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Frailty Questionnaire Is Not a Strong Prognostic Factor for Functional Outcomes in Hip or Knee Arthroplasty Patients

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Abstract

Introduction: Up to 33% and 25% of patients with end-stage hip and knee osteoarthritis (OA) are considered frail by the Groningen Frailty Indicator (GFI). This study aims to assess whether frail patients have lower functional gains after arthroplasty and to assess GFI as a tool to discriminate between good and adverse change score. **Materials and Methods:** Patients with end-stage hip/knee OA scheduled for arthroplasty were recruited from the *Longitudinal Leiden Orthopaedics Outcomes of Osteo-Arthritis Study*. Functional outcome was measured as change score on the Hip Osteoarthritis Outcome Score/Knee Osteoarthritis Outcome Score (HOOS/KOOS), by subtracting preoperative score from 1-year postsurgery score and then dichotomized based on a cutoff of 20 points. For each HOOS/KOOS subscale, 3 models were estimated: GFI univariate (model 1), GFI and baseline score (model 2), and baseline score univariate (model 3). A receiver operating characteristic analysis was performed to assess the discriminative ability of each model. **Results:** Eight hundred five patients with end-stage hip OA (31.4% frail) and 640 patients with end-stage knee OA (25.4% frail) were included. Frail patients were older, had a higher body mass index, had more comorbidities, and lived more often alone. Persons considered frail by GFI had significant lower baseline score; however, except for "function in sports and recreation" and "quality of life," change scores were similar in frail and nonfrail persons. The discriminatory value of GFI was negligible for all HOOS/KOOS subscales. Baseline score, however, was adequate to discriminate between total knee arthroplasty patients with more or less than twice the minimally clinically important difference on KOOS symptoms subscale (area under the curve = 0.802). **Discussion/Conclusion:** Although frail patients with OA have lower functioning scores at baseline, the change scores on HOOS/KOOS subscales are similar for both frail and nonfrail patients. Exploring other heath assessements may improve patient-specific outcome prediction.

Keywords

frailty, arthroplasty, osteoarthritis, rehabilitation

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Introduction

Osteoarthritis (OA) is a common, degenerative, disabling joint disease, affecting up to 23.1% of persons older than 70 years.[1] These numbers are likely to increase due to population aging and the epidemic proportions of obesity in the general population.[2,3] Thus far, no cure for OA has been found; instead when pain relief is not sufficient anymore, the final treatment option is total joint arthroplasty (TJA) in hip (total hip arthroplasty [THA]) or knee (total knee arthroplasty [TKA]). In the Netherlands, 28 798 THAs and 24 107 TKAs were performed in 2015, with up to 50% of the THA and 42% of TKA in persons aged ≥70 years.[4]

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Despite these large numbers, about 10% to 20% of all THA and TKA patients are not satisfied with their postoperative results.[5,6] One of the reasons might be preoperative state of the patient, reflected by frailty.

Frailty is a common syndrome in the elderly patients, with an overall prevalence of frailty of 10.7% among people aged ≥65 years.[7,8] Frailty, as a representative of health and functional status, hampers the capacity to resist stressors, which in turn leads to increased susceptibility for adverse outcomes after surgery.[8-12] Reported levels of frailty vary greatly among age groups, with the pooled prevalence rates for persons aged between 65 and 69 years being below 5%, while for those aged 80 to 85 years, this is over 15%, and even over 25% for persons aged ≥85 years.[7] Within persons of the same age-group, substantial heterogeneity is present to the levels of frailty an individual might experience.[9,10,13-15]

Previously, we have shown that the Groningen Frailty Indicator (GFI) is a feasible and validated questionnaire in persons with end-stage hip or knee OA.[16] Using the GFI with a cutoff value of 4, we demonstrated that up to one-third of the patients with end-stage OA scheduled to undergo THA and one-quarter of those scheduled for TKA are considered to be frail.[16]

Mandl et al have addressed adverse events after TJA in 241 frail and nonfrail patients and found that there was only an association between activities of daily life and adverse events after TJA. However, this study had a follow-up period of only 30 days and is not representative for the long-term functional outcome of TJA in patients with end-stage hip or knee OA.[17] A study by McIsaac et al (follow-up of 1 year) in 125 163 TJA patients studied health-care resource usage but not functional outcomes. They found frail patients to have increased mortality, increased length of stay in hospital, higher chance of readmission, and higher rates of discharge to institutional care after TJA as compared to nonfrail TJA patients.[18] A study on the impact of frailty on the long-term postoperative function has, to our knowledge, not yet been performed.

