Ethnic and Gender Differences in the Functional Disparities after Primary Total Knee Arthroplasty

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Abstract

Background The benefits of TKA have been well documented. Whether these benefits apply equally across gender and ethnic groups is unclear. Given the underuse of TKA among certain demographic groups, it is important to understand whether gender or ethnicity influence pain and function after TKA.

Questions/purposes We determined (1) the influence of race, gender, and body mass index (BMI) on primary TKA functional scores and ROM before gender-specific implants; and (2) whether comorbidities influenced ROM and functional scores.

Patients and Methods We reviewed all 202 patients who underwent primary TKAs in 2004. We contacted 185 of the

202 patients, including 90 African-Americans, 87 Caucasians, four Asians, and four Hispanics (55 men, 130 women). Their average age was 66 years, and average BMI was 34.4 (range, 20–55). Knee Society scores (KSS) and ROM, patient demographics, and the Charlson Comorbidity Index (CCI) were recorded. Minimum followup was 24 months (average, 29.1 months; range, 24–60.3 months). **Results** African-Americans had longer delays to presentation, higher BMI, and worse 2-year KSS. Women (all races) had higher BMI and worse preoperative flexion/arc ROM. African-American women had worse final ROM and had similar final gains in ROM (postoperative minus preoperative ROM) after controlling for confounders.

Conclusions Gender and race affected functional KSS and ROM variables. The worse results experienced by African-American women may be attributable to a longer delay to presentation. However, the scores and motion were high for all subgroups, and underuse of TKA in women and African-Americans cannot be justified based on a perception of lesser functional gains.

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

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at The University of Pennsylvania.

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Introduction

Knee osteoarthritis (OA) is a leading cause of disability in the United States today, affecting approximately 6% of the adult population [5]. More than 800,000 primary hip and knee arthroplasties are performed annually in the United States [19]. Primary TKA remains an effective and safe treatment for advanced OA of the knee, especially when medical management fails [13, 31].

Despite the efficacy of TKA, there is a documented underuse across gender and ethnicity [5, 7, 21, 24, 25, 34, 35]. Underuse of total joint arthroplasty for minorities is but one part of the total economic cost of health disparities: it is estimated eliminating health disparities for minorities would have reduced direct medical care expenditures by \$229.4 billion for 2003 to 2006 [20]. The economic and societal benefits of improved mobility and decreased disability and dependency after TKA may outweigh the costs of the intervention.

Several studies document disparities in use of TKA among ethnic and gender groups. Dunlop et al. [6] reported a higher prevalence of OA in the African-American (40%) and Hispanic (44%) populations of noninstitutionalized individuals 70 years and older when compared with a non-Hispanic Caucasian (25%) population [6]. However, there is little association between OA disease rates and use of TKA among racial subgroups: disease rates in African-Americans are increasing compared with rates seen in Caucasians, whereas use rates are trending in the opposite direction [15, 24]. Other reports confirm the rates of primary TKA in the African-American and Hispanic populations remain lower than that of a nonHispanic Caucasian population [7, 25]. In 2006, the rate of TKAs in African-Americans was 39% lower than that for Caucasians [19]. A similar trend exists between the genders, with TKA being underused in women almost three times more than men [13].

Several studies suggest differences in function between races after joint arthroplasty [8, 11, 19, 33]. Others have reported differences in the experience of pain by patients and in the management of that pain [8, 33]. Green et al. [11] found chronic pain affects the quality of life and health status of the African-American population to a greater extent than in Caucasians in the United States. In 2009, Lavernia et al. [19] reported the perception of pain and fear of postoperative complications were reflected in a longer wait time for surgery, rather than an actual racial disparity in pain or function. One study showed a disparity in TKA rates for African-American women only after age 65 years [6]. However, not all studies show a negative correlation between gender or ethnicity and relief of pain or functional restoration after TKA: Gandhi et al. [10] found only age, followup time, comorbidity, and mental health as negative prognostic factors; their study was limited by a minimum 1-year followup and greater than 25% missing data. In a time when healthcare disparity remains at the forefront of medical and political arenas, more study is required to understand the extent and causes of barriers and differentials in care. Moreover, relatively little is known regarding the functional scores after arthroplasty in gender and ethnic (eg, African-American, Asian, and Hispanic) subgroups.

