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Dependence on Walking Aids and Patient-Reported Outcomes after Total Knee Arthroplasty

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Abstract

Objective: To assess the association of post-arthroplasty dependence on walking aids with outcomes after primary TKA.

Methods: We used prospectively collected Total Joint Registry data from 1993-2005 to assess the association of dependence on walking aids (some, complete) with moderate-severe pain and activity limitations 2- and 5-years after primary TKA. We used multivariable-adjusted multinomial logistic regression analyses adjusted for age, sex, Deyo-Charlson index, anxiety, depression, body mass index, income, distance to medical center, operative diagnosis, ASA class, preoperative pain and preoperative activity limitation.

Results: 7,139 patients provided 2-year and 4,234 provided 5-year data. Some vs. complete dependence on walking aids post-primary TKA was common: 4.9% and 6.2% at 2-years; 6.3% and 8.2% at 5-years. Compared to no dependence on walking aids, patients with dependence on walking aids had significantly higher odds (95% confidence interval; p-value) of: (1) moderate-severe pain at 2-years, 1.96 (1.17, 3.28; p=0.01) and 1.99 at 5-years (1.14, 3.48; p<0.001), associated with some dependence; and with complete dependence, 1.94 (1.16, 3.24; p=0.012) at 2-years and 2.92 (1.73, 4.91; p<0.001) at 5-years; and (2) moderate-severe activity limitation, 9.03 (5.93, 13.80; p<0.001) and 11.25 (7.11, 17.80; p<0.001) at 5-years, with some dependence on walking aids at 2-years; and with complete dependence, 16.09 (9.45, 27.40; p<0.001) at 2-years and 13.31 (7.78, 23.20; p<0.001) at 5-years.

Conclusions: Dependence on walking aids was associated with significantly higher risk of moderate-severe pain and activity limitation after primary TKA. Studies of mediators of this association can help us target modifiable factors and improve TKA outcomes.

Keywords: Total knee arthroplasty; Knee replacement; Dependence; Walking aids; Frailty; Primary TKA; Revision TKA; Pain; ADL limitation

Introduction

Total knee arthroplasty (TKA), is a well-established surgical treatment for end-stage knee arthritis done primarily for improvement in pain, function and quality of life. 7-13% patients have persistent knee pain and 21-27% have suboptimal functional recovery after TKA [1,2]. Given that 719,000 primary TKAs were performed annually in the U.S. in 2010 [3], at least 50,300-93,500 Americans will have painful TKA and 150,990-194,130 develop functional TKA failure, annually. Thus, TKA failure is a major public health problem. Given the aging U.S. population and the rapidly increasing rate of TKA is in the U.S. [4], it will become an even greater challenge for the U.S. health care system.

Patients using walking aids have higher level of disability, increased risk of falls and indicate reduced mobility [5,6]. Dependence on walking aids indicates frailty, [6] especially in the elderly population, who constitute the majority of TKA patients in the U.S [7]. Importantly, postoperative dependence on walking aids is common in TKA patients [2,8].

To our knowledge, only two studies have assessed the association of dependence on walking aids and TKA outcomes. In a study of 75 elderly patients who underwent TKA or of 712 patients who underwent TKA or hip arthroplasty, preoperative dependence on walking aids was predictive of longer index hospital stay [9,10]. It is not known whether postoperative dependence on walking aids, correlates with short- and intermediate-term arthroplasty outcomes. Demographic and comorbidity factors, such as age, gender, obesity and medical and psychiatric conditions are associated with suboptimal pain and function outcomes after TKA [2,8,11-14]. Our aim was to assess whether post-TKA dependence on walking aids is independently associated with post-TKA pain and ADL limitation in patients who underwent primary TKA, after accounting for other known factors associated with pain and ADL limitation outcomes.

Methods

Study cohort

We used the Mayo Clinic Total Joint Registry to perform this study. Patients were included in the study if they underwent primary TKA between 1993-2005 and had completed either a 2- or 5-year Mayo Knee Survey. The Mayo Knee Survey is a validated survey [15], similar to the Knee Society Scale, the most commonly used scale, mailed to patients or administered in clinic to every patient undergoing TKA at baseline preoperative and at 2- and 5-years post-TKA. Trained registry staff administered the survey on the phone for patients who

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missed their appointment and failed to mail back the survey. The Mayo Clinic Institutional Review Board approved the study. We describe the methods and results of our study according to the recommendations from the Strengthening of Reporting in Observational studies in Epidemiology (STROBE) statement.

