The Impact of Gender, Age, and Preoperative Pain Severity on Pain After TKA

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Abstract Do gender and age affect knee arthroplasty outcomes? In a cohort of patients who underwent primary or revision TKA between 1996 and 2004 and responded to a followup questionnaire 2 and 5 years after arthroplasty, we investigated the impact of gender and age on the prevalence of moderate or severe post-TKA knee pain (primary TKA: 2 years, 5290; 5 years, 2602; revision TKA: 2 years, 1109; 5 years, 505). Moderate-severe pain was higher in women than men after primary TKA at 2 and

5 years (9% versus 6.6% and 7.9% versus 6.5%) and post-revision TKA at 2 and 5 years (28.6% versus 22% and 28.9% versus 18.3%). More women compared to men and fewer patients between 61 and 70 years (versus patients ≤ 60) had moderate-severe pain 2 years after primary TKA adjusting for gender, age, and preoperative pain severity. In the post-revision TKA group, the odds of moderate-severe pain were lower in patients older than 80 years (versus those ≤ 60) at 2 years and higher in patients with moderate-severe preoperative pain at 2 and 5 years postoperatively, after adjustment for gender, age, and preoperative pain severity. We conclude female gender, younger age, and worse preoperative pain predict greater risk of moderate-severe pain postoperatively in patients with primary and revision TKA.

Level of Evidence: Level II, prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Introduction

Do gender and age affect knee arthroplasty outcomes? With the recent introduction of gender-specific implants, a debate has emerged about whether these implants have potential benefit. Proponents of gender-specific implants cite differences in joint anatomy as their rationale, while critics ask for evidence of differences in outcomes [2]. If women indeed have worse outcomes with standard TKA implants compared to men, and if the differences can be attributed to implant design, this might suggest a potential benefit to gender-based alterations in surgical technique or implant design.

The current data regarding gender are contradictory. The 2003 NIH consensus statement concluded age or gender

were not strongly associated with short-term functional outcomes as assessed by the WOMAC, SF-36, or Knee Society score (KSS) [14]. In three small prospective studies of under 300 patients each, neither age nor gender was associated with any difference in prevalence of substantial pain up to 6 months [9] or up to 12 months [3] or with higher WOMAC pain at 6 months post-TKA [7]. On the contrary, a multinational randomized study of 860 TKA patients reported worse pain in women on the WOMAC pain scale at 1 and 2 years post-TKA, but no age differences [11].

The data regarding the effect of age on patient-reported outcomes are also somewhat contradictory. While some studies report better outcomes in older patients [5, 6], others have reported similar outcomes in all age groups [3, 7, 9, 18]. In a community-based study of 257 patients undergoing TKA, age was not a determinant of WOMAC pain scores at 6 months after TKA [9]. Another study reported older patients have better outcomes [12]. Whether a better outcome in older patients is due to less demand on the replaced joint or different level of expectation of outcomes compared to younger patients is unclear.

Recent debates have focused on whether gender and age differences exist in pain outcomes of patients undergoing knee arthroplasty. We examined whether gender, age, and preoperative pain severity influenced the 2- and 5-year pain outcomes of primary TKA and revision TKA.

Materials and Methods

We retrospectively reviewed the records of all patients who underwent primary or revision TKA during the calendar years 1996 to 2004 at the Mayo Clinic and had responded to the pain questionnaire by mail, by phone, or in the clinic during followup at 2 or 5 years (Tables 1, 2). The Mayo Clinic Joint Registry [15, 16] has collected prospective data on implant survival and outcomes since 1969 for all patients who underwent joint arthroplasty at the Mayo Clinic and since 1993 had captured patient-reported pain severity in the operated knee. Detailed demographic and underlying diagnoses for the primary and revision TKA cohorts were recorded (Tables 1, 2). Eligibility criteria included being alive at 2- or 5-year followup and absence of revision for primary TKA or rerevision for revision TKA. For 2-year followup, 5290 of 7770 eligible patients with primary TKA and 1109 of 1813 eligible patients with revision TKA responded to the questionnaire; for 5-year followup, 2602 of 4647 eligible patients with primary TKA and 505 of the 966 eligible patients with revision TKA responded to the questionnaire (Tables 1, 2). The response