Our purposes therefore were to determine (1) the influence of race, gender, and BMI on primary TKA functional

scores and ROM parameters before gender-specific implants; (2) whether comorbidities, such as diabetes, and tobacco use, and the CCI, time to presentation, or history of Workers Compensation claims influence ROM and functional scores.

Patients and Methods

We retrospectively reviewed all 202 patients who underwent primary TKA in 2004. Of the 202 patients who underwent surgery during this 12-month period, 57 underwent bilateral primary TKAs. We excluded 17 patients with a followup less than 2 years, age younger than 18 years, or those lost to followup phone interviews. The exclusions left 185 patients remaining in the study, including 47 who had bilateral procedures. These patients were contacted and seen by us and had functional assessments at a minimum of 2 years postoperatively. There were 130 women and 55 men. There were 90 African-Americans, 87 Caucasians, four Asians, and four Hispanics (Table 1). For statistical purposes, patients were grouped into two categories: African-American and nonAfrican-American. With continuous or semicontinuous primary outcome variables with gender and race as covariates, our power calculation was based on the one-way ANOVA. To achieve a standardized medium-sized difference $f = (0.25)$ with a Type I error rate of 0.05 and a power of 0.80, 52 patients would be needed per group. The mean age of the patients was 66 years (range, 31.8–93.1 years). The minimum followup was 24 months (average, 29.1 months; range, 24–60.3 months). No patients were lost by the 2-year clinical followup. The study was approved by the institutional review board.

The average BMI was 34.0 (confidence interval, 32.9, 35.1) (Table 2). Women had a higher average BMI at 35.2 (33.8, 36.6) compared with men at 31.0 (29.4, 32.6).

Table 1. Patient demographics

Variable	Value
Total number of patients	185
Gender (number of patients)	
Male	55 (30%)
Female	130 (70%)
Ethnicity (number of patients)	
African-American	90 (49%)
Caucasian	87 (47%)
Asian	4 (2%)
Hispanic	4 (2%)
Age (years)*	66.1 (32–93)
Followup (months)*	29.1 (24–60)

* Values are expressed as means, with range in parentheses.

African-Americans had a higher average BMI (35.7 [34.2, 37.2]) compared with Caucasians and other races (32.4 [35.6, 38.8]). African-American women had the highest average BMI of 36.7 (35.1, 38.5), compared with 31.7 (28.9, 34.5) in African-American men, 33.4 (31.2, 35.6) in other women, and 30.4 (28.6, 32.4) in other men. Overall, African-American women had a higher BMI of 36.7 (35.1, 38.5) at the time of surgery when compared with all others. African-Americans (male/female) had a longer delay to presentation than other groups (Table 3). The average baseline preoperative arc ROM was similar between African-Americans and nonAfrican-Americans (96.7° versus 99°, respectively). Likewise, age at the time of surgery was not different (65.5 versus 66.7 years). Baseline preoperative arc ROM was similar between women (97.6°) and men (98.7°), and there was no preoperative difference in age at surgery (66 versus 66.2 years).

All surgeries were performed by one of two fellowship-trained adult reconstruction surgeons (CLN, CLI). A standard medial parapatellar approach was used for all patients. The Zimmer NexGen® TKA prosthesis (Zimmer Inc, Warsaw, IN, USA) was implanted in all patients. Continuous passive motion machines were used postoperatively beginning in the recovery room.

All patients received standardized physical therapy protocols while in the hospital. All patients were weight-bearing as tolerated with physical therapy on Postoperative Day 1, and ROM and mobility were advanced as tolerated. Assistive devices were used at the discretion of the

physical therapists for safety and gait training. All patients received a physical therapy session each day, lasting approximately 30 minutes per session. Patients were encouraged to continue using the continuous passive motion machine while not working with therapy, for cycles of 2 hours of use followed by 1 to 2 hours of rest. The majority of patients were discharged to home or a rehabilitation facility by Postoperative Day 3 based on the evaluation of the physical therapist, social worker, and orthopaedic physician.