Independent variable

For this study, post-TKA dependence on walking aids, a marker of frailty, was the independent variable of interest. Dependence on walking aids was assessed based on the response to the question, "Do you use any supports when you walk? Responses were categorized as no, some or complete dependence as follows: "none" or "cane for long walks"= no dependence; "cane full time"= some dependence; "crutch" "two canes", "two crutches", "walker" or "unable to walk"= complete dependence/unable.

Study outcome

Moderate-severe pain and moderate-severe ADL limitations at 2- or 5-years were the outcomes of interest. Pain in knee joint was assessed in response to a question, "Do you have pain in the knee in which the joint was replaced?" Moderate and severe pain categories were combined and no or mild pain was the reference category, as previously [13,16]. Overall moderate-severe ADL limitation was defined as the moderate or severe limitation in ≥ 2 of the 3 activities (walking, climbing stairs, and rising from chair) assessed, as previously [2,17].

Covariates and potential confounders

We included several demographic and clinical factors previously shown to be associated with outcomes after TKA or suspected to be potential confounders, including the following TKA [2,8,11-14,18]: age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) class, distance from the medical center, Deyo-Charlson index [19], underlying diagnosis, depression, anxiety, preoperative pain and preoperative ADL limitation. As previously, age was categorized into ≤ 60, 61-70, 71-80 and >80, BMI into ≤ 25, 25.1-29.9, 30-34.9, 35-39.9 and ≥ 40, distance from the medical center into 0-100 miles, >100-500 miles, >500 miles and ASA class into I-II vs. III-IV and underlying diagnosis into osteoarthritis, rheumatoid/inflammatory arthritis and other. Deyo-Charlson index is a weighted scale of 17 comorbidities (including cardiac, pulmonary, renal, hepatic disease, diabetes, cancer, HIV etc.), expressed as a summative score where a higher score indicates more comorbidity. Depression and anxiety were assessed by the presence of ICD-9 codes in the medical records before the TKA, as previously [18]. Preoperative pain and ADL limitation were assessed by questions similar to the outcomes at the preoperative time and categorized into moderate-severe vs. not.

Bias, sample size and statistical analyses

We used generalized estimating equations (GEE) to account for correlation of >1 observation within a patient (simultaneous or sequential bilateral TKA). We decreased confounding bias by including known/potential confounders for PRO outcomes. We did not perform formal sample size calculations, but aimed to have large enough sample size to allow at least several hundred patients with these outcomes.

We used t-test for comparing continuous and chi-squared tests for categorical baseline patient characteristics. We compared characteristics of survey responders and non-responders using logistic regression analyses. Hierarchical multivariable-adjusted multinomial logistic regression analyses were used to assess the association of post-TKA dependence on walking aids (some vs. none; complete/unable vs. none) at 2- and 5-years post-primary TKA: age, sex, Deyo-Charlson index (Model 1); model 1 + anxiety and depression (Model 2); model 2 + BMI, income, distance to medical center, operative diagnosis and ASA class (Model 3); Model 2 + preoperative pain (Model 4); Model 3 + preoperative pain (Model 5); Model 3 + preoperative pain + preoperative ADL limitation (Model 6). A p-value <0.05 was considered significant.

Results

Cohort characteristics and prevalence of dependence on walking aids

7,139 patients provided 2-year follow-up data and 4.234 provided 5-year data (Table 1). Mean age of the 2-year TKA cohort was 68 years and 56% were women. 18% were 60 years or younger, 13% had BMI <25 kg/m^2 and the underlying diagnosis was osteoarthritis in 94%. The characteristics of the 5-year cohort were similar (Table 1). Post-TKA dependence on walking aids was common at the 2- and 5-year follow-up, some dependence on walking aids in 4.9-6.3% patients and complete dependence in 6.2-8.2% patients (Appendix 1). Survey non-responder characteristics are shown in Appendix 2.

