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ARTHROPLASTY

Predicting early clinical function after hip or knee arthroplasty

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Objectives

Patient function after arthroplasty should ideally quickly improve. It is not known which peri-operative function assessments predict length of stay (LOS) and short-term functional recovery. The objective of this study was to identify peri-operative functions assessments predictive of hospital LOS and short-term function after hospital discharge in hip or knee arthroplasty patients.

Methods

In total, 108 patients were assessed peri-operatively with the timed-up-and-go (TUG), Iowa level of assistance scale, post-operative quality of recovery scale, readiness for hospital discharge scale, and the Western Ontario and McMaster Osteoarthritis Index (WOMAC). The older Americans resources and services activities of daily living (ADL) questionnaire (OARS) was used to assess function two weeks after discharge.

Results

Following multiple regressions, the pre- and post-operative day two TUG was significantly associated with LOS and OARS score, while the pre-operative WOMAC function subscale was associated with the OARS score. Pre-operatively, a cut-off TUG time of 11.7 seconds for LOS and 10.3 seconds for short-term recovery yielded the highest sensitivity and specificity, while a cut-off WOMAC function score of 48.5/100 yielded the highest sensitivity and specificity. Post-operatively, a cut-off day two TUG time of 31.5 seconds for LOS and 30.9 seconds for short-term function yielded the highest sensitivity and specificity.

Conclusions

The pre- and post-operative day two TUG can indicate hospital LOS and short-term functional capacities, while the pre-operative WOMAC function subscale can indicate short-term functional capacities.

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Keywords: Arthroplasty, functional recovery, early, predictor, functional assessment

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Article focus

- To identify peri-operative function assessments predictive of hospital LOS and short-term function after hospital discharge in hip or knee arthroplasty patients.

Key messages

- The pre- and post-operative day two TUG was associated with LOS and OARS score, while the pre-operative WOMAC function subscale was associated with the OARS score. Pre-operatively, a cut-off TUG time of 11.7 seconds for LOS and 10.3 seconds for short-term recovery yielded the highest sensitivity and specificity, while a cut-off WOMAC function score of 48.5/100 yielded the highest sensitivity and specificity. Post-operatively, a cut-off day two TUG time of 31.5 seconds for LOS and 30.9 seconds for short-term function yielded the highest sensitivity and specificity.

Strengths and limitations

- Strength: Validated outcome measures were used and assessed systematically.
- Limitation: As the regression variance and sensitivity/specificity are moderate, there are other factors associated with function after

hospital discharge. Results of this study and cut-offs should therefore not be used exclusively when determining functional discharge disposition.

Introduction

Lower-limb joint arthroplasties incur significant costs, notably because of the associated hospitalisation.[1] Consequently, there has been a steady decrease in hospital length of stay (LOS) following lower-limb joint arthroplasty in order to minimise the burden on the healthcare system and return patients to function at home as quickly as possible. In the United States, the average LOS has decreased to a current median of three days.[2] Similar LOS data has also been observed in Denmark.[3] However, a significant portion of patients still have longer hospital stays. Hospital discharge readiness and disposition following arthroplasty has traditionally focused on minimising the possibility of serious adverse events associated with the intervention, such as infection, cardiac events, deep vein thrombosis and hip dislocation.[4] Although serious and often associated with hospital readmission, these events are relatively rare.[5] The focus on factors associated with these adverse events limits the capacity to determine hospital discharge disposition for the majority of the population undergoing lower-limb joint arthroplasty.

Apart from avoiding serious adverse events, a core hospital discharge objective following arthroplasty is to ensure that the patient is sufficiently functional post-operatively to be able to perform basic activities of daily living (ADL), such as walking, getting in and out of bed, and climbing stairs. The inability to perform basic ADLs following surgery can isolate the patient, increase the need for external resources, and expose the patient to events such as falls.[6] Functional discharge readiness criteria have been proposed and used in other studies. However, these criteria have not been validated.[7,8] To our knowledge, only one study has evaluated acute post-operative function assessments associated with function after discharge.[9] However, this study evaluated long-term, as opposed to short-term, function after discharge, limiting its usefulness in determining functional discharge disposition. Also, it has been well demonstrated that pre-operative function is predictive of long-term function.[9-12] However, the relationship between pre-operative and short-term function has not been assessed.