In this study, we aim to assess whether frail persons (cutoff value GFI ≥4) have lower gain in postoperative function and quality of life (QoL). We also assess by receiver operating characteristic curves whether the preoperative GFI is valuable tool to discriminate between THA and TKA with high (good) and low (adverse) gain in function at 1 year postoperatively.

Materials and Methods

Study Design

This analysis was performed in the longitudinal prospective cohort study "Longitudinal Leiden Orthopaedics Outcomes of Osteo-Arthritis Study (LOAS, Trial ID NTR3348)," which consists of patients undergoing THA or TKA for primary OA. Participants were selected from 7 participating hospitals (the Leiden University Medical Center, Leiden; Alrijne Hospital, Leiden/Leiderdorp [former Diaconessenhuis and Rijnland Hospital]; Groene Hart Hospital, Gouda; LangeLand Hospital, Zoetermeer; Reinier de Graaf Gasthuis, Delft; Albert Schweitzer Hospital, Dordrecht; and Waterland Hospital, Purmerend).

Patients

All TJA patients older than 18 years able to complete questionnaires in Dutch were eligible for participation. Patients were excluded if their physical or mental status did not allow participation or in case they did not sign the informed consent. Written and oral information about the study was given by the treating medical specialist at the outpatient clinic.

Patients willing to be approached by the researcher received additional written information about the study by regular mail or e-mail, as well as a questionnaire, a stamped return envelope, and a consent form. Patients were included once written informed consent was obtained according to the Declaration of Helsinki.[19]

For the purpose of the present analysis, only data from patients who returned both the preoperative and the 12-month follow-up questionnaires were included. Ethical approval was obtained from the Medial Ethics Committee of the Leiden University Medical Center (registration number P12.047) and funding was received from the Dutch Arthritis Foundation (LLP13).

Assessments

Demographic variables. The collected sociodemographic characteristics of the patients included age (years), sex, and length (cm) and weight (kg) to calculate the body mass index (BMI). Living situation was also collected and divided into "living alone" or "living together," the latter category included persons living with family members as well as persons living in community housing.

Comorbidities. The presence of comorbidities was assessed by a self-reported questionnaire comprised of 19 different comorbidities. Patients were asked to respond with either yes or no to the question, "Have you received any treatment for [disease] in the past year?" The included diseases were then clustered in 2 groups: musculoskeletal comorbidities (severe back pain, severe neck or shoulder pain, severe elbow wrist or hand pain, inflammatory arthritis, or other joint conditions) or other comorbidities (asthma or chronic obstructive pulmonary disease, cardiac disorder or coronary disease, arteriosclerosis, hypertension, stroke, severe bowel disorder, diabetes mellitus, migraine, psoriasis, chronic eczema, cancer and urine incontinence, hearing or visual impairments, and dizziness in combination with falling).

Groningen Frailty Indicator. The presence of frailty was analyzed by the GFI. The GFI is a 15-item validated questionnaire based on many aspects of life, such as activities of daily life, medication use, mental state, vision, and hearing. Each item can give 1 point, resulting in a maximum score of 15. A patient with a score of ≥4 was considered frail.[20-23] The GFI has been