Table 1. Demographic and clinical characteristics of primary TKA cohort

Variable	Primary TKA	
	2 years	5 years
All in database	8128	8128
Patients eligible (alive and without revision)	7770	4647
Responders to survey	5290	2602
Mean age ($\pm$ standard deviation)	68.2 $\pm$ 10.1	68.3 $\pm$ 9.5
Women/men	2960 (56%)/2330 (44%)	1454 (55.9%)/1148 (44.1%)
Age groups		
$\leq$ 60 years	1041 (19.7%)	475 (18.3%)
> 60–70 years	1848 (34.9%)	976 (37.5%)
> 70–80 years	1969 (37.2%)	974 (37.4%)
> 80 years	432 (8.2%)	177 (6.8%)
Underlying diagnosis		
Osteoarthritis	5002/5289 (94.6%)	2438/2602 (93.7%)
Rheumatoid arthritis	146/5289 (2.8%)	90/2602 (3.5%)
Other inflammatory arthritis conditions	30/5289 (0.6%)	14/2602 (0.5%)
Avascular necrosis	61/5289 (1.2%)	35/2602 (1.3%)
Other	50/5289 (0.9%)	25/2602 (1.0%)

rates were higher for 2-year followup (68% and 61%) than for 5-year follow-up (56% and 52%) for primary and revision TKA, respectively. Nonresponders were more likely to be female (odds ratio, 1.10–1.49) and 60 years old or younger (odds ratio, 1.08–1.58). The primary TKA cohorts (2- and 5-year followup) had a mean age of 68 years (standard deviation (SD), 9.5–10.1 years); 56% were women and 44% were men. The underlying diagnosis was osteoarthritis in 94% to 95%, rheumatoid arthritis in 3% to 4%, avascular necrosis in 1%, and other diagnoses in 1%. The revision TKA cohorts (2- and 5-year followup) had a mean age of 69 years (SD, 10 years); 47% to 50% were women and 50% to 53% were men. The underlying diagnosis was loosening/wear in 51% to 56%, dislocation/instability/fracture in 20% to 23%, failure of previous surgery in 18% to 19%, osteolysis in 4% to 5%, and infection in 1% to 2%.

As a part of routine clinical followup, all patients are contacted via mail at 2 and 5 years after knee arthroplasty. The pain question is similar to the pain question in the American Knee Society (AKS) questionnaire: “Do you have pain in the knee in which the joint was replaced? (Please make only one answer).” The responses were “no pain,” “mild (occasional),” “stairs only,” “walking and stairs,” “moderate (occasional),” “moderate (continuous),” and “severe.” For the purposes of the analyses, we

Table 2. Demographic and clinical characteristics of revision TKA cohort

Variable	Revision TKA	
	2 years	5 years
All in database	2042	2042
Patients eligible (alive and without rerevision)	1813	966
Responders to survey	1109 at 2 years	505 at 5 years
Mean age ($\pm$ standard deviation)	69 $\pm$ 10.3	69.1 $\pm$ 10
Women/men	555 (50%)/ 554 (50%)	237 (46.9%)/ 268 (53.1%)
Age groups		
$\leq$ 60 years	209 (18.8%)	88 (17.4%)
> 60–70 years	330 (29.8%)	156 (30.9%)
> 70–80 years	469 (42.3%)	218 (43.2%)
> 80 years	101 (9.1%)	43 (8.5%)
Underlying diagnosis		
Loosening/wear	569 (51.3%)	284 (56.2%)
Dislocation, bone or prostheses fracture, instability	251 (22.6%)	102 (20.2%)
Failed prior arthroplasty with components removed	205 (18.5%)	89 (17.6%)
Osteolysis	53 (4.8%)	18 (3.6%)
Nonunion	9 (0.8%)	5 (1%)
Infection	22 (2%)	7 (1.4%)

combined the two moderate and the severe pain categories for the “moderate-severe” category. The categories of no or mild pain (which constituted the vast majority of the patients, as expected) was the reference category. Because there was no specification of pain severity for two response categories, ie, pain with “stairs only” or “walking and

stairs” responses, these were set to missing (< 5% of total responses). We obtained patient gender, age, and the preoperative pain severity (assessed by the same pain question as above) for each patient from the registry.

The outcome of interest was the prevalence of moderate-severe pain at the 2- and 5-year followup visits. The main predictor of interest was gender, with men as the reference category. Covariates included age categorized as 60 years and younger (reference category), between 60 and 70 years, between 70 and 80 years, and older than 80 years and preoperative pain categorized as moderate-severe pain or no/mild pain (reference category), categorized similar to outcome of interest.