Preoperative function and postoperative variables were quantitatively measured. All patients were followed clinically and radiographically beyond 24 months after index surgery. Patients were seen in the clinic within 10–14 days from the time of surgery for removal of staples, wound check, radiographic assessment, and measurements of functional status and knee ROM. Knee ROM data included extension, flexion, and total knee arc ROM (knee flexion minus knee extension). Patients were seen routinely at 3-, 6-, 12-, and 24-months for clinical and radiographic evaluations. Two of the treating surgeons (CLN, CLI) and a dedicated adult reconstruction research assistant (KM) made these measurements at the preoperative visit and at 12- and 24-month followups using a standard goniometer. Knee motion gain was measured by subtracting knee arc measured preoperatively from the knee arc measured at the 12 and 24 month followups, respectively. For morbidly obese patients, the measured arcs of motion were based on fixed bony landmarks palpated along the shaft of the femur and tibia. KSSs [21] were collected at the three times of measurement. We did not study the effect of bilaterality on ROM or KSS.

Patient data included ethnicity (African-American, Caucasian, Asian, or Hispanic), gender, age, and duration of symptoms before presentation to the orthopaedic surgeon. Discharge disposition (home, rehabilitation facility, or skilled nursing facility), etiology of arthritis (OA, rheumatoid arthritis, posttraumatic), prior orthopaedic surgeries, substance abuse history, venous thromboembolism prophylaxis regimen, and Workers Compensation status were recorded. Additional demographic data collected for the

Table 2. Preoperative body mass index values

Patients	Preoperative body mass index
All patients	34.0 (32.9, 35.1)
Women	35.2 (33.8, 36.6)*
Men	31.0 (29.4, 32.6)
African-Americans	35.7 (34.2, 37.2)†
NonAfrican-Americans	32.4 (35.6, 38.8)

Values are expressed as means, with confidence intervals in parentheses; * significantly different when compared with men; † significantly different when compared with nonAfrican-Americans.

Table 3. Preoperative data and postoperative outcomes combining ethnicity and gender

Variable	African-American men	African-American women	Other men	Other women	p Value
Age (years)	66.0 (61.8, 70.2)	65.4 (63.1, 67.7)	66.4 (61.0, 69.8)	66.8 (64.2, 69.4)	0.879
Preoperative BMI	31.7 (28.9, 34.5)	36.7 (35.1, 38.5)	30.4 (28.6, 32.4)	33.4 (31.2, 35.6)	0.001*
Delay to presentation (months)	29.9 (17.2, 42.6)	36.7 (24.9, 48.5)	20.0 (4.4, 35.6)	15.3 (11.7, 18.9)	0.105
Flexion (°) at > 2 years postoperatively	118.6 (115.6, 121.6)	113.9 (111.2, 116.6)	120.8 (118.8, 122.8)	116.7 (114.4, 119.0)	0.030
KSS at > 2 years postoperatively	89.6 (85.0, 94.2)	86.8 (84.3, 89.1)	94.1 (91.2, 97.0)	92.9 (90.5, 95.3)	0.004*

Values are expressed as means, with confidence intervals in parentheses; BMI = body mass index; KSS = Knee Society score; * equals significant after Bonferroni adjustment for multiple tests with threshold 0.01.

patients included BMI, CCI, diabetes status, and tobacco use. Any complications, such as infection or need for revision surgery, also were recorded.

Demographics were analyzed descriptively. A stepwise, backward, automatic linear regression analysis was performed to identify independent predictors of function based on primary research importance of ethnicity and gender. We started with a saturated model, then removed any variable at each step with an alpha less than 0.10 starting with the least significant. The least significant variable at each step was removed, and the model rechecked. Inclusion threshold for alpha in the final model was less than 0.05. All statistics were calculated with SPSS® Version 15.0 (SPSS Inc, Chicago, IL, USA).

