Comparative Demographics, ROM, and Function After TKA in Chinese, Malays, and Indians

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Abstract

Background There is marked racial disparity in TKA use rates, demographics, and outcomes between white and Afro-Caribbean Americans. Comparative studies of ethnicity in patients undergoing TKAs have been mostly in American populations with an underrepresentation of Asian groups. It is unclear whether these disparities exist in Chinese, Malays, and Indians.

Questions/purposes We therefore determined whether (1) TKA use; (2) demographics and preoperative statuses; and (3) functional outcomes at 2 years after TKA differed among three ethnic groups, namely, Chinese, Malays, and Indians who underwent TKA.

Methods From our hospital joint registry we identified 5332 patients who had a primary TKA from 2004 to 2009. The cohort was stratified by race and subsequently compared for demographics, preoperative knee ROM, and deformity. At the second postoperative year we determined

Knee Society scores, Oxford knee scores, and obtained SF-36 health questionnaires.

Results Six percent more Chinese patients underwent TKAs compared with Malays or Indians. Malays were operated on at a younger age with a higher body mass index. Chinese patients had more severe preoperative varus deformity. There were no major differences in joint ROM in all races. For Knee Society, Oxford knee, and SF-36 scores, Chinese patients had consistently higher preoperative and postoperative scores. Malays presented with the lowest preoperative scores but had the greatest improvement in scores at followup with postoperative scores similar to Chinese counterparts. Indians had the lowest postoperative scores and worst improvement of all.

Conclusions The variations in demographics, preoperative statuses, and subsequent postoperative outcomes between the races should be considered when comparing TKA outcome studies in Asian populations.

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

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Introduction

Knee osteoarthritis is common worldwide in the elderly with attendant disability sufficient enough to impact society socioeconomically [2, 31]. TKA is a proven procedure that enables disabled patients to return to meaningful functional activity. Second only to cataract surgery, it reportedly provides the greatest improvement in health-related quality of life [20]. In the United States, there is persistent inequality in the provision of hip and knee arthroplasty procedures to the minority races [22]. Afro-Caribbean Americans, especially females, have lower functional and health-related quality-of-life outcomes

compared with Hispanic and white populations for hip and knee arthroplasty [12, 15, 18]. Much research has been focused on elucidating the causes for this disparity, which include biological factors like a higher body mass index (BMI) [9], more severe osteoarthritis at presentation, and sociocultural factors such as a greater distrust of the health establishment [3], a later initial presentation [10], an innate fear of surgery [19], and an inherent healthcare provider selection bias to the various races [22].

There is also some evidence that disparities occur in Asian populations. Joshy et al. [14] showed that Asian patients of Indian and Pakistani origin had lower preoperative Knee Society function scores compared with their white contemporaries in Birmingham, UK. This was attributed to differing cultural beliefs and social support. When studying patients of South Asian or East Asian ethnicity in Toronto, Canada, Gandhi et al. [9] found Asian patients presented for surgery at a younger age and lower mean BMI with greater pain and dysfunction than their white counterparts. However, it is unclear whether function after TKA differs among the various Asian races. Singapore is an equatorial island nation state with a multiracial community of Chinese, Malays, and Indians with similar access to health care within the same dense urban environment and receiving similar standards of care. Therefore, it is an appropriate location for studying racial differences.

We therefore determined whether (1) TKA use; (2) demographics and preoperative statuses; and (3) functional outcomes at 2 years after TKA differed among three ethnic groups, namely, Chinese, Malays, and Indians who underwent TKA at the Singapore General Hospital (SGH).

Patients and Methods

A retrospective observational demographic study was conducted in SGH, which is a high-volume tertiary referral center for adult joint reconstruction with over 60% of all knee arthroplasties performed nationwide within this single institution alone from 2005 to 2008 [21]. Since 2004, SGH has maintained a prospective joint registry for knee arthroplasties. Of the 7403 patients added to the database from January 2004 to May 2009, we excluded 2071 patients (28%) for the following reasons: (1) 1048 patients were excluded because they did not undergo a primary TKA (ie, unicompartmental, bicompartamental, and revision TKAs); (2) 921 patients (12% of total recruited) failed to attend both sixth-month and second-year postoperative assessments; and (3) 102 patients were from other races or of mixed parentage. Another 459 patients were assessed at the sixth-month postoperative interval but subsequently failed their second-year followup; however, this latter group was still included in the study by using their sixth-month