Dependence on walking aids and moderate-severe pain after primary TKA

Compared to patients with no dependence, unadjusted odds of moderate-severe pain at 2-year post-TKA with some dependence on walking aids was 3.13 and with complete dependence 3.31 times (Table 2). In multivariable-adjusted models that adjusted for preoperative pain or both preoperative pain and preoperative ADL limitation, some or complete dependence on walking aids was associated with 2-2.3 times

	2-year (n=7,139)	5-year (n=4,234)
Mean Age (± SD)	68 ± 10	68 ± 10
Men/Women (%)	44%/56%	45%/55%
% bilateral	20%	23%
Age groups n (%)		
≤60 yrs	18%	18%
>60-70 yrs	35%	37%
>70-80 yrs	38%	38%
>80 yrs	8%	7%
Body Mass index (in kg/m^2)		
<25	13%	13%
25-29.9	35%	36%
30-34.9	29%	43%
35-39.9	14%	7%
≥ 40	9%	7%
ASA Score		
Class I-II	58%	58%
Class III-IV	42%	41%
Cemented		
Yes	98%	99.5%
Hybrid	2%	0.5%
Underlying Diagnoses		
Rheumatoid Arthritis/ Other Inflammatory arthritis conditions	4%	4%
Osteoarthritis	94%	93%
Other[a]	2%	3%

[a] Other category includes avascular necrosis, fracture, neoplasms, Paget's disease, septic arthritis etc.

Table 1: Characteristics of patients with primary TKA.

higher odds for moderate severe pain at 2-year post-TKA (Table 2). Similar odds were noted for the 5-year outcomes in both unadjusted and multivariable-adjusted models (Table 2).

Dependence on walking aids and moderate-severe ADL limitation after primary TKA

Compared to patients with no dependence, unadjusted odds of moderate-severe ADL limitation at 2-years post-TKA with some dependence on walking aids was 12.9 and with complete dependence, 18.9 times. In multivariable-adjusted models that also included preoperative pain or both preoperative pain and ADL limitation, some dependence on walking aids was associated with 9.41 at 2-years and 9.03-times odds at 5-years and complete dependence with 16.31 and 16.09-times higher odds of moderate-severe ADL limitation, respectively (Table 3).

Discussion

Our study findings are significant and merit further discussion. This study shows that dependence on walking aids in patients who have undergone TKA is associated with significantly higher risk of post-TKA moderate-severe pain and moderate-severe ADL limitation. Dependence on walking aids likely indicates frailty in this elderly population. These associations were independent of other important covariates such as age, gender, comorbidity, underlying diagnosis as well as preoperative pain and ADL limitation.

To our knowledge, there are no studies assessing the association of postoperative dependence on walking aids with post-TKA pain and ADL limitations. Previous studies found that preoperative use of walking aids predicted longer hospital stay and patient satisfaction [9,10]. Our findings of the association of postoperative frailty with poorer patient-reported outcomes 2- and 5-years after primary TKA, in concert with these earlier findings, indicate that dependence on walking aids is associated with TKA pain and function outcomes.

The association of walking aid dependence with moderate-severe pain is also a novel finding. Frailty, as indicated by the dependence on walking aids, was associated with 2-3 times higher odds of moderate-severe pain. Potential explanations inctlude: (1) previously noted association of frailty with intrusive pain in the elderly [20]; (2) a potential negative impact of walking aid dependence on the ability to do optimal physical rehabilitation therapy that is required for optimal recovery (pain and function) after arthroplasty [21,22]; and (3) the association of dependence on walking aids with peripheral neuropathy and peripheral vascular disease [23], painful conditions of the lower extremity, may contribute to worse index knee pain after TKA. Patients may not be able to distinguish between various sources/types of knee pain.