We compared women to men, various age groups, and preoperative pain severity groups for the prevalence of postoperative moderate-severe pain at each followup. For unadjusted logistic regression analyses, we compared the odds of moderate-severe postoperative pain with each covariate, gender, age, and preoperative pain categories. We examined the association of gender and age with moderate-severe postoperative knee pain at 2 and 5 years after primary and revision TKA by performing multivariable logistic regression models that adjusted for gender, age, and preoperative pain simultaneously. Odds ratios with 95% confidence intervals are presented, with odds ratios of more than one indicating a higher risk of moderate-severe pain in the respective category. Analyses were performed using SAS[®] Version 9.0 (SAS Institute, Cary, NC).

Results

Approximately 36% and 37% more women than men had moderate-severe pain 2 and 5 years after primary TKA, respectively (Tables 3, 4). After adjustment for preoperative

Table 3. Gender and age are associated with moderate or severe pain at 2 years post-primary TKA

Variable	Event (n/N)	Univariate			Multivariable		
		OR	95% CI	p value	OR	95% CI	p value
Age							
$\leq$ 60 years (reference category)	101/977 (10.3%)						
> 60–70 years	107/1716 (6.3%)	0.58	(0.43, 0.78)	< 0.001	0.49	(0.31, 0.77)	0.002
> 70–80 years	136/1845 (7.4%)	0.69	(0.52, 0.92)	0.01	0.68	(0.44, 1.05)	0.08
> 80 years	45/393 (11.4%)	1.12	(0.77, 1.64)	0.56	1.18	(0.65, 2.13)	0.59
Gender							
Male (reference category)	143/2181 (6.6%)						
Female	246/2750 (9%)	1.40	(1.12, 1.76)	0.004	1.45	(1.01, 2.08)	0.04
Preoperative pain							
Mild/none (reference category)	6/102 (5.9%)						
Moderate/severe	156/1975 (7.9%)	1.37	(0.59, 3.17)	0.46	1.31	(0.57, 3.03)	0.53

OR = odds ratio; CI = confidence interval.

Table 4. Gender and age are not associated with moderate or severe pain at 5 years post-primary TKA

Variable	Event (n/N)	Univariate			Multivariable		
		OR	95% CI	p value	OR	95% CI	p value
Age							
≤ 60 years (reference category)	45/440 (10.2%)						
> 60–70 years	58/925 (6.2%)	0.59	(0.38, 0.91)	0.02	0.66	(0.35, 1.25)	0.20
> 70–80 years	63/905 (7%)	0.66	(0.42, 1.02)	0.06	0.73	(0.38, 1.40)	0.34
> 80 years	11/163 (6.7%)	0.64	(0.30, 1.34)	0.23	0.70	(0.21, 2.31)	0.56
Gender							
Male (reference category)	70/1076 (6.5%)						
Female	107/1357 (7.9%)	1.23	(0.87, 1.73)	0.23	1.23	(0.74, 2.02)	0.42
Preoperative pain							
Mild/none (reference category)	1/58 (1.7%)						
Moderate/severe	81/1017 (8%)	4.93	(0.67, 36.25)	0.12	4.60	(0.61, 34.74)	0.14

OR = odds ratio; CI = confidence interval.

Table 5. Preoperative pain severity and age but not gender are associated with moderate or severe pain at 2 years post-revision TKA

Variable	Event (n/N)	Univariate		Multivariable			
		OR	95% CI	p value	OR	95% CI	p value
Age							
≤ 60 years (reference category)	66/184 (35.9%)						
> 60–70 years	68/301 (22.6%)	0.52	(0.34, 0.79)	0.002	0.63	(0.31, 1.26)	0.19
> 70–80 years	99/418 (23.7%)	0.55	(0.38, 0.82)	0.003	0.72	(0.38, 1.37)	0.31
> 80 years	19/89 (21.4%)	0.49	(0.26, 0.90)	0.02	0.27	(0.08, 0.89)	0.03
Gender							
Male (reference category)	109/492 (22%)						
Female	143/500 (28.6%)	1.41	(1.05, 1.89)	0.02	1.35	(0.82, 2.23)	0.23
Preoperative pain							
Mild/none (reference category)	14/105 (13.3%)						
Moderate/severe	74/256 (28.9%)	2.64	(1.41, 4.95)	0.002	2.57	(1.36, 4.84)	0.004

OR = odds ratio; CI = confidence interval.

pain level and age differences, women were more likely to report moderate-severe pain at 2 years ($p = 0.04$), but not at 5 years ($p = 0.42$); and patients 61 to 70 years old had lower odds of reporting moderate-severe pain 2 years post-primary TKA compared to those at most 60 years old ($p = 0.002$). Age or preoperative pain severity were not associated with moderate-severe pain at the 5-year followup.