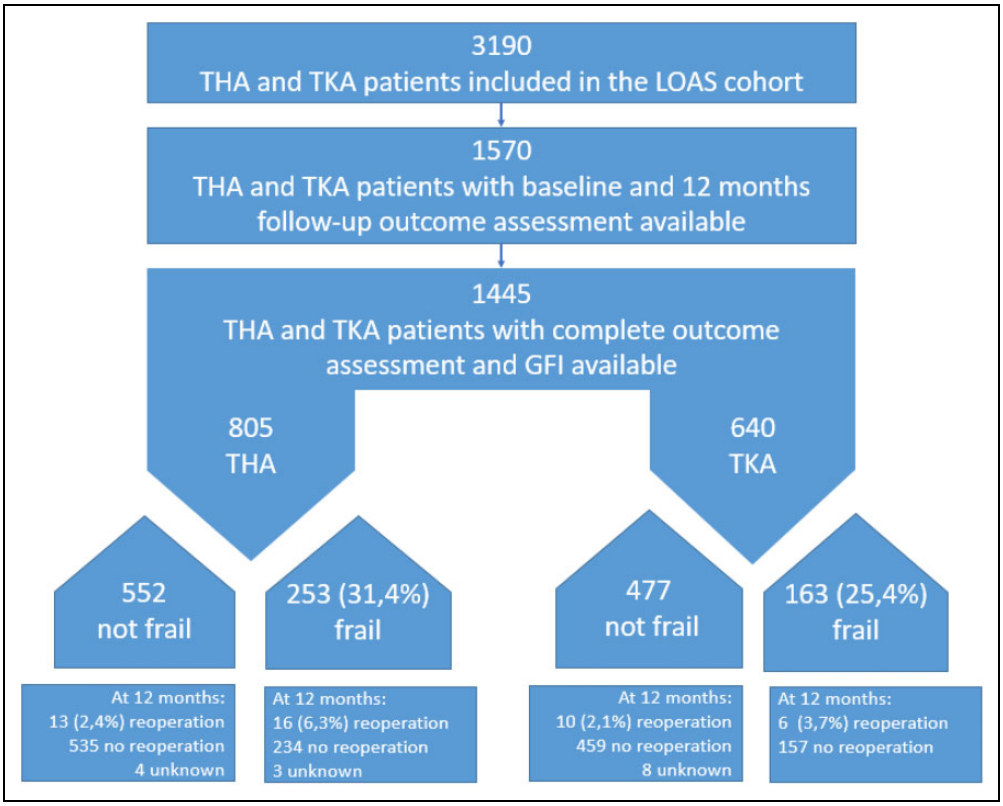

Figure 1. Flowchart of end-stage hip/knee osteoarthritis patients included in the study.

validated to be used in patients with end-stage OA scheduled to undergo arthroplasty surgery.[16]

Functional outcome by Hip disability Osteoarthritis Outcome Score/ Knee injury Osteoarthritis Outcome Score. Patient function was assessed by the validated Hip disability Osteoarthritis Outcome Score/Knee injury Osteoarthritis Outcome Score (HOOS/ KOOS) questionnaires for hip and knee patients, respectively. Both questionnaires comprise 5 domains: activities of daily living (ADL), QoL, sports (SP), symptoms (SYM), and pain (P).[24,25] For the current study, the validated Dutch versions of the HOOS/KOOS were used.[26,27]

Statistical Analyses

Demographic characteristics of frail and nonfrail patients were compared for hip and knee arthroplasty separately by Student t test (continuous, normally distributed variables), Mann-Whitney U test (continuous, not normally distributed variables), or χ^2 (categorical variables), whichever was appropriate, per joint site.

Functional outcomes were assessed by the 5 subscales of the HOOS/KOOS questionnaire: Pain (P), Symptoms (S), Activity limitations of daily living (A), Sport and recreation functioning (SP), and Joint-related QoL. Scores were compared between frail and nonfrail patients by Mann-Whitney U test for each time point (baseline and 12 months) separately. In addition, for each of these scores, a change score was calculated by subtracting presurgery score from the 1-year follow-up scores. These were compared between frail and nonfrail patients (cut-off value GFI $\geq$4) by Mann-Whitney U test.

Adverse outcome was defined as improving less than twice the minimally clinically important difference (MCID), meaning an improvement of less than 20 points on the HOOS/KOOS in the year after surgery.[24] This binary score (more or less than twice MCID) was calculated for each subscale of the HOOS/ KOOS. For each subscale, a logistic regression model was estimated with the binary outcome score and GFI as continuous independent risk factor (model 1). Then a multivariable logistic regression model with GFI and baseline HOOS/KOOS score as prognostic factor was estimated (model 2). Finally, a univariate logistic regression model was estimated to assess the association of baseline HOOS/KOOS score on GFI (model 3). Area under the curve (AUC) was estimated to assess the discriminatory ability of the logistic regression models.[28]

All analyses were performed separately for THA and TKA patients. Data were analyzed using the SPSS statistical package (version 20.0; SPSS, Chicago, Illinois). The level of statistical significance was set at $P \leq .05$ for all analyses.

Results

Among the 3190 patients who were included in the LOAS cohort, 1570 (873 THA and 697 TKA) completed the HOOS/ KOOS questionnaires at baseline and at 12-month follow-up. Of these, 92% also completed the GFI, resulting in 1445

Table 1. Demographic Characteristics of Frail and Nonfrail (As Defined by the Groningen Frailty Indicator [GFI]) Patients With End-Stage Osteoarthritis.