Previous studies of have found patient demographics, pre-operative pain and comorbidity as predictors of post-TKA poor pain outcome, with odds ranging 1.3-1.8 [2,8,11-14,18]. The magnitude of the

	2-year post-TKA moderate-severe pain		5-year post-TKA moderate-severe pain	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Unadjusted				
Some dependence	3.13 (2.29, 4.26)	<0.001	2.43 (1.66, 3.58)	<0.001
Complete dependence	3.31 (2.46, 4.46)	<0.001	3.86 (1.11, 5.32)	<0.001
Model 1: Age, sex, Deyo-Charlson				
Some dependence	3.10 (2.25, 4.27)	<0.001	2.51 (1.70, 3.72)	<0.001
Complete dependence	3.07 (2.26, 4.19)	<0.001	3.91 (2.78, 5.50)	<0.001
Model 2: Age, sex, Deyo-Charlson, anxiety, depression				
Some dependence	3.07 (2.22, 4.24)	<0.001	2.56 (1.72, 3.80)	<0.001
Complete dependence	3.01 (2.21, 4.11)	<0.001	3.81 (2.70, 5.38)	<0.001
Model 3: Model 2 + BMI, income, distance to medical center, operative diagnosis, ASA class				
Some dependence	3.28 (2.30, 4.66)	<0.001	2.47 (1.59, 3.84)	<0.001
Complete dependence	2.86 (2.00, 4.09)	<0.001	3.45 (2.32, 5.14)	<0.001
Model 4: Model 2 + preoperative pain				
Some dependence	1.94 (1.22, 3.09)	0.005	1.93 (1.18, 3.17)	0.01
Complete dependence	2.30 (1.48, 3.56)	<0.001	3.23 (2.06, 5.07)	<0.001
Model 5: Model 3 + preoperative pain				
Some dependence	2.23 (1.36, 3.66)	0.002	2.03 (1.17, 3.51)	0.01
Complete dependence	1.98 (1.19, 3.29)	0.009	2.83 (1.68, 4.75)	<0.001
Model 6: Model 3 + preoperative pain + preoperative ADL limitation				
Some dependence	1.96 (1.17, 3.28)	0.01	1.99 (1.14, 3.48)	<0.001
Complete dependence	1.94 (1.16, 3.24)	0.012	2.92 (1.73, 4.91)	<0.001

Table 2: Univariate and multivariable-adjusted predictors of moderate-severe pain after primary TKA.

	2-year post-TKA moderate-severe ADL limitation		5-year post-TKA moderate-severe ADL limitation	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Unadjusted				
Some dependence	12.90 (9.92, 16.70)	<0.001	14.48 (10.26, 20.40)	<0.001
Complete dependence	18.90 (14.07, 25.40)	<0.001	15.78 (11.34, 22.00)	<0.001
Model 1: Age, sex, Deyo-Charlson				
Some dependence	11.19 (8.51, 14.70)	<0.001	13.08 (9.18, 18.70)	<0.001
Complete dependence	15.71 (11.48, 21.50)	<0.001	13.40 (9.51, 18.90)	<0.001
Model 2: Age, sex, Deyo-Charlson, anxiety, depression				
Some dependence	11.12 (8.45, 14.60)	<0.001	13.17 (9.24, 18.70)	<0.001
Complete dependence	15.55 (11.36, 21.30)	<0.001	13.28 (9.41, 18.70)	<0.001
Model 3: Model 2 + BMI, income, distance to medical center, operative diagnosis, ASA class				
Some dependence	10.19 (7.49, 13.90)	<0.001	12.71 (8.58, 18.80)	<0.001
Complete dependence	13.64 (9.56, 19.50)	<0.001	13.80 (9.06, 21.00)	<0.001
Model 4: Model 2 + preoperative pain				
Some dependence	9.98 (6.92, 14.40)	<0.001	11.91 (7.68, 18.50)	<0.001
Complete dependence	18.10 (11.32, 28.90)	<0.001	11.89 (7.69, 18.40)	<0.001
Model 5: Model 3 + preoperative pain				
Some dependence	9.41 (6.18, 14.30)	<0.001	11.73 (7.43, 18.50)	<0.001
Complete dependence	16.31 (9.59, 27.70)	<0.001	13.63 (7.92, 23.40)	<0.001
Model 6: Model 3 + preoperative pain + preoperative ADL limitation				
Some dependence	9.03 (5.93, 13.80)	<0.001	11.25 (7.11, 17.80)	<0.001
Complete dependence	16.09 (9.45, 27.40)	<0.001	13.31 (7.78, 23.20)	<0.001

Table 3: Univariate and multivariable-adjusted predictors of moderate-severe ADL limitation after primary TKA.

association of dependence on walking aids with odds for moderate-severe pain ranging 1.9-3.3 at 2-years post-primary TKA and 1.9-3.9 at 5-years, are 2-3 times higher than that previously reported for other factors. The odds of moderate-severe ADL limitation were even higher. This provides a context for the importance of walking aids dependence for these important PROs after primary TKA. The identification of frailty, as assessed by the dependence on walking aids, as a risk factor for post-TKA outcomes, adds to the current knowledge.