The identification of pre-operative functional assessments predictive of short-term post-operative function could be used pre-operatively to identify patients potentially requiring additional resources post-operatively.[6] The objective of this study was to identify pre- and acute post-operative functional assessments predictive of hospital LOS and short-term function after hospital discharge in patients undergoing primary hip or knee arthroplasty.

Patients and Methods

Study design and setting. Two categories of instruments can be used to assess function: performance measures and patient reported outcome measures (PROMs). For performance measures, the timed-up-and-go (TUG) and the Iowa level of assistance scale (ILAS) were selected. The TUG assesses the time that a patient takes to rise from a chair, walk three metres, turn around, walk back to the chair, and sit down.[13] The ILAS assesses the capacity of the patient to perform five tasks (supine to sitting, sitting to standing, walking, stairs, and walking speed), with a global score out of 50.[14] The TUG is purely a timed measure, while the ILAS takes into account the assessor's perception of patient's safety while doing the task. Both instruments have shown good psychometric properties in patients undergoing lower-limb joint arthroplasty, and are recommended as core performance measures in patients with hip or knee osteoarthritis (OA).[15] The TUG is one of the most commonly used performance measures in arthroplasty centres.[16] For PROMs, the post-operative quality of recovery scale (PQRS) and the readiness for hospital discharge scale (RHDS) were selected for this study. The PQRS is composed of 13 questions assessing the patient's perceived status on four dimensions (pain, emotions, function, and cognition), with scoring determined by return to pre-operative status.[17] Since the objective of this study was to predict post-discharge function, the function subscale of the PQRS was selected. The PQRS has shown good psychometric properties in various surgical patients,[18] and has been used to study recovery patterns of patients undergoing knee arthroplasty.[19] The RHDS is composed of 23 questions assessing the patient's perceived readiness to discharge on four dimensions: personal status, knowledge about what to do after discharge, coping ability, and expected support.[20] The personal status score was used in this study as it reflects the patient's perceived capacities. The RHDS has been validated with various surgical populations.[20,21]

The TUG, ILAS and PQRS were administered pre-operatively, and one and two days post-operatively. The RHDS was administered one and two days post-operatively, as it is not assessed pre-operatively. As around half of the participants had been discharged by post-operative day three, only post-operative day one and two data were used. The TUG and ILAS were completed by trained physical therapists, the PQRS was done through interviews completed by trained research assistants, and the RHDS was completed by the patient. Patients were blinded to performance scores, and physical therapists were blinded to PROM scores. If a patient was not able to complete an assessment, reasons were noted by the assessor using a standardised chart. Demographic variables and Western Ontario and McMaster Osteoarthritis Index (WOMAC) scores[22] were also collected before surgery. WOMAC was not assessed post-operatively since it has been shown to be less responsive to change compared with performance measures shortly after surgery.[23-25]

To assess short-term function after discharge, the older Americans resources and services (OARS) ADL scale was used. It is composed of 14 questions which assess the patient's perceived capacity to perform basic ADLs at home, such as bathing, dressing, getting in and out of bed, housekeeping, and getting around.[26] It has been extensively validated to assess basic function at home following surgery[27] and used to follow patients after arthroplasty.[28,29] The three questions of the OARS associated with cognitive function were excluded from the total score, since they assess a different construct than physical function.[30,31] The OARS was assessed two weeks after surgery by research assistants.

