range of motion

1

2

Table 5: Association between range of motion of each joint and disability in daily activity based on HAQ-DI category using ROC analysis in patients without history of joint surgery

A: Assessment by area under the ROC curve

		HAQ-DI category							
		Dressing	Arising	Eating	Walking	Hygiene	Reach	Grip	Activity
shoulder	abduction	.675 **	.615 *	.703 **	.663 **	.705 *	.632 **	.659 **	.696 **
elbow	extension	.652 **	.622 **	.643 **	.572	.586	.597	.592	.604 *
	flexion	.609 *	.599 *	.525	.587	.604 *	.488	.531	.544
	flexion-extension	.651 **	.628 **	.593 *	.592 *	.608 *	.550	.570	.588
wrist	pronation	.628 **	.549	.603 *	.552	.557	.560	.553	.582
	supination	.623 **	.533	.608 *	.521	.576	.529	.527	.539
	supination-pronation	.640 **	.548	.632 **	.541	.573	.550	.548	.566
wrist	extension	.676 **	.644 **	.645 *	.580	.627 **	.639 **	.625 *	.601
	flextion	.600 *	.592	.615 *	.566	.609 *	.609 *	.630 *	.605 *
	flexion-extension	.642 **	.622 **	.640 **	.576	.630 **	.635 *	.639 **	.611 *
hip	extension	.616 *	.611 *	.513	.683 **	.578	.562	.524	.631 **
	flextion	.678 **	.733 **	.501	.743 **	.596 *	.585	.603 *	.594
	flexion-extension	.674 **	.708 **	.516	.764 **	.596 *	.589	.584	.628 **
knee	extension	.501	.626 **	.491	.659 **	.552	.472	.490	.535
	flextion	.586	.713 **	.472	.778 **	.602 *	.536	.577	.568
	flexion-extension	.587	.724 **	.471	.787 **	.614 *	.527	.562	.574
ankle	extension	.482	.555	.529	.594 *	.539	.498	.513	.521
	flextion	.586	.579	.545	.610 *	.558	.541	.565	.554
	flexion-extension	.588	.612	.571	.675 **	.574	.549	.576	.576

**p<0.01, *p<0.05

B: Cut-off value of ROM of each joint

		Dressing	Arising	Eating	Walking	Hygiene	Reach	Grip	Activity
		Cut-off							
				sensitivity		specificity			
shoulder	abduction	147	143	162	143	146	157	151	143
		0.82 0.53	0.84 0.46	0.58 0.73	0.89 0.46	0.83 0.55	0.65 0.56	0.76 0.48	0.89 0.40
elbow	extension	-6	-8	-4					
		0.64 0.61	0.71 0.52	0.52 0.75					
	flexion	141	136			143			
		0.50 0.71	0.73 0.47			0.38 0.83			
	flexion-extension	126	123	114	123	126			
		0.79 0.44	0.82 0.42	0.91 0.25	0.82 0.39	0.77 0.43			
wrist	pronation	75		79					
		0.66 0.60		0.51 0.67					
	supination	79		79					
		0.73 0.54		0.72 0.49					
	supination-pronation	152		152					
		0.70 0.56		0.71 0.53					
wrist	extension	42	43	48		47	56	55	
		0.65 0.64	0.58 0.66	0.48 0.76		0.49 0.74	0.39 0.88	0.43 0.83	
	flexion	34		44		34	48	48	55
		0.66 0.53		0.57 0.67		0.67 0.54	0.52 0.76	0.52 0.75	0.38 0.84
	flexion-extension	79	70	89		85	85	96	96
		0.63 0.64	0.71 0.51	0.57 0.70		0.57 0.69	0.64 0.64	0.52 0.74	0.49 0.74
hip	extension	14	14		11				14
		0.73 0.53	0.73 0.53		0.83 0.49				0.78 0.49
	flexion	114	114		106	109		119	
		0.78 0.60	0.78 0.60		0.96 0.39	0.85 0.36		0.59 0.61	
	flexion-extension	124	124		126	116			116
		0.83 0.51	0.83 0.51		0.85 0.57	0.86 0.35			0.93 0.32
knee	extension		-4		-1				
			0.81 0.43		0.79 0.52				
	flexion		134		141	129			
			0.82 0.54		0.64 0.80	0.80 0.40			
	flexion-extension		131		131	131			
			0.82 0.62		0.88 0.58	0.72 0.51			
ankle	extension				19				
					0.72 0.44				
	flexion				41				
					0.65 0.60				
	flexion-extension		61		59				
			0.59 0.63		0.76 0.57				

Cut-off values were determined using ROC curves when a significant association (p<0.05) was found between ROM and disability in Sensitivity and specificity of each cut-off value are shown.