Table 1. Population composition and representation

Representation	Chinese	Malay	Indian	Other races
Study subjects	4713	304	315	87
Census in 2000 [6]	550,400	68,656	49,015	9443
Census in 2010 [7]	878,000	115,000	70,600	18,500
Study ratio	86.9%	5.6%	5.8%	1.6%
Average census ratio	81.2%	10.4%	6.8%	1.6%
Over (+)/under (–)	+5.7%	–4.8%	–1.0%	0.0%

assessment data for analysis. These 2071 exclusions left 5332 patients who had demographic data with both preoperative and postoperative scoring data eligible for analysis. The study cohort was composed of 4713 Chinese, 304 Malays, and 315 Indians (Table 1). The mean age was 67 years with 20%, 44%, and 36% of patients undergoing a knee arthroplasty younger than 60 years, between 60 and 70 years, and older than 70 years of age, respectively. No patients were recalled specifically for this study; all data were prospectively entered into the registry database as part of routine assessment for all patients undergoing knee arthroplasty procedures. Ethical approval was obtained from the local institutional review board.

Demographic details, which included age, sex, and race assignment, were sourced from a centralized government database. Physiotherapists specially trained in outcomes scoring independently assessed patients preoperatively for height, weight, joint ROM, and varus/valgus deformity. Patients were then assessed preoperatively and subsequently at the sixth-month and second-year postoperative intervals for functional outcomes and health-related quality-of-life scores. These included the Knee Society score (with both knee and functional subsets) [13], the Oxford knee score [6], and the SF-36 health questionnaire [28].

Relative TKA use rates among ethnic groups in our study were compared with the average general population by using published population censuses for individuals aged 50 years and older. We determined differences in demographics and knee ROM/deformity data between racial groups using one-tailed analysis of variance (ANOVA). When $p < 0.05$, we performed pairwise comparisons among racial groups using post hoc analysis with Bonferroni Holms correction. These mentioned variables were later controlled for in subsequent analyses. Any differences among the races for the various outcome scores, both preoperatively and postoperatively, were ascertained using multivariate analysis of covariance (MANCOVA) after controlling for age, sex, height, weight, knee ROM, and knee varus/valgus deformity covariates. Levene's test and Box's test ($p > 0.001$) were used to assess the homogeneity assumption within groups required for ANOVA and MANCOVA testing, respectively. All statistical analysis was performed using SPSS Version 20 (IBM Corporation, Armonk, NY, USA).

Results

Demographic features and preoperative statuses differed among three ethnic groups. Compared with published population statistics for the general population aged 50 years old and older [7, 8], there was a 5.7% overrepresentation of Chinese and 4.8% underrepresentation of Malays who underwent TKAs (Table 1).

Malay patients had surgery at a younger age (63 years) compared with their Chinese counterparts (68 years) with a mean age difference ($p < 0.001$) of 5 years (Table 2). Females predominated with an overall sex ratio of 82:18 females:males. Indians had a sex ratio of 75:25 females:males, which became progressively skewed in Malay (78:22 females:males) and Chinese racial groups (81:19 females:males). Chinese patients presented with the lightest ($p < 0.001$) mean weight of 64.9 kg compared with Malays (73.6 kg) and Indians (72.8 kg). Malays had the highest ($p = 0.001$) overall BMI of all groups (31.5 kg/m²). We found no differences ($p = 0.621$) for flexion and extension among the ethnic races preoperatively. The majority had genu varum preoperatively (76% of cohort) with a mean 5° varus (Table 3). Only 22% of the cohort had valgus deformity. Chinese patients presented with more genu varum compared with Malays and Indians ($p = 0.025$). When

stratified by severity (ie, varus/valgus $\geq 15^\circ$), Chinese patients presented with more severe genu vara (9.3% within the Chinese group) compared with their racial peers (8.9% and 8.6% in Malays and Indians, respectively; $p = 0.021$). There were no appreciable differences ($p = 0.093$) in genu valgus severity among the races.