It was not surprising that dependence on walking aids was a predictor of post-TKA ADL limitation, with odds increased to 12-15 times higher. The interesting aspect was that these associations were noted even in models that adjusted for preoperative pain and ADL limitations.

The robustness of our findings is confirmed by stability of the estimates in multiple hierarchical multivariable-adjusted models, adjusted also for preoperative pain and ADL limitation. This indicates that postoperative dependence on walking aids captures a unique domain of function in patients with arthroplasty, above and beyond that captured by preoperative ADL limitation.

Our study has several limitations. Generalizability of these findings to other populations may be questioned since this was a study based on data from an institutional joint registry. However, the similarity of characteristics of our patient population to other TKA cohorts [24] and representative national U.S. cohort [25] indicates that our cohort is representative of patients undergoing TKA in the U.S. We used ICD-9 codes for anxiety and depression, which may have led to their under-recognition compared to a validated questionnaire or prospective physician assessment. Residual confounding is possible despite our efforts to adjust for a multitude of covariates and potential confounders, since this is a cohort study, not a randomized trial. We did not assess dependence on preoperative walking aids, which might have led to residual confounding. However, we controlled for pre-operative function and pain, so it's unlikely that this postoperative dependence represents pre-operative disability or pain. Lastly, we are describing the associations between frailty and PROs, not determining cause and effect, given that these postoperative assessments were done at the same time. It is quite likely that post-TKA dependence on walking aids is the result of moderate-severe pain and accompanying inability to do optimal rehabilitation of the operated knee. Future studies need to examine this in more detail to assess cause and effect between post-TKA pain, functional limitation and dependence on walking aids.

In conclusion, we found that frailty, as determined by patient's dependence on walking aids after primary TKA was associated with significantly worse pain and ADL limitation outcomes after primary TKA. This association was independent of the severity of preoperative pain and ADL limitation and demographic and other clinical factors. The associations were strong with odds of 2-4 times for moderate-severe pain and 9-19 times for moderate severe ADL limitation. With an aging U.S. population, the prevalence of frailty is increasing in the population. Hence, frailty will also be more prevalent among TKA recipients in the future. More studies are needed to further investigate these important associations and the mediators for these associations. This will lead to development of interventions that can improve PROs after primary TKA.

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Financial conflicts

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Author contributions

JAS designed the study and developed the protocol and performed analyses; JAS and DGL interpreted data; JAS wrote the first draft of the manuscript; JAS and DGL performed critical revisions and made the decision to submit the manuscript.

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Disclaimer

"The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

IRB approval

The Mayo Clinic Institutional Review Board approved this study and all investigations were conducted in conformity with ethical principles of research.