Results

ROM and KSS were influenced by gender and ethnicity. Women had worse ROM at 2 years postoperatively, including lower average flexion and arc ROM (Table 4). Of all groups, African-American women exhibited decreased average flexion and arc of ROM (Table 3). African-American women had a lower average KSS compared with African-American men, other women, and other men (Table 3). African-American female status was the only risk factor associated with lower ($p = 0.002$) functional knee scores at 2 years. With respect to race alone, African-Americans experienced a difference in 2-year KSSs when compared with other races: African-Americans had a lower ($p = 0.001$) average 2-year KSS (86.8 [84.3, 89.1]) compared with scores other races (92.7 [90.7, 94.8]).

Table 4. Postoperative flexion

Patients	Average arc (°) at > 2 years postoperatively
All women	115.3 (113.3, 117.3)
All men	120.1 (118.4, 121.8)

Values are expressed as means, with confidence intervals in parentheses; * significantly different ($p = 0.001$) when compared with men.

After controlling for other factors, such as age, BMI, CCI, Workers Compensation, and diabetes, African-American women did worse than other groups in terms of final ROM (beta value -4.7 [-8.2 , -1.1]). African-American women had no difference in final gain ROM (postoperative minus preoperative ROM) after controlling for confounders. Comorbidities (eg, diabetes, CCI, tobacco use), time to presentation, and Workers Compensation status did not influence the primary outcome variables (KSS, ROM) (Table 5).

Complications in the study patients included two infections requiring incision and drainage and polyethylene exchange (one African-American woman, one nonAfrican-American man); one patient (nonAfrican-American man) required revision surgery for mechanical loosening. Three patients (one African-American woman, two nonAfrican-American men) died during the followup period of causes not directly related to the index TKA. Seventeen patients were discharged to home; 148 went to acute rehabilitation or skilled nursing facilities.

Discussion

There is documented underuse of TKA in African-Americans and Hispanics despite an equal or greater prevalence of osteoarthritis in these populations. In addition, although use of TKA is slightly greater in women than men, given the prevalence of OA in women, there is underuse of TKA in female patients as well. Moreover, orthopaedic surgeons may be more likely to recommend TKA for men than women with moderate OA. Given the variability in the use of TKA, our primary question was to determine the influence of race and gender on pain relief and function. Secondary questions included the influence of comorbidities, time to presentation, and Workers Compensation claims on the same variables.

There are study limitations. First, this retrospective analysis may involve selection and recall bias and lack of standardized measurement points that may compromise

Table 5. Effects of comorbidity, time to presentation, and Workers Compensation variables on outcome scores

Variable	p Value for KSS	p Value for final flexion	p Value for final arc of ROM
Diabetes*	0.471	0.758	0.781
Body mass index†	0.190 ($R = -0.128$)	0.168 ($R = -0.123$)	0.131 ($R = -0.136$)
Tobacco use*	0.823	0.558	0.584
Charlson Comorbidity Index‡	0.945	0.962	0.968
Time to presentation†	0.060 ($R = -0.293$)	0.374 ($R = -0.128$)	0.374 ($R = -0.128$)
Workers Compensation*	0.928	0.786	0.783

* Mann-Whitney U test; †Spearman correlation; ‡Kruskal-Wallis.

study quality. Second, the population is not necessarily generalizable: subjects represent a Northeastern United States inner-city and suburban cohort, which may present different rates of obesity, barriers to care, and knowledge of TKA [25, 30, 31]. Third, there may be inherent physician- and systems-based biases regarding care for specific gender and racial groups, which has been seen in other medical fields [22, 29]. Although this is a relatively large sample, more conclusive data, including further demographic subgroup analysis, can be drawn from larger studies. Fourth, we can make no comments regarding the debate regarding anatomic gender differences [2, 9] or the role of gender-specific implants [18, 23, 27].