Function 2 years after TKA differed among ethnic groups not only in levels, but also in change amount. Chinese patients had consistently higher preoperative Knee Society knee scores ($p < 0.001$), higher Knee Society function scores ($p = 0.007$), and lower Oxford Knee scores ($p < 0.001$) than their Indian and Malay counterparts. This trend is similarly reflected in the SF-36 health questionnaire with consistently higher scores for physical function, physical role, and bodily pain subscales for the Chinese group compared with other races ($p < 0.001$) (Table 4). No differences were noted in pairwise comparisons between Malay and Indian groups for most preoperative outcome scores likely from lower patient numbers recruited in these groups ($n < 320$ for both groups; $p = 0.517$ to $p = 1.000$). The only exception was in Knee Society function scores in which Malays had worse scores ($p < 0.001$) than Indians. Postoperatively, Indians consistently had the poorest scores ($p < 0.001$ to $p = 0.073$) compared with Chinese and Malays. Exceptions were in the Knee Society function

Table 2. Demographics of patients undergoing TKA

Demographic	Chinese	Malay	Indian	Analysis of variance (p value)	Chinese versus Malays (p value)	Chinese versus Indians (p value)	Malays versus Indians (p value)
Age (years)	67.5 (7.4)	62.8 (7.9)	65.1 (8.1)	< 0.001	< 0.001	< 0.001	< 0.001
Side (left:right)	53:47	49:51	47:53	0.067	0.462	0.163	1.000
Sex (female:male)	82:18	78:22	75:25	0.001	0.244	0.003	0.837
Weight (kg)	64.9 (11.6)	73.7 (13.5)	72.8 (14.2)	< 0.001	< 0.001	< 0.001	1.000
Height (cm)	153.6 (7.4)	153 (8.1)	155.2 (9.0)	< 0.001	0.449	0.001	0.001
Body mass index (kg/m ²)	27.5 (4.3)	31.5 (5.1)	30.2 (5.4)	< 0.001	< 0.001	< 0.001	0.001

Numbers in parentheses are SD.

Table 3. Preoperative knee ROM and deformity

Parameter	Chinese	Malay	Indian	Analysis of variance (p value)	Chinese versus Malays (p value)	Chinese versus Indians (p value)	Malays versus Indians (p value)
Preoperative ROM							
Extension (°)	6.9	7.4	4.8	< 0.001	0.846	< 0.001	0.001
Flexion (°)	116.1	115.9	114.8	0.449	1.000	0.621	1.000
Alignment (°)	5.2	4.1	3.9	0.004	0.082	0.023	1.000
Preoperative varus/valgus deformity							
Valgus ($\geq 15^\circ$)	179 (3.8%)	12 (3.9%)	11 (3.5%)				
Valgus ($< 14^\circ$)	823 (17.5%)	71 (23.4%)	70 (22.2%)				
Neutral (0°)	64 (1.4%)	7 (2.3%)	15 (4.8%)				
Varus ($< 14^\circ$)	3146 (66.8%)	182 (59.9%)	189 (60%)				
Varus ($\geq 15^\circ$)	501 (10.6%)	32 (10.5%)	30 (9.5%)				

Table 4. Postoperative ROM and Preoperative and postoperative functional/outcome scores