	Hip, N = 805					Knee, N = 640				
	Nonfrail, N = 552		Frail (GFI ≥ 4), N = 253 (31.4%)			Nonfrail, N = 477		Frail (GFI ≥ 4), N = 163 (25.4%)		
	N/Mean	%/SD	N/Mean	%/SD	P[a]	N/Mean	%/SD	N/Mean	%/SD	P[a]
Female	312	56.5	187	74.2	<.001	291	61.5	125	76.7	<.001
Age	66.2	9.1	68.3	10.3	.004	66.1	8.6	68.2	8.7	.010
BMI	26.6	3.8	28.1	5.3	<.001	28.9	4.4	30.0	5.2	.022
Musculoskeletal comorbidities[b]	64	12.0	60	25.0	<.001	98	21.6	44	29.3	.054
Other comorbidities[c]	321	65.0	185	84.1	<.001	294	70.5	117	84.2	.001
Living alone	66	12.0	88	34.8	<.001	78	16.4	66	40.5	<.001

Abbreviations: BMI, body mass index; SD, standard deviation.
[a]*P* Value corresponding to χ^2 (discrete variables) or *t* test (normally distributed continuous variables) for differences between frail and nonfrail persons within joint-specific group.
[b]Musculoskeletal comorbidities include severe back pain, severe neck or shoulder pain, severe elbow wrist or hand pain, inflammatory arthritis, or other joint conditions.
[c]Other comorbidities include asthma or COPD, cardiac disorder or coronary disease, arteriosclerosis, hypertension, stroke, severe bowel disorder, diabetes mellitus, migraine, psoriasis, chronic eczema, cancer and urine incontinence, hearing or visual impairments, and dizziness in combination with falling.

persons in our analyses (805 THA and 640 TKA; see also Figure 1). Patients who did not complete the GFI were significantly older than those who did (mean [standard deviation, SD] age in years completed: 66 [9.1], mean [SD] age not completed: 69 [8.6], $P = .008$) and female (72.8% female not completed, 63.5% female completed, $P = .04$). No significant differences for BMI, musculoskeletal, or other comorbidities were observed.

Upon comparing frail patients to nonfrail patients, significant differences were found for almost all the sociodemographic characteristics included in the analyses. Frail persons were more often female, older, had more comorbidities, a higher BMI, and were more often living alone as compared to nonfrail patients with end-stage hip or knee OA (see also Table 1). Within the group of frail patients, frail patients with knee OA had significant higher BMI as compared to frail patients with hip OA (results not shown).

Table 2 shows the crude baseline and the 12-month follow-up scores on each of the HOOS/KOOS subscales as well as the change score. Except for the KOOS symptoms subscale, all baseline and 12-month scores of the HOOS/KOOS subscales were statistically significantly different in the frail persons as compared to nonfrail patients. However, the significant difference between frail and nonfrail is only clinically relevant at baseline in the subscale pain for hip and subscale ADL for both hip and knee. At 12 months, the MCID threshold of 10 is only reached in ADL for hip patients and in the subscale Sports for hip and knee patients.[24]

The change score for the Sports subscale was lower in frail as compared to nonfrail in both hip ($P = .002$) and knee ($P < .001$). Also for the QoL subscale in knee, a lower outcome change score was found for frail persons ($P = .02$). This suggests that the development over time, that is, the change score, in most subscales is similar in frail and nonfrail persons. Only in Sports and QoL, nonfrail persons have a more rapid increase in functioning after arthroplasty.

Using the continuous scores of GFI (range 0-15; Figure 2), the potential of the GFI to discriminate between outcomes was assessed by constructing 3 models and the AUC for each model was estimated (Table 3). The model that included only GFI had poor discriminatory value (maximum AUC was 0.643 for Sports subscale in THA). The AUC for the model with GFI and baseline score as risk factors was equal to 0.804 for Symptoms in TKA, while the model with only baseline score as risk factor had an AUC equal to 0.802 for Symptoms in TKA (Table 3).

Finally, we assessed the number of reoperations that were performed in the first 12 months post primary hip or knee arthroplasty and compared the rates of frail to the rate in the nonfrail patients (Figure 1). Of the 163 frail patients with a knee replacement, 6 (3.7%) had to be reoperated on the same knee within 12 months; this rate was lower in the nonfrail knee patients (2.1%, $P = .278$). For persons with a hip replacement, we did see a significant lower rate of reoperations in the nonfrail patients (2.4%) as compared to the frail patients (6.4%, $P = .005$).