We found women had higher BMI at surgery; the magnitude of effect is unclear. Winiarsky et al. [36] reported lower KSSs for morbidly obese (BMI > 40) patients, but no difference in ROM or radiographic parameters, when compared with historical, nonmorbidly obese control subjects. The effect of BMI on TKA survivorship is unclear. Women may have a greater propensity toward obesity, and obesity in African-American females (38%) is more prevalent than for Caucasian females (26%) [6]. This contrasts a study that observed no difference between genders in OA prevalence [4]. The true prevalence across gender may relate to differential geographic rates of obesity. TKA use is lower in African-American men than nonHispanic Caucasian men in nearly every United States hospital region [30]. Obesity, coupled with higher genetic risk for having OA develop [26], may explain why women had worse 2-year flexion. Obesity creates soft tissue impingement of the knee, limiting flexion arc directly related to limb girth. As ROM is a large component of the KSS, the obese may be disadvantaged. Higher obesity and arthritis rates in women older than 65 years—above all other chronic conditions—may account for a higher disability rate. Borrero et al. [4] reported women have worse pain and function at the time of joint arthroplasty and worse pain and function postoperatively. Although the estimated need for arthroplasty was more than twice as great in women because of higher arthritis prevalence [13], this has not translated into increased use of TKA. After stratification for ethnicity in this study, African-Americans had higher BMI and worse 2-year KSSs. Allen et al. [1] found African-Americans with knee OA had higher pain and lower functional subscale scores compared with Caucasians when controlling for age, gender, and education; when controlling for BMI, they observed no differences. They posited measures to reduce BMI may reduce disparities [1]. Postoperative rehabilitation may play into ROM postoperatively. Only 30.8% of African-American women had someone at home to care for them after surgery compared with 50% of African-American men and 75% of Caucasians [5].

Longer delay to presentation for African-Americans may partly explain worse KSSs postoperatively. Santaguida et al. [28] found women had worse function than men after THA, perhaps owing to more advanced disease at the time of presentation. Focus groups highlight men were more likely to choose surgery earlier and had higher expectations for success after total joint arthroplasty, whereas women were more fearful of surgery [17]. Halbert et al. [12] reported African-Americans were more likely than Caucasians to use acute-care facilities, rather than primary care, to access health care. Of the African-Americans who did not report a physician's office as their main source of care, there was a reported lower sense of trust [12]. Caucasians are more likely to know someone who underwent total joint arthroplasty [14] or know someone with a good outcome after arthroplasty [5] than African-Americans. In the Hispanic community, low arthroplasty rates may translate to less opportunity for knowing someone who has had an arthroplasty [7]. Joshy et al. [16] found similar lower preoperative KSSs when comparing Asians with Caucasians. Chang et al. [5] theorized that as Caucasian men ask the most questions during examinations, most medical literature available to patients address concerns of Caucasian males. In the sphere of heart care, Schulman et al. [29] observed the patient's race and gender strongly influenced physicians' recommendations in those with active chest pain. This was most striking for African-American women, who were less likely to be referred for cardiac catheterization than Caucasian men [29]. In a simulated study [3], orthopaedic physicians also have been implicated in preferentially advising TKA to men. Likewise, disparate rates of complications may confound outcomes across demographics: SooHoo et al. [32] reported an association between African-Americans and thromboembolic complications and Hispanics and infectious complications. The low complication rate seen in our TKA cohort is not comparable with that in a recent systematic review suggesting older men are at increased risk of revision and mortality after arthroplasty [28]. When controlling for comorbidities or Workers Compensation status, we found African-American women experienced worse overall final ROM, but there was no difference in final gain of ROM. This suggests, although African-American women may make similar gains in ROM, they start at a lower preoperative baseline and reach a lower postoperative level. Nevertheless, all demographic groups showed improvements, and these results should not be misconstrued to justify decreased use of TKA in African-American women or other subgroup. Our qualitative satisfaction scoring showed universal satisfaction across all subgroups.

In this study, gender and race affected functional scores after TKA. Worse results experienced by African-American

women may be attributable to a longer delay to presentation. Documented underuse of TKA for African-Americans and surgeons' propensity to recommend arthroplasty at a greater rate for men should be explored further.

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