Participants. Patients scheduled for unilateral primary partial or total knee or hip arthroplasty to manage surgically OA in a university-affiliated hospital in Ottawa, Canada, were invited to participate in the study between March and October 2013. All patients received the standardised process of care map used at the Ottawa Hospital for joint arthroplasty. This consists of pre-operative patient education with an accompanying booklet on the surgery and recovery process, anaesthesia consisting of local infiltration and multimodal oral analgesia, post-operative education, early mobilisation and ambulation, post-operative analgesia, discharge planning, and standardised post-operative range of movement exercises. Patients were excluded if they had any of the following characteristics: knee or hip arthroplasty in the month preceding surgery; revision arthroplasty; diagnosed neurological or musculoskeletal disease (excluding OA) adversely affecting gait or bearing weight; unable to read and/or understand English; documented cognitive impairment precluding questionnaire completion; under 18 years of age; not living in the area of the surgery hospital. For an α level of 0.05, a β level of 0.8, five independent variables in the multivariate regression model and a moderate effect size of 0.15 on the OARS ADL scale, the minimum sample size is 96.[32] Taking into account an expected drop-out rate of 10%, 108 patients were recruited, with half undergoing hip arthroplasty (n = 54) and the other half knee arthroplasty. Approval was obtained from the hospital's institutional review board. All patients gave their informed written consent for participation in the study.

Statistical analysis. Stepwise multiple regression analysis was used to study the relationship between the OARS and PROMs/performance measures, with the OARS being the dependant variable and PROMS/performance measures the independent variables. Only the variables significantly associated with OARS scores in bivariate analyses (*t*-tests for dichotomous variables and Pearson correlation coefficients for continuous variables) were included in the regression model. Separate regressions were accomplished for pre- and post-operative variables. Demographic variables, including surgery site and total *versus* partial arthroplasty, were also included if significantly associated with the OARS. For variables significantly associated with the OARS, receiver operating characteristic (ROC) curves were used to identify a cut-off point associated with the OARS. A cut-off of 19/22 for the OARS was used for the ROC curve analyses, as a reduction of four points is considered to be a clinically significant decrease in function.[33-35] Missing variables of the PROMs were addressed using the respective authors' instructions. There were no missing variables for the performance measures. Logistic regression with forward selection (likelihood ratio) was used to study the relationship between LOS and PROMs/performance measures. As LOS was not normally distributed, it was dichotomised: three days or less; more than three days. The same model building procedure as the one used with the multiple regression was used with the logistic regression. All statistical analyses were performed using SPSS version 21 (SPSS Inc, Chicago, Illinois). A two-tailed level of significance of $p < 0.05$ was used in all analyses.

Results

In order to obtain the target sample size, 120 knee patients and 115 hip patients were screened. Of these, 54 knee patients and 36 hip patients were not eligible for the following reasons: comorbidities (17 knee and six hip patients); follow-up not done at the surgical hospital (14 knee and 18 hip patients); intervention other than arthroplasty (three knee and two hip patients); bilateral intervention (four hip patients); patient in the same-day discharge pilot project (ten knee patients); patient missed at baseline appointment (six knee and two hip patients); and language (four knee and four hip patients). There were no significant differences with regard to age or gender when comparing participants with non-participants. In total, 12 knee patients and 25 hip patients declined participation. Of the 108 participants, 54 were women (50%). The mean age was 64 years (standard deviation (SD) 12.5), while the mean body mass index (BMI) was 30.4 (SD 6.2). A total of 79 patients underwent total joint arthroplasty, while 27 underwent partial arthroplasty. The median hospital LOS was three days (SD 1.7), with 17 patients (15.7%) staying more than three days and accounting for 31.1% of hospital days. In total, 101 patients (93.5%) were discharged home. Table I provides descriptive data of the PROMs and performance measures. The TUG data for post-operative day one was not used as 16 participants (15%) were not able to complete it for the following reasons: dizziness/nausea (n = 7); general weakness (n = 2); cardiac or respiratory problems (n = 3); uncontrolled pain (n = 4); or wound bleeding (n = 1), thus, the data were not missing at random. The mean OARS score at two weeks was 18.9 (SD 2.2), with 34 patients (33%) having a score lower than 19.