Discussion

Although obvious preoperative (ie, baseline) differences in values for the HOOS/KOOS subscales existed between frail and nonfrail patients who undergo TJA, frailty did not discriminate between good and adverse outcomes. A model for TKA including GFI and preoperative Symptoms baseline score has an AUC equal to 80.4% for distinguishing between patients with a 2-fold MCID change on the symptoms subscale of the HOOS/KOOS. When only the preoperative score was used, a similar AUC was found (80.2%), indicating that frailty has only a marginal additional value to increase this discriminatory value of postsurgery outcome in THA and TKA patients.

One reason might be the presence of selection bias, since only persons who are scheduled to undergo arthroplasty were

Table 2. Baseline, 12 Month and Change Scores of the HOOS/KOOS Subscales.[a]

	Hip					Knee				
	Nonfrail		Frail (GFI ≥ 4)			Nonfrail		Frail (GFI ≥ 4)		
	Mean	SD	Mean	SD	*P* Value[b]	Mean	SD	Mean	SD	*P* Value[b]
Pain										
Baseline score	40.9	17.9	30.9	17.8	<.001	41.0	17.1	33.6	17.5	<.001
12-month score	89.8	15.4	82.3	20.9	<.001	87.5	17.3	81.1	19.0	<.001
Change score	48.8	20.6	51.6	24.1	.068	46.7	21.6	47.6	23.3	.713
Symptoms										
Baseline score	41.4	18.5	35.2	17.3	<.001	44.3	12.9	41.9	13.6	.058
12-month score	82.7	18.6	73.0	20.5	<.001	57.1	12.6	55.5	13.6	.257
Change score	41.3	23.1	37.8	24.5	.057	12.9	16.1	13.6	16.3	.768
ADL										
Baseline score	43.8	18.7	31.3	17.9	<.001	48.8	17.0	37.8	17.8	<.001
12-month score	87.5	15.7	76.7	22.0	<.001	85.9	16.4	77.7	19.3	<.001
Change score	43.7	20.5	45.4	24.5	.261	37.1	19.9	39.9	22.6	.136
Sports										
Baseline score	21.1	19.6	11.6	14.7	<.001	11.3	14.2	7.4	12.5	<.001
12-month score	70.5	25.0	54.3	29.0	<.001	47.7	27.9	35.3	29.0	<.001
Change score	49.4	27.9	42.6	29.9	.002	36.4	26.7	27.9	27.7	<.001
QoL										
Baseline score	34.2	10.5	31.7	9.6	.003	35.3	10.5	32.4	9.7	.001
12-month score	60.5	15.7	56.1	18.3	.003	54.4	16.3	48.5	15.4	<.001
Change score	26.3	16.6	24.5	19.7	.188	19.1	17.8	16.1	15.5	.020

Abbreviations: ADL, activities of daily living; GFI, Groningen Frailty Indicator; HOOS/KOOS, Hip Osteoarthritis Outcome Score/Knee Osteoarthritis Outcome Score; SD, standard deviation; QoL, quality of life.
[a]Scores of the HOOS/KOOS subscales at baseline and at 12 months. Included are also the change scores.
[b]Differences between frail and nonfrail patients assessed by Mann-Whitney test for nonparametric distributions.

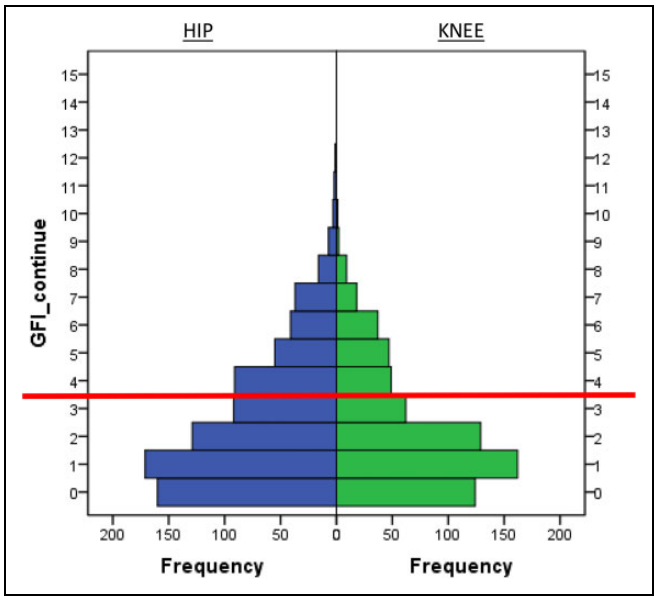

Figure 2. Distribution of the Groningen Frailty Indicator (GFI) scores (range: 0-15) stratified for affected joint.

included. This also explains skewed distribution of the continuous GFI scores. These persons have all undergone selection by the orthopedic surgeon and those not considered fit to have surgery were excluded. The levels of frailty in this rejected group were unknown. However, among those undergoing surgery, still 31.4% in hip and 25.4% in knee are considered frail by GFI (cutoff value of 4). Another problem may be the selection bias which is induced by excluding patients who, based on their mental or physical status, could not complete the questionnaires. Exactly these patients may be those who are most frail. Unfortunately, we did not have data to assess exactly how many patients were not capable to complete the questionnaires.