Parameter	Chinese	Malay	Indian	MANCOVA (p)	Chinese versus Malays (p value)	Chinese versus Indians (p value)	Malays versus Indians (p value)
Postoperative ROM							
Extension (°)	1.9	1.3	0.7	0.001	0.333	0.002	0.634
Flexion (°)	116.2	117	117.6	0.209	1.000	0.345	1.000
Alignment (°)	−5.1	−5.5	−5.3	0.008	0.017	0.306	1.000
Knee Society knee score							
Preoperative	38.3 (19.0)	33.1 (19.8)	34.9 (18.9)	< 0.001	< 0.001	< 0.001	1.000
Postoperative	84.6 (10.8)	85.2 (10.6)	82.7 (13.5)	0.002	1.000	0.002	0.012
Change, Δ	46.3	52.1	47.8	< 0.001	< 0.001	0.033	0.470
Knee Society functional score							
Preoperative	51.0 (18.4)	43.3 (19.7)	49.0 (19.1)	< 0.001	< 0.001	0.007	< 0.001
Postoperative	70.6 (20.0)	67.6 (17.5)	67.3 (19.3)	< 0.001	< 0.001	< 0.001	1.000
Change, Δ	19.6	24.4	18.3	0.003	0.005	0.970	0.006
Oxford knee score							
Preoperative	35.3 (19.0)	40.1 (21.8)	38.3 (22.4)	< 0.001	< 0.001	< 0.001	0.517
Postoperative	18.8 (5.8)	19.2 (4.9)	20.2 (6.5)	< 0.001	0.249	< 0.001	0.167
Change, Δ	16.4	20.3	18.1	< 0.001	< 0.001	0.001	0.031
SF-36 physical function							
Preoperative	36.9 (22.4)	29.5 (21.8)	32.7 (22.4)	< 0.001	< 0.001	< 0.001	0.902
Postoperative	65.5 (21.7)	62.6 (21.1)	60.8 (22.4)	< 0.001	0.001	< 0.001	1.000
Change, Δ	28.7	33.2	29	0.050	0.043	1.000	0.327
SF-36 role physical							
Preoperative	28.2 (40.5)	16.9 (33.6)	20.7 (37.1)	< 0.001	< 0.001	< 0.008	1.000
Postoperative	74.4 (39.8)	74.7 (38.6)	65.5 (42.4)	0.001	1.000	< 0.001	0.027
Change, Δ	46.2	57.6	44.7	0.004	0.004	1.000	0.011
SF-36 bodily pain							
Preoperative	37.7 (19.2)	30.4 (19.2)	30.9 (18.9)	< 0.001	< 0.001	< 0.001	1.000
Postoperative	70.4 (24.9)	66.0 (26.3)	61.3 (25.2)	< 0.001	0.081	< 0.001	0.027
Change, Δ	32.7	35.7	30.3	0.096	0.239	0.815	0.101

Numbers in parentheses represent one standard deviation; MANCOVA = multivariate analysis of covariance.

score and SF-36 physical function subscale in which no differences ($p = 1.000$) could be found in pairwise comparison between Malay and Indian groups. Malays showed the greatest improvement ($p < 0.001$) from preoperative to second-year postoperative scores for Knee Society functional score, Oxford knee score, and the SF-36 physical role subscale score compared with the other groups. Indeed, for Knee Society knee score and other SF-36 physical subscales, Malays, who had the poorest preoperative scores, had marked improvement to such extent that there were no comparable postoperative differences with their Chinese counterparts (Table 4).

Discussion

Studies investigating racial disparity in TKA use rates between races reveal marked differences in demographics

and outcomes between Afro-Caribbean and white Americans in the United States. However, comparative studies of ethnicity in patients undergoing TKAs have been mostly in American populations with an underrepresentation of Asian ethnic groups. Only a few studies have compared Asian with white populations and none so far has compared major Asian racial groups. Singapore is an island nation with a multiracial community of Chinese, Malays, and Indians with similar access to health care within the same dense urban environment and receiving similar standards of care. We determined whether (1) TKA use; (2) demographics and preoperative statuses; and (3) functional outcomes at 2 years after TKA differed among three ethnic groups, namely, Chinese, Malays, and Indians who underwent TKA at SGH.

Despite the size of our study, we note the following limitations. First, our study was conducted in a single center with the potential for misrepresentation of the general population in Singapore. This is unlikely because more than 60% of all

knee arthroplasties performed in both public and private institutions in Singapore were performed in this high-volume tertiary referral center alone during the study period [21]. Second, there is heterogeneity in service provision with TKAs being performed by different surgeons who might use different clinical indications, surgical approaches, implant designs, makes, and instrumentation types. Third, although the Oxford knee score and SF-36 score systems have been localized for the Chinese population in Singapore [17, 30], these scoring systems have yet to be adapted to the Malay language. The use of the Malay language without the use or validation of localized language-specific pro forma can introduce systemic errors in the form of reporting and observer bias either through language translation or cultural interpretation errors. Finally, because all preoperative parameters were measured only after patients had already decided for surgery to account and control for these variables in subsequent functional outcome assessment, we were

unable to assess the effect of these parameters in decision-making for knee arthroplasty.