Table I. The outcome measures and percentage of patients recovered according to the post-operative quality of recovery scale. Data are presented as means with standard deviations (SD), unless otherwise stated

	Pre-operative	**Post-operative**	
		Day one	Day two
Timed-up-and-go (secs)	11.4 (SD 4.4)	70.1 (SD 54.6)	41.9 (SD 30.5)
Iowa level of assistance scale (score out of 50)	0.3 (SD 1.0)	19.3 (SD 10.7)	12.7 (SD 8.5)
Readiness for hospital discharge personal status subscale (score out of 10)	-	5.2 (SD 2.2)	6.4 (SD 1.8)
Post-operative quality of recovery function subscale (% recovered)	-	1.9	14.1

Table II. Bivariate analyses results of the relationship between post-operative variables and the older Americans resources and services activities of daily living questionnaire

			p-value	**n**
Surgery site	t-statistic	-0.993	0.323	103
Total *versus* partial arthroplasty	t-statistic	2.724	0.008*	103
RHDS post-operative day one	Pearson correlation	0.260	0.008*	102
RHDS post-operative day two	Pearson correlation	0.379	0.000*	96
PQRS post-operative day one	t-statistic	1.034	0.304	100
PQRS post-operative day two	t-statistic	1.045	0.299	95
ILAS post-operative day one	Pearson correlation	-0.270	0.006*	102
ILAS post-operative day two	Pearson correlation	-0.310	0.002*	98
TUG post-operative day two	Pearson correlation	-0.452	0.000*	96

* $p < 0.05$
RHDS, readiness for hospital discharge scale; PQRS, post-operative quality of recovery scale; ILAS, Iowa level of assistance scale; TUG, timed-up-and-go

Table III. Stepwise multiple regression results between post-operative variables and the older Americans resources and services activities of daily living questionnaire

	Beta	**Standard error**	**t-value**	**p-value**	**R^2**
TUG post-operative day two	-0.040	0.009	-4.404	< 0.001	0.18

TUG, timed-up-and-go

Table IV. Bivariate analyses results of the relationship between pre-operative variables and the older Americans resources and services activities of daily living questionnaire

			p-value	**n**
Age (yrs)	Pearson correlation	-0.053	0.593	103
BMI	Pearson correlation	-0.262	0.008*	103
Gender	t-statistic	2.469	0.015*	103
WOMAC pain	Pearson correlation	-0.189	0.076	89
WOMAC function	Pearson correlation	-0.354	0.001*	89
WOMAC stiffness	Pearson correlation	-0.290	0.006*	89
ILAS	Pearson correlation	-0.220	0.027*	102
TUG	Pearson correlation	-0.307	0.002*	102

* $p < 0.05$
BMI, body mass index; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; ILAS, Iowa level of assistance scale; TUG, timed-up-and-go

Table II describes the relationship of the post-operative variables to the OARS in the bivariate analyses. Following theses analyses, total *versus* partial arthroplasty, RHDS, ILAS and TUG were significantly associated with the OARS and included in the regression, while surgery site and PQRS were not, and were therefore excluded. Table III describes the results of the stepwise multiple regression. Only TUG post-operative day two was significantly associated with the OARS. All other variables were not, and were thus excluded from the ROC curve analysis. The area under the ROC curve between the OARS and TUG post-operative day two was 0.60 ($p = 0.004$). A cut-off point of 30.9 seconds on the TUG post-operative day two yielded a sensitivity of 75% and a specificity of 58%.