Female gender was associated with 41% and 82% higher odds of moderate-severe pain at 2 ($p = 0.02$) and 5 years ($p = 0.009$) post-revision TKA, respectively, in univariate analyses. These differences were no longer significant after adjusting for age and preoperative pain severity ($p = 0.23$ and $p = 0.30$, respectively) (Tables 5, 6). Patients older than 80 years were less likely than patients 60 years and younger to report moderate-severe pain at 2 years post-revision TKA ($p = 0.03$), after adjusting for gender and preoperative pain severity. Presence of moderate-severe

preoperative pain severity was a predictor of moderate-severe pain at both 2 and 5 years after revision TKA, in univariate ($p = 0.002$; $p = 0.003$) as well as multivariable ($p = 0.004$; $p < 0.001$) analyses. The odds ratios ranged from 2.6 at 2 years to 5.4 to 5.8 at 5 years.

Discussion

The current literature provides contradictory conclusions as to whether gender influences the outcomes of TKA [3, 7, 9, 11, 14]. We therefore asked whether gender, age, and preoperative pain are associated with the prevalence of moderate-severe pain after knee arthroplasty. Specifically, we assessed whether these factors influenced the 2- and 5-year pain outcomes after primary and revision TKA.

Table 6. Preoperative pain severity but not gender or age are associated with moderate or severe pain at 5 years post-revision TKA

Variable	Event (n/N)	Univariate			Multivariable		
		OR	95% CI	p value	OR	95% CI	p value
Age							
≤ 60 years (reference category)	23/79 (29.1%)						
> 60–70 years	35/140 (25%)	0.81	(0.43, 1.53)	0.52	0.80	(0.26, 2.41)	0.69
> 70–80 years	38/187 (20.3%)	0.62	(0.34, 1.15)	0.13	0.54	(0.20, 1.46)	0.23
> 80 years	9/42 (21.5%)	0.66	(0.27, 1.62)	0.37	0.16	(0.02, 1.53)	0.11
Gender							
Male (reference category)	42/230 (18.3%)						
Female	63/218 (28.9%)	1.82	(1.16, 2.85)	0.009	1.50	(0.70, 3.23)	0.30
Preoperative pain							
Mild/none (reference category)	4/50 (8%)						
Moderate/severe	36/113 (31.9%)	5.38	(1.79, 16.11)	0.003	5.75	(2.04, 16.18)	< 0.001

OR = odds ratio; CI = confidence interval.

Our study has the limitations of an observational study in that residual confounding factors cannot be ruled out. However, performing a randomized study with large sample size and long followup to examine these associations would be difficult, and therefore these outcomes can only be practically studied with a retrospective/prospective cohort design similar to our study. Nonresponse bias and single study center limits the generalizability of study findings; however, these data come from one of the largest volume joint arthroplasty centers. Nonresponders were more likely to be female and to be 60 years or younger and because both factors were associated with worse outcome, this biased our study toward null. This implies the estimates provided here are conservative and could have been more impressive had the full cohort of TKA patients responded to the questionnaire. These findings require replication in other large datasets of patients followed prospectively. Longer-term outcome studies focused on these groups are needed. The confounding effect of previous trauma and previous surgery could not be studied in this dataset due to the lack of complete information. Although not population-based in the true sense, our study has the advantage of including patients from a large multispecialty group who were followed as part of regular clinical surveillance.

Our data provide estimates of moderate-severe index joint pain up to 5 years postoperatively by gender and age for a large group of patients who participated in prospective clinical surveillance. These observational data are hypothesis-generating and should not be overinterpreted. Only two previous studies examining gender/age effects had sample sizes greater than 500 and study duration longer than 2 years [5, 11] (Table 7). The prevalence of moderate-severe pain after primary TKA in our study is similar to recent studies reporting a 5-year prevalence of