We found minor racial disparity with Chinese 5.8% more likely and Malays 4.7% less likely to undergo knee arthroplasty when compared with the general population racial mix in Singapore. One possible cause for this is financial concerns/constraints [4]. Singapore practices a hybrid welfare system, which, although not providing universal health care for all, provides equitable access to health care by providing healthcare subsidies to those eligible after household means testing. All patients were treated in similar wards with similar levels of care, implant use, postoperative management, and physiotherapy protocols in our institution. The major financial constraint would be in implant hardware costs, which is partially subsidized. Means tested subsidized care might have offset financial concerns in the local races compared with what is experienced by Afro-Caribbean Americans in the United States.

Table 5. Comparison of demographics and outcome scores with other studies

Race	Study population	Followup (years)	Age (years)	Sex (female:male)	Body mass index (kg/m ²)	Preoperative KSS	Preoperative KSF	Postoperative KSS	Postoperative KSF	Preoperative SF-36 physical function
Joshy et al. [14]										
Indian	63	NA	64.4	62:28	NA	37.6	32.5	–	–	–
White	63	NA	64.7	62:28	NA	41.5	45	–	–	–
Gandhi et al. [9]										
White	1876	NA	70.5	57:43	30.1	–	–	–	–	–
Indian	107	NA	66.9	79:21	28.7	–	–	–	–	–
Lavernia et al.* [18]										
White NH	176	> 2	67.4	64:36	NA	–	–	88	–	21.1
White H	731	> 2	69.7	78:22	NA	–	–	91.9	–	13.8
AA NH	74	4.3	62.5	80:20	NA	–	–	–	–	12.7
AA H	29	4.6	64.5	100:0	NA	–	–	82.5	–	11.4
Kamath et al. [15]										
AA	90	> 2	65.6		35.7	–	–	87.1	–	–
White + others	95	> 2	66.7	69:31	32.4	–	–	93.4	–	–
Allen et al. [1]										
White	324	NA	66.2	61:39	32.1	–	–	–	–	–
AA	216	NA	64.0	72:28	35.6	–	–	–	–	–
Kim et al. [16]										
Korean	47,961	NA	71.2	91:9	26.7	–	–	–	–	–
Current study										
Chinese	4713	2	67.5	82:18	27.5	38.3	51	84.6	70.6	–
Malay	304	2	62.8	78:22	31.5	33.1	43.3	85.2	67.6	–
Indian	315	2	65.1	75:25	30.2	34.9	49	82.7	67.3	–

* NH = non-Hispanic; H = Hispanic; AA = African American; KSS = Knee Society knee score; KSF = Knee Society function score; NA = not available.

We also found that Malays underwent knee arthroplasties 5 years earlier than Chinese. The higher BMI observed in Malays compared with other races will naturally predispose this group to experience more severe knee osteoarthritis by exposure to increased joint load forces. This BMI-young age-severe osteoarthritis relationship has been observed in other studies [9]. In contrast, Chinese patients might present at a later age as a result of a higher innate fear of surgery, a lack of social-home support (compared with the larger multigenerational nuclear families in Malays), and/or work commitments because the retirement age in Singapore is 65 years, which corresponded to the Chinese median operative age of 68 years in this study. Features such as age are remarkably similar in studies reporting demographic differences in populations of TKA, but others such as female:male ratios have varied considerably (Table 5). Qualitatively, the mean age for Chinese, Malays, and Indians was similar to other centers within the 60- to 70-year age bracket with the sole outlier being in a Korean joint registry study by Kim et al., which showed an above 70-year mean age of TKA [16]. BMI for most races in American studies was higher than Chinese, Malays, or Indians in our study, although Chinese patients were similar in BMI to Korean patients [16]. Although there were no clinically important differences in preoperative knee ROM among the races, Chinese patients tend to present with a greater severity of genu varus deformity than other Asian racial groups. Anthropometric studies suggest that Chinese and Japanese have smaller knee sizes, greater physiological genu varum [33], greater inclined tibial plateaus [32], different femoral and tibial aspect ratios [5, 11, 27], and greater femoral mechanical axis offsets [25, 26] compared with white patients. A greater physiological genu varum will likely predispose these groups to differential joint loading with expected greater medial compartment and medial patellofemoral compartment osteoarthritis. Although genu varum is more prevalent in Asian races, our study suggests it is most marked in Asian races. More work is needed to further define and assess this deformity radiographically between the Asian races.