Table IV describes the relationship of pre-operative and demographic variables to the OARS in the bivariate analyses. Following these analyses, WOMAC function, WOMAC stiffness, pre-operative ILAS, pre-operative TUG,

Table V. Stepwise multiple regression results between pre-operative variables and the older Americans resources and services activities of daily living questionnaire

	Beta	Standard error	t-value	p-value	R^2
WOMAC function subscale	-0.035	0.011	-3.155	0.002	WOMAC function only: 0.13
TUG	-0.109	0.045	-2.416	0.018	WOMAC function + TUG: 0.18

WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; TUG, timed-up-and-go

Table VI. Bivariate analyses results of the relationship between post-operative variables and hospital length of stay

			p-value	n
Surgery site	chi-squared	0.63	0.43	108
RHDS post-operative day one	t-statistic	1.80	0.07	105
RHDS post-operative day two	t-statistic	3.86	0.00*	99
PQRS post-operative day one	chi-squared	0.37	0.55	105
PQRS post-operative day two	chi-squared	1.15	0.28	99
ILAS post-operative day one	t-statistic	3.54	0.00*	105
ILAS post-operative day two	t-statistic	3.78	0.00*	100
TUG post-operative day two	t-statistic	2.93	0.01*	98

* p < 0.05

Table VII. Bivariate analyses results of the relationship between pre-operative variables and hospital length of stay

			p-value	n
Age (yrs)	t-statistic	-2.04	0.04*	108
BMI	t-statistic	-0.80	0.43	108
Gender	chi-squared	5.66	0.02*	108
WOMAC pain	t-statistic	0.68	0.50	92
WOMAC function	t-statistic	0.56	0.58	92
WOMAC stiffness	t-statistic	0.36	0.72	92
ILAS	t-statistic	-1.66	0.12	107
TUG	t-statistic	-3.54	0.00*	017

* p < 0.05
BMI, body mass index; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; ILAS, Iowa level of assistance scale; TUG, timed-up-and-go

BMI and gender were significantly associated with the OARS and included in the regression, while WOMAC pain and age were not, and were, therefore, excluded. Table V describes the results of the stepwise multiple regression. Only pre-operative TUG and WOMAC function were significantly associated with the OARS. All other variables were not, and were thus excluded from the ROC curve analysis. The area under the ROC curve between the pre-operative TUG and OARS was 0.73 (p < 0.001). A cut-off point of 10.3 seconds on the pre-operative TUG yielded a sensitivity of 74% and a specificity of 62%. The area under the ROC curve between the WOMAC function and OARS was 0.67 (p = 0.013). A cut-off score of 48.5/100 on the WOMAC function yielded a sensitivity of 75% and a specificity of 59%.

Table VI describes the bivariate relationship results between post-operative variables and LOS. ILAS, post-operative day two RHDS and TUG were significantly associated with LOS and included in the regression. Only post-operative day two TUG was significant in the regression (Exp(*B*) = 1.038; p = 0.00). The area under the ROC curve between post-operative day two TUG and LOS was 0.75 (p = 0.001). A cut-off of 31.5 seconds on the post-operative day two TUG yielded a sensitivity of 88% and a specificity of 54%. As for the relationship between pre-operative variables and LOS (Table VII), age, gender and TUG were significantly related to LOS. Only pre-operative TUG was significant in the regression (Exp(*B*) = 1.173; p = 0.00). The area under the ROC curve between pre-operative TUG and LOS was 0.76 (p = 0.001). A cut-off of 11.7 seconds on the pre-operative TUG yielded a sensitivity of 77% and a specificity of 76%.

Discussion

The current study, to our knowledge, is the first to assess the capacity of pre- and post-operative functional assessments to predict LOS and short-term basic function following hospital discharge in patients undergoing hip or knee arthroplasty. Results demonstrate that pre- and post-operative TUG is indicative of both LOS and short-term basic function after hospital discharge. Previous studies have demonstrated that pre- and post-operative function are predictive of long-term function.[9-11] The results of this study indicate that pre- and post-operative function also appear to predict short-term function after hospital discharge. Other studies have demonstrated that pre-operative functional assessments, such as sit-to-stand and stair climbing, can predict LOS.[36,37] This study is the first to show that function assessed during hospitalisation can also predict LOS.