Table 6: Association between range of motion of each joint and disability in daily activity based on HAQ-DI category using ROC analysis in patients with history of joint surgery

A: Assessment by area under the ROC curve

		HAQ-DI category							
		Dressing	Arising	Eating	Walking	Hygiene	Reach	Grip	Activity
shoulder	abduction	.703 **	.637 **	.671 **	.587 *	.711 **	.660 **	.627 *	.689 **
elbow	extension	.659 **	.517	.600 *	.449	.635 **	.564	.614 *	.521
	flexion	.615 **	.523	.516	.506	.546	.532	.506	.525
	flexion-extension	.670 **	.535	.578	.489	.625 **	.559	.581	.536
wrist	pronation	.639 **	.476	.600 *	.470	.596 *	.552	.542	.551
	supination	.653 **	.511	.539	.493	.620 **	.574	.567	.617 *
	supination-pronation	.677 **	.497	.582	.472	.621 **	.584	.564	.592
wrist	extension	.643 **	.522	.734 **	.477	.642 **	.657 *	.637 *	.543
	flextion	.574	.494	.661 **	.448	.591 *	.516	.553	.444
	flexion-extension	.611 **	.505	.710 **	.451	.623 **	.579	.598	.476
hip	extension	.641 **	.652 **	.565	.675 **	.589 *	.664 **	.621 *	.646 **
	flextion	.606 **	.681 **	.567	.696 **	.633 **	.692 **	.589	.669 **
	flexion-extension	.646 **	.703 **	.579	.717 **	.640 **	.705 **	.625 *	.695 **
knee	extension	.509	.579 *	.506	.603 **	.520	.548	.559	.541
	flextion	.560	.635 **	.456	.692 **	.580 *	.536	.522	.589
	flexion-extension	.562	.636 **	.460	.696 **	.579 *	.545	.532	.592
ankle	extension	.609 **	.593 *	.544	.593 *	.607 **	.528	.548	.540
	flextion	.590 *	.579 *	.572	.645 **	.542	.583	.609 *	.545
	flexion-extension	.671 **	.624 **	.613 *	.662 **	.622 **	.612 *	.611 *	.572

**p<0.01, *p<0.05

B: Cut-off value of ROM of each joint

		Dressing	Arising	Eating	Walking	Hygiene	Reach	Grip	Activity
				Cut-off					
				sensitivity		specificity			
shoulder	abduction	131	141	131	131	131	136	131	139
		0.92 0.51	0.71 0.57	0.91 0.44	0.75 0.44	0.86 0.54	0.90 0.47	0.83 0.41	0.91 0.52
elbow	extension	-16		-16		-16		-18	
		0.85 0.51		0.82 0.45		0.78 0.51		0.83 0.41	
	flexion	141							
		0.48 0.78							
	flexion-extension	121				122			
		0.81 0.55				0.72 0.55			
wrist	pronation	68		73		68			
		0.73 0.53		0.61 0.59		0.68 0.53			
	supination	76				76			76
		0.79 0.48				0.72 0.48			0.79 0.44
	supination-pronation	150				153			
		0.72 0.62				0.60 0.64			
wrist	extension	25		26		16	27	47	
		0.77 0.46		0.85 0.50		0.88 0.33	0.81 0.49	0.41 0.86	
	flexion			29		27			
				0.65 0.65		0.53 0.62			
	flexion-extension	94		53		68			
		0.27 0.90		0.73 0.60		0.43 0.76			
hip	extension	14	14		14	11	14	16	14
		0.67 0.58	0.66 0.61		0.71 0.60	0.69 0.52	0.80 0.55	0.54 0.68	0.70 0.54
	flexion	119	114		111	114	111		109
		0.41 0.74	0.64 0.66		0.73 0.60	0.61 0.64	0.83 0.54		0.81 0.42
	flexion-extension	126	134		121	126	126	131	126
		0.68 0.56	0.54 0.80		0.86 0.48	0.67 0.59	0.83 0.54	0.60 0.66	0.77 0.55
knee	extension		-1		-1				
			0.74 0.42		0.79 0.43				
	flexion		139		136	141			
			0.46 0.80		0.55 0.76	0.33 0.84			
	flexion-extension		139		134	141			
			0.43 0.83		0.56 0.75	0.32 0.84			
ankle	extension	19	16		19	16			
		0.65 0.56	0.71 0.51		0.65 0.56	0.70 0.51			
	flexion	44	39		39			39	
		0.41 0.73	0.53 0.62		0.61 0.65			0.63 0.59	
	flexion-extension	49	61	49	59	54	61	61	
		0.81 0.43	0.45 0.74	0.84 0.39	0.57 0.65	0.67 0.54	0.50 0.69	0.51 0.70	

Cut-off values were determined using ROC curves when a significant association (p<0.05) was found between ROM and disability in Sensitivity and specificity of each cut-off value are shown.