When confounders like age, sex, and preoperative knee ROM and deformity were controlled for, we found Chinese patients had consistently better preoperative and postoperative Knee Society scores (knee score and function score), Oxford knee scores, and SF-36 physical subscale scores than Malays or Indians. Surprisingly, although preoperative scores reportedly best predict postoperative function and outcome scores [23], Malay patients who presented with the poorest preoperative scores had the greatest improvement in outcome scores at second-year followup to such extent that postoperative scores in Malays were comparable to those of Chinese. Indians had intermediate preoperative scores but the poorest postoperative scores throughout. These findings are likely

multifactorial in origin with biological, cultural, and socio-logical causes. Lower perceived pain thresholds and different cultural expressions of pain might explain the poorer functional outcome score improvements in Indian patients compared with the other races [24, 29]. Kneeling, which is of vital importance in Malays as a result of their inherent religious commitments, could explain the high physical function scores postoperatively because their perception of well-being and functional outcome could be colored by their renewed ability to kneel postoperatively. This is in contrast to Chinese or Indians who might not see kneeling as an important activity in comparison to squatting, which is technically difficult to achieve with current implant designs.

In conclusion, there are distinct variations in demographic and preoperative statuses among Chinese, Malays, and Indians undergoing primary TKAs and, even when controlled for, there are still notable differences in preoperative and second-year postoperative outcomes among the races. This has implications with regard to the interpretation of published outcomes of knee arthroplasty in Asian populations in preexisting studies and future studies. Further study is needed in ascertaining the causes of these differences in outcomes between the races.

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References

1. Allen K, Helmick C, Schwartz T, DeVellis R, Renner J, Jordan J. Racial differences in self-reported pain and function among individuals with radiographic hip and knee osteoarthritis: the Johnston County Osteoarthritis Project. *Osteoarthritis Cartilage*. 2009;17:1132–1136.
2. Bitton R. The economic burden of osteoarthritis. *Am J Manag Care*. 2009;15:S230–S235.
3. Byrne M, Soucek J, Richardson M, Suarez-Almazor M. Racial/ethnic differences in preferences for total knee replacement surgery. *J Clin Epidemiol*. 2006;59:1078–1086.
4. Chang H, Mehta P, Rosenberg A, Scrimshaw S. Concerns of patients actively contemplating total knee replacement: differences by race and gender. *Arthritis Rheum*. 2004;51:117–123.
5. Chin P, Tey T, Ibrahim M, Chia S, Yeo S, Lo N. Intraoperative morphometric study of gender differences in Asian femurs. *J Arthroplasty*. 2011;26:984–988.
6. Dawson J, Fitzpatrick R, Murray D, Carr A. Questionnaire on the perceptions of patients about total knee replacement. *J Bone Joint Surg Br*. 1998;80:63–69.
7. Department of Statistics Singapore. *Singapore Census of Population 2000: Statistical Release 1: Demographic Characteristics*. Singapore: Department of Statistics; 2001.
8. Department of Statistics Singapore. *Singapore Census of Population 2010: Statistical Release 1: Demographic Characteristics, Education, Language and Religion*. Singapore: Department of Statistics, Singapore; 2011.
9. Gandhi R, Razak F, Mahomed N. Ethnic differences in the relationship between obesity and joint pain and function in a joint arthroplasty population. *J Rheumatol*. 2008;35:1874–1877.