7% to 13% at 1 year [3, 5] but lower than studies from 1987 to 1994 reporting 22% at 7 years [13] and 51% at 1 year [4] (pain ≥ 3 on 0–10 visual analog scale). This suggests these outcomes may be improving over time. Our finding that women were 45% more likely to report moderate-severe pain 2 years after primary TKA, after adjusting for age and preoperative pain severity differences, is novel and adds to the current knowledge. This is a somewhat larger difference than the 1- to 2-point difference in KSS pain scores by gender (women with more pain than men) reported by Ritter et al. [17] during 5-year followup post-primary TKA in a large sample with a slightly different patient population (osteoarthritis versus all causes for TKA). Both studies adjusted for important covariates and had a similar age and gender mix. Randomized trials (as opposed to population-based studies) have reported either worse pain in women versus men [11] or no gender differences [5], while nonrandomized prospective studies of smaller sample sizes and shorter duration [3, 6, 7, 9, 18] reported no gender differences (possible Type II error due to small sample size). Fewer patients 61 to 70 years old (compared to ≤ 60 years) had moderate-severe pain 2 years post-primary TKA, similar to studies 1 year [6] and 5 years [5] in duration, but in contrast to those reporting no age-related differences at 6 months to 2 years followup [3, 7, 9, 18]. Possible explanations include higher pain tolerance in older patients or more peripheral neuropathy and less scar formation with less stiffness in older patients, leading to less pain. Recent reviews have summarized predictors/factors associated with persistent post-TKA pain in general [8] and for complex regional pain syndrome [1, 19]. Residual confounding, adjustment for different sets of variables, different assessments of pain, and different age categorizations for analyses may explain differing study results.

Table 7. Summary of studies of gender, age, and preoperative pain as predictors of post-primary TKA pain

Study	Type of study/followup	Sample size	Pain outcome measure	Multivariable adjustment?	Gender	Age	Preoperative pain
Jones et al. [9]	Prospective cohort/ 6 months	257 TKAs	WOMAC pain	Yes	Not associated	Not associated	Higher preop pain associated with higher postop pain
Roth et al. [18]	Prospective cohort/ 3 days	68 TKAs	Short-form McGill pain	Yes	Not associated	Not associated	Not assessed
Fortin et al. [7]	Prospective/6 months	106 TKAs	WOMAC pain	Yes	Not associated	Not associated	Higher preop pain associated with higher postop pain
Fitzgerald et al. [6]	Prospective/12 months	131 TKAs	SF-36 pain subscale	Yes	Not associated	Age > 75 years associated with less postop pain	Higher preop pain associated with higher postop pain
Elson and Brenkel [5]	Prospective/5 years	622 TKAs	Moderate-severe category on KSS pain scale	Yes	Not associated	Age < 60 years associated with more pain postop	Not assessed
Lingard et al. [11]	Randomized trial/2 years	800 TKAs	WOMAC pain	Yes	Female gender associated with more postop pain	Not associated	Higher preop pain associated with higher postop pain
Brander et al. [3]	Prospective cohort/1 year	149 TKAs	Visual analog pain scale	No	Not assessed	Not assessed	Not assessed
Murray and Frost [13]	Prospective cohort/7 years	1429 TKAs	Mild, moderate, or severe pain	No	Not assessed	Not assessed	Not assessed
Ritter et al. [17]	Prospective cohort/~ 5 years	7326 TKAs	KSS pain scale	Yes	Women with worse postop pain scores	Not assessed	Not assessed
Current study	Prospective cohort/5 years	8128 TKAs	Similar to KSS pain question	Yes	Women with worse postop pain scores at 2 but not at 5 years	61–70 years old with better postop pain (versus ≤ 60 years) at 2 but not at 5 years	Not associated at 2 or 5 years

KSS = Knee Society score.

We found no published studies investigating the prevalence of moderate-severe pain during intermediate-term followup of revision TKA to compare to our reported prevalence of 18% to 22% in men and 29% in women. Better pain outcomes were reported in those older than 80 years in the revision TKA category; we are not aware of any population-based studies that have reported these outcomes for this age category. In patients undergoing revision TKA, the predictors of moderate-severe pain are different from those for primary TKA, ie, preoperative pain severity is a consistently a strong risk factor for 2- and 5-year risk of moderate-severe pain post-revision TKA. Revision TKA patients with moderate-severe preoperative pain were three to six times as likely to report moderate-severe pain during followup compared to patients with lesser severity of preoperative pain. A less strong association has been reported for patients after primary TKA [6, 9, 11, 18], and our study extends this to 2- and 5-year outcomes in patients with revision TKA. Clearly, more research is needed in this area to identify reasons for poorer outcomes in younger patients and to devise interventions for modifiable factors.