References

1. Brander VA, Stulberg SD, Adams AD, Harden RN, Bruehl S, et al. (2003) Predicting total knee replacement pain: a prospective, observational study. Clin Orthop Relat Res: 27-36.
2. Singh JA, O'Byrne M, Harmsen S, Lewallen D (2010) Predictors of moderate-severe functional limitation after primary Total Knee Arthroplasty (TKA): 4701 TKAs at 2-years and 2935 TKAs at 5-years. Osteoarthritis Cartilage 18: 515-521.
3. http://www.cdc.gov/nchs/data/nhds/4procedures/2010pro4_numberprocedureage.pdf
4. Kurtz S, Ong K, Lau E, Mowat F, Halpern M (2007) Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 89: 780-785.
5. Deandrea S, Bravi F, Turati F, Lucenteforte E, La Vecchia C, et al. (2013) Risk factors for falls in older people in nursing homes and hospitals. A systematic review and meta-analysis. Arch Gerontol Geriatr 56: 407-415.
6. Morley JE, Haren MT, Rolland Y, Kim MJ (2006) Frailty. Med Clin North Am 90: 837-847.
7. Khatod M, Inacio M, Paxton EW, Bini SA, Namba RS, et al. (2008) Knee replacement: epidemiology, outcomes, and trends in Southern California: 17,080 replacements from 1995 through 2004. Acta Orthop 79: 812-819.
8. Singh JA, O'Byrne MM, Harmsen WS, Lewallen DG (2010) Predictors of moderate-severe functional limitation 2 and 5 years after revision total knee arthroplasty. J Arthroplasty 25: 1091-1095, 1095.
9. Raut S, Mertes SC, Muniz-Terrera G, Khanduja V (2012) Factors associated with prolonged length of stay following a total knee replacement in patients aged over 75. Int Orthop 36: 1601-1608.
10. Husted H, Holm G, Jacobsen S (2008) Predictors of length of stay and patient satisfaction after hip and knee replacement surgery: fast-track experience in 712 patients. Acta Orthop 79: 168-173.
11. Fitzgerald JD, Orav EJ, Lee TH, Marcantonio ER, Poss R, et al. (2004) Patient quality of life during the 12 months following joint replacement surgery. Arthritis Rheum 51: 100-109.
12. Jones CA, Voaklander DC, Johnston DW, Suarez-Almazor ME (2001) The effect of age on pain, function, and quality of life after total hip and knee arthroplasty. Arch Intern Med 161: 454-460.
13. Singh JA, Gabriel S, Lewallen D (2008) The impact of gender, age, and preoperative pain severity on pain after TKA. Clin Orthop Relat Res 466: 2717-2723.
14. Wasielewski RC, Weed H, Prezioso C, Nicholson C, Puri RD (1998) Patient comorbidity: relationship to outcomes of total knee arthroplasty. Clin Orthop Relat Res: 85-92.
15. McGrory BJ, Morrey BF, Rand JA, Ilstrup DM (1996) Correlation of patient questionnaire responses and physician history in grading clinical outcome following hip and knee arthroplasty. A prospective study of 201 joint arthroplasties. J Arthroplasty 11: 47-57.
16. Singh JA, Lewallen D (2010) Predictors of pain and use of pain medications following primary Total Hip Arthroplasty (THA): 5,707 THAs at 2-years and 3,289 THAs at 5-years. BMC Musculoskelet Disord 11: 90.
17. Singh JA, Lewallen DG (2010) Predictors of activity limitation and dependence on walking aids after primary total hip arthroplasty. J Am Geriatr Soc 58: 2387-2393.
18. Singh JA, Lewallen DG (2013) Medical and psychological comorbidity predicts poor pain outcomes after total knee arthroplasty. Rheumatology (Oxford) 52: 916-923.
19. Deyo RA, Cherkin DC, Ciol MA (1992) Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 45: 613-619.
20. Blyth FM, Rochat S, Cumming RG, Creasey H, Handelsman DJ, et al. (2008) Pain, frailty and comorbidity on older men: the CHAMP study. Pain 140: 224-230.
21. Brueilly KE, Pabian P, Straut L, Freve L, Kolber M (2012) Factors contributing to rehabilitation outcomes following hip arthroplasty. Physical Therapy Reviews 17: 301-310.
22. Bade MJ, Stevens-Lapsley JE (2011) Early high-intensity rehabilitation following total knee arthroplasty improves outcomes. J Orthop Sports Phys Ther 41: 932-941.
23. Bruce DG, Davis WA, Davis TM (2005) Longitudinal predictors of reduced mobility and physical disability in patients with type 2 diabetes: the Fremantle Diabetes Study. Diabetes Care 28: 2441-2447.
24. Zeni JA Jr, Snyder-Mackler L (2010) Most patients gain weight in the 2 years after total knee arthroplasty: comparison to a healthy control group. Osteoarthritis Cartilage 18: 510-514.
25. Hervey SL, Purves HR, Guller U, Toth AP, Vail TP, et al. (2003) Provider Volume of Total Knee Arthroplasties and Patient Outcomes in the HCUP-Nationwide Inpatient Sample. J Bone Joint Surg Am 85-85A: 1775-1783.