10. Groeneveld P, Kwok C, Mor M, Appelt C, Geng M, Gutierrez J, Wessel D, Ibrahim S. Racial differences in expectations of joint replacement surgery outcomes. *Arthritis Rheum.* 2008;59:730–737.
11. Hussain F, Kadir A, Rafiq M, Zulkifly A, Aziz A, et al. Three dimensional anthropometric measurements of the distal femur and proximal tibia for the Malay population. In: *2010 IEEE EMBS Conference on Biomedical Engineering & Sciences (IECBES 2010)* 291–291, Kuala Lumpur, Malaysia, 2010. DOI: [10.1109/IECBES.2010.5742246](https://doi.org/10.1109/IECBES.2010.5742246).
12. Ibrahim S, Stone R, Han X, Cohen P, Fine M, Henderson W, Khuri S, Kwok C. Racial/ethnic differences in surgical outcomes in veterans following knee or hip arthroplasty. *Arthritis Rheum.* 2005;52:3143–3151.
13. Insall J, Dorr L, Scott R, Scott W. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res.* 1989;248:13–14.
14. Joshy S, Datta A, Perera A, Thomas B, Gogi N, Kumar S. Ethnic differences in preoperative function of patients undergoing total knee arthroplasty. *Int Orthop.* 2006;30:426–428.
15. Kamath AF, Horneff JG, Gaffney V, Israelite CL, Nelson CL. Ethnic and gender differences in the functional disparities after primary total knee arthroplasty. *Clin Orthop Relat Res.* 2010;468:3355–3361.
16. Kim H, Kim S, Seo Y, Choi H, Seong S, Song Y, Hunter D, Zhang Y. The epidemiology of total knee replacement in South Korea: national registry data. *Rheumatology (Oxf).* 2008;47:88–91.
17. Ko Y, Lo N, Yeo S, Yang K, Yeo W, Chong H, Thumboo J. Rasch analysis of the Oxford knee score. *Osteoarthritis Cartilage.* 2009;17:1163–1169.
18. Lavernia CJ, Alcerro JC, Contreras JS, Rossi MD. Ethnic and racial factors influencing well-being, perceived pain, and physical function after primary total joint arthroplasty. *Clin Orthop Relat Res.* 2011;469:1838–1845.
19. Lavernia CJ, Alcerro JC, Rossi MD. Fear in arthroplasty surgery: the role of race. *Clin Orthop Relat Res.* 2010;468:547–554.
20. Lowry F. Satisfaction rate extremely high after total knee replacement. Available at: www.medscape.com/viewarticle/719003. Accessed April 29, 2012.
21. Ministry of Health Singapore. Hospital bill sizes: knee replacement surgery. Available at: www.moh.gov.sg/content/moh_web/home/costs_and_financing/HospitalBillSize/knee_replacement_surgery.html. Accessed February 2012.
22. Morgan RC, Slover J. Breakout Session: ethnic and racial disparities in joint arthroplasty. *Clin Orthop Relat Res.* 2011;469:1886–1890.
23. Olivier E, Olivier B, Florent R, Charles D, Jean-Yves R. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. *J Bone Joint Surg Am.* 2004;86:963–974.
24. Tan E, Lim Y, Teo Y, Goh R, Law H, Sia A. Ethnic differences in pain perception and patient-controlled analgesia usage for post-operative pain. *J Pain.* 2008;9:849–855.
25. Tang W, Zhu Y, Chiu K. Axial alignment of the lower extremity in Chinese adults. *J Bone Joint Surg Am.* 2000;82:1603–1608.
26. Ueno M, Urabe K, Fujita M, Aikawa J, Kobayashi A, Itoman M. Discrepancy between anatomical axis and stem position of various femoral components in Japanese. *J Orthop Surg (Hong Kong).* 2010;18:11–14.
27. Urabe K, Mahoney O, Mabuchi K, Itoman M. Morphologic differences of the distal femur between Caucasian and Japanese women. *J Orthop Surg (Hong Kong).* 2008;16:312–315.
28. Ware JE, Kosinski M, Dewey JE. *How to Score Version Two of the SF-36 Health Survey.* Lincoln, RI, USA: QualityMetric Incorporated; 2000.
29. Watson P, Latif R, Rowbotham D. Ethnic differences in thermal pain responses: a comparison of South Asian and white British healthy males. *Pain.* 2005;118:194–200.
30. Xie F, Li S, Lo N, Yeo S, Yang K, Yeo W, Chong H, Fong K, Thumboo J. Cross-cultural adaptation and validation of Singapore English and Chinese versions of the Oxford Knee Score (OKS) in knee osteoarthritis patients undergoing total knee replacement. *Osteoarthritis Cartilage.* 2007;15:1019–1024.
31. Xie F, Thumboo J, Fong KY, Lo NN, Yeo SJ, Yang KY, Li SC. Direct and indirect costs of osteoarthritis in Singapore: a comparative study among multiethnic Asian patients with osteoarthritis. *J Rheumatol.* 2007;34:165–171.
32. Yoga R, Sivapathasundaram N, Suresh C. Posterior slope of the tibia plateau in Malaysian patients undergoing total knee replacement. *Malay.* 2009;10:4–21.
33. Yue B, Varadarajan K, Ai S, Tang T, Rubash H, Li G. Differences of knee anthropometry between Chinese and white men and women. *J Arthroplasty.* 2011;26:124–130.