Female gender predicted worse pain outcomes at 2 years in patients with primary TKA. Younger age was a risk factor for poorer outcomes in primary and revision TKA at 2 years. Poorer preoperative pain scores predicted postoperative pain severity at 2- and 5-year followup in patients with revision TKA. These gender differences/odds may be considered small or huge depending on the perspective. If replicated in other large US datasets, with an average yearly volume of 450,000 TKAs in the United States [10], a 2.3% higher prevalence in women equals 5400 more women than men with moderate-severe pain after primary TKA in a given year. This would be considered meaningful by policy makers, epidemiologists, and many practicing surgeons. These findings suggest certain patient and clinical characteristics are associated with worse pain outcomes and may help us identify at-risk patients.

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References

- Atkins RM. Complex regional pain syndrome. *J Bone Joint Surg Br.* 2003;85:1100–1106.
- Barrett WP. The need for gender-specific prostheses in TKA: does size make a difference? *Orthopedics.* 2006;29:S53–S55.
- Brander VA, Stulberg SD, Adams AD, Harden RN, Bruehl S, Stanos SP, Houle T. Predicting total knee replacement pain: a prospective, observational study. *Clin Orthop Relat Res.* 2003;416:27–36.
- Dickstein R, Heffes Y, Shabtai EI, Markowitz E. Total knee arthroplasty in the elderly: patients' self-appraisal 6 and 12 months postoperatively. *Gerontology.* 1998;44:204–210.
- Elson DW, Brenkel IJ. Predicting pain after total knee arthroplasty. *J Arthroplasty.* 2006;21:1047–1053.
- Fitzgerald JD, Orav EJ, Lee TH, Marcantonio ER, Poss R, Goldman L, Mangione CM. Patient quality of life during the 12 months following joint replacement surgery. *Arthritis Rheum.* 2004;51:100–109.
- Fortin PR, Clarke AE, Joseph L, Liang MH, Tanzer M, Ferland D, Phillips C, Partridge AJ, Bélisle P, Fossel AH, Mahomed N, Sledge CB, Katz JN. Outcomes of total hip and knee replacement: preoperative functional status predicts outcomes at six months after surgery. *Arthritis Rheum.* 1999;42:1722–1728.
- Gonzalez MH, Mekhail AO. The failed total knee arthroplasty: evaluation and etiology. *J Am Acad Orthop Surg.* 2004;12:436–446.
- Jones CA, Voaklander DC, Johnston DW, Suarez-Almazor ME. The effect of age on pain, function, and quality of life after total hip and knee arthroplasty. *Arch Intern Med.* 2001;161:454–460.
- Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am.* 2007;89:780–785.
- Lingard EA, Katz JN, Wright EA, Sledge CB. Predicting the outcome of total knee arthroplasty. *J Bone Joint Surg Am.* 2004;86:2179–2186.
- March LM, Cross MJ, Lapsley H, Brnabic AJ, Tribe KL, Bachmeier CJ, Courtenay BG, Brooks PM. Outcomes after hip or knee replacement surgery for osteoarthritis: a prospective cohort study comparing patients' quality of life before and after surgery with age-related population norms. *Med J Aust.* 1999;171:235–238.
- Murray DW, Frost SJ. Pain in the assessment of total knee replacement. *J Bone Joint Surg Br.* 1998;80:426–431.
- NIH Consensus Development Conference on Total Knee Replacement. National Institutes of Health Consensus Development Conference Statement December 8–10, 2003. Available at: <http://consensus.nih.gov/2003/2003TotalKneeReplacement117.html.htm>. Accessed 12 July 2008.
- Rand JA, Ilstrup DM. Survivorship analysis of total knee arthroplasty: cumulative rates of survival of 9200 total knee arthroplasties. *J Bone Joint Surg Am.* 1991;73:397–409.
- Rand JA, Trousdale RT, Ilstrup DM, Harmsen WS. Factors affecting the durability of primary total knee prostheses. *J Bone Joint Surg Am.* 2003;85:259–265.
- Ritter MA, Wing JT, Berend ME, Davis KE, Meding JB. The clinical effect of gender on outcome of total knee arthroplasty. *J Arthroplasty.* 2008;23:331–336.
- Roth ML, Tripp DA, Harrison MH, Sullivan M, Carson P. Demographic and psychosocial predictors of acute perioperative pain for total knee arthroplasty. *Pain Res Manag.* 2007;12:185–194.
- Tietjen R. Reflex sympathetic dystrophy of the knee. *Clin Orthop Relat Res.* 1986;209:234–243.