A study by O'Neill et al demonstrated that the initial clinical impression by a physician of a patient is a useful screening tool to predict for mortality in patients undergoing major surgery.[29] Also, a study conducted by Gerdhem et al has demonstrated the subjective estimate of physicians of biological age is appropriate.[30] Our results support these studies in the sense that improving outcome within the current selection of the physician, who apparently allowed GFI-indicated frail patients, is not possible by GFI since both frail and nonfrail profited almost equally from the operation.

In our study, we did find that persons who are considered frail by GFI have more often comorbidities and higher BMI; however, this is not a strong prognostic factor for postoperative functional outcomes. This might be due to selection bias by the treating orthopedic surgeon (ie, more severe comorbid patients or patients with even higher BMI were not selected). However, our results are in line with a study in patients with head and neck cancer, showing that frailty as measured by the GFI is not

Table 3. Discriminatory Power Between More or Less Than Twice the MCID Increase for Various Models Including and Excluding Groningen Frailty Indicator (GFI).[a]

	Hip			Knee		
	Model 1[b]	Model 2[c]	Model 3[d]	Model 1[b]	Model 2[c]	Model 3[d]
Pain	0.498	0.712	0.697	0.543	0.730	0.705
Symptoms	0.549	0.797	0.767	0.510	0.804	0.802
Activities of daily life	0.532	0.795	0.753	0.539	0.734	0.708
Sport	0.643	0.705	0.573	0.588	0.597	0.557
Quality of life	0.575	0.623	0.623	0.561	0.611	0.582

Abbreviation: MCID, minimally clinically important difference.
[a]Area under the estimated receiver operating characteristic curve corresponding to different models.
[b]Model 1: Univariate analysis with GFI score as prognostic factor.
[c]Model 2: Multivariate analysis with GFI and baseline score as prognostic factor.
[d]Model 3: Univariate analysis with baseline score as prognostic factor.

predictive for postoperative complications after surgery.[31] In contrast, a study by Baitar et al found that GFI is able to separate patients with cancer with normal and abnormal Comprehensive Geriatric Assessment.[32]

We did find a higher reoperation rate in the frail patients as compared to the nonfrail patients, confirming previous studies that found that frailty is a predictor for adverse events such as complications, readmission, and reoperation.[33-35] This could be related to the increased number of comorbidities as we saw in our frail population; however, this should be further assessed in future studies.

For functional recovery after arthroplasty surgery, we have now shown that GFI is not a strong prognostic factor. We found that the functional baseline score is a strong prognostic score which can fairly well discriminate between good and adverse functional outcomes. In addition, we found that frail persons have significantly lower functional baseline scores than nonfrail persons. Therefore, baseline score seems a better measurement to give any indication about the to-be-expected outcome of surgery over frailty score when focusing on functionality, not necessarily when focusing on QoL or health-care use. Jiang et al have also identified that worse baseline scores of Oxford Knee Score (OKS) are associated with worse postsurgery OKS up to 10 years after TKA.[36] Exploring what other health assessments apart from functional parameters would predict postsurgery functionality, such as metabolic and inflammatory conditions at baseline, might improve patient-specific outcome prediction.

The cutoff of more or less than twice the MCID to assess the effect of GFI was arbitrarily; however, if we set the threshold at once the MCID (ie, 10-point increase), similar results were found.

A limitation of this study is the aforementioned selection bias, as we only assessed persons selected by their treating surgeon to undergo surgery and did not have information of patients who were not selected to undergo surgery. These latter patients are most likely to be frail. Nevertheless, up to one-third of the patients who do undergo surgery are considered frail as measured by the GFI.

Conclusion

Among the patients selected for THA and TKA, baseline frailty assessed by the GFI did not provide added value in distinguishing between patients with more or less than twice the MCID change on functional outcome score by the HOOS/KOOS index, 1 year postoperatively.

Although frail patients with OA have lower functioning scores at baseline, the change scores on HOOS/KOOS subscales are similar for both frail and nonfrail patients.

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