In accordance with previous studies, results seem to indicate that PROMs (PQRS and RHDS in this study) are less appropriate than performance measures to assess function shortly after surgery.[23-25,38,39] PROMs are a measure of the patient's perceived function. It has been demonstrated that some patients tend to overestimate their function post-operatively, because of the beneficial impact of arthroplasty and post-surgical analgesia on pain, which in turn influences perception of function.[23-25,38,39] In addition, surgery can have a psychological impact on patients during hospitalisation, affecting levels of anxietyand stress, and coping and recovery expectations, which can negatively influence patient perception of function.[40,41] The results of this and other studies question the utility of PROMs to assess function in the days after surgery. The pre-operative WOMAC function subscale, a PROM, was, however, indicative of short-term post-operative function, and has also been shown to predict long-term function.[11,42,43] Thus, it appears that patient perception of function is influenced less by other factors pre-operatively than during hospitalisation. These results suggest that the pre-operative WOMAC function subscale can be useful to indicate both short and long-term post-operative function. However, the pre-operative WOMAC did not predict LOS. LOS thus appears to be more associated with the actual functional capacities of patients (performance measures), instead of patient function perceptions (PROMs).

Although performance measures seem more appropriate to assess function shortly after surgery when compared with PROMs, of the two performance measures assessed in this study, the TUG was a better predictor of short-term function after hospital discharge than the ILAS. The ILAS partly relies on the assessor's perception of patient safety when completing the task. It has been shown that clinicians can be precautionary when assessing patients with regard to levels of safety.[44] The TUG is not influenced by clinicians' perceptions as it is purely a timed measure. Additionally, the TUG is much quicker and less resource-intensive than the ILAS, consisting of one task instead of five for the ILAS.

The results of the present study could be used clinically in several ways. The pre-operative TUG cut-off could be used pre-operatively to help in planning recovery times and discharge disposition, as the cut-off is associated with LOS and functional capacities shortly after discharge. Patients below the cut-off would be expected to recover function faster and have shorter LOS, while patients above the cut-off would be expected to recover function more slowly, thus requiring additional resources or recovery time. Interestingly, the pre-operative ten-second TUG cut-off found in this study is the same cut-off time found in a previous study to predict long-term function in arthroplasty patients.[10] The pre-operative 48.5/100 WOMAC cut-off could also be used to help with discharge planning, although is not related to LOS. This cut-off is similar to the 51/100 WOMAC cut-off found to predict long-term function in arthroplasty patients.[43] Post-operatively, the 30 second TUG cut-off could help in determining functional discharge readiness and disposition, as it is associated with the patient's LOS and functional capacities shortly after discharge. It is expected that patients under the post-operative TUG cut-off would tend to be functionally independent at home, while patients above the cut-off would need additional resources, either through inpatient rehabilitation, or at home. In frail elderly patients, this 30 second TUG cut-off was also associated with functional dependence.[13] Although TUG data on post-operative day one were not used, the inability to perform the TUG would also signal the need for further hospital recovery time, or additional rehabilitation resources. The results also seem to apply to both total and partial knee and hip arthroplasty, as procedure and site of surgery were not significant factors. Although it has been demonstrated that hip arthroplasty patients generally tend to recover function more quickly than knee arthroplasty patients, this has been shown mostly beyond one month.[40,45] Results of this study also support the use of the TUG as a short-term outcome measure, both clinically, and for research.

As the regression variances are around 0.20, there are other factors associated with function after hospital discharge. Therefore, results of this study and cut-offs should not be used exclusively when determining functional discharge disposition, which will be influenced by factors other than patient function, including pre-operative education, available home support and access to rehabilitation.[46] The results of the current study are limited to the context in which they were collected, i.e., a large Canadian university-affiliated hospital with a high arthroplasty volume. Care should be taken when transposing the present results to other settings. This study should, therefore, be replicated in other contexts.

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ICMJE Conflict of Interest:

- None declared