Influence of sex on surgical time in primary total knee arthroplasty

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Accepted for publication Mar. 15, 2010

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Background: Total knee arthroplasty (TKA) is widely recognized as an effective procedure for treatment of knee arthritis. However, there have been documented differences between men and women with respect to anatomic variability, timing of access to surgical care and surgical outcomes. We examined the influence of sex on the technical difficulty of TKA using a tourniquet and overall surgical time as a surrogate for complexity of exposure, soft-tissue balancing and implantation.

Methods: We performed a retrospective database review of patients who underwent primary TKA over a 5-year period. Tourniquet time, wound closure time and surgical time from 54 consecutive men (58 knees) and 48 women (58 knees) who underwent primary cemented TKA were recorded.

Results: The mean surgical time among men (108.2, standard deviation [SD] 17 min) was significantly longer than among women (96.8 [SD 14.8] min; $p = 0.001$). Similarly, the mean tourniquet time among men (75.9 [SD 11.7] min) was significantly longer than among women (65.9 [SD 11.8] min; $p = 0.001$).

Conclusion: Total knee arthroplasty in men requires more time than in women because of the complexity of exposure and to achieve the desired alignment of the components. Our data may allow a better resolution of surgery time planning, which could lead to better use of health system resources.

Contexte : L'arthroplastie totale du genou (ATG) est généralement reconnue comme une intervention efficace pour traiter l'arthrite dans le genou. Il y a toutefois des différences documentées entre les hommes et les femmes en ce qui concerne la variabilité anatomique, le moment de l'accès aux soins chirurgicaux et les résultats chirurgicaux. Nous avons étudié l'influence du sexe sur la difficulté technique de l'ATG en utilisant la durée d'application du tourniquet et la durée totale de l'intervention chirurgicale comme substituts de la complexité sur les plans de l'exposition, de l'équilibrage des tissus mous et de l'implantation.

Méthodes : Nous avons procédé à une analyse rétrospective de bases de données portant sur des patients qui ont subi une ATG primitive en cinq ans. On a consigné la durée d'application du tourniquet, le temps nécessaire pour refermer la plaie et la durée de l'intervention chirurgicale dans le cas de 54 hommes consécutifs (58 genoux) et de 48 femmes (58 genoux) qui ont subi une ATG cimentée primitive.

Résultats : L'intervention chirurgicale a duré en moyenne beaucoup plus longtemps chez les hommes (108,2, écart-type [ET] 17 min.) que chez les femmes (96,8 [ET 14,8] min.; $p = 0{,}001$). De même, la durée moyenne d'application du tourniquet était beaucoup plus longue chez les hommes (75,9 [ET 11,7] min.) que chez les femmes (65,9 [ET 11,8] min.; $p = 0{,}001$).

Conclusion : L'arthroplastie totale du genou prend plus de temps chez les hommes que chez les femmes à cause de la complexité de l'exposition et parce qu'il faut produire l'alignement désiré des pièces. Nos données peuvent permettre de mieux planifier le temps en chirurgie, ce qui pourrait améliorer l'utilisation des ressources du système de santé.

Total knee arthroplasty (TKA) is widely recognized as an effective procedure for treatment of knee arthritis. The number of primary TKAs performed in the United States increased substantially from 129 000 in 1990 to 381 000 in 2002.[1]

Recently, there has been significant interest in sex differences in TKA. The

prevalence of TKAs among women is 50%–67% higher than among men, resulting in a ratio of completed TKAs for men and women of 6:4 and 5:3, respectively.[1,2] There have been documented differences between sexes with respect to anatomic variability, timing of access to surgical care and surgical outcomes.

Women have significantly greater Q angles (17.5°, standard deviation [SD] 3.8° v. 13.1° [SD 3.0°]),[3–9] although this difference can be attributed to variations in height between the sexes.[10] In addition, female knees tend to be narrower than male knees for any given anteroposterior width.[11–13] The literature is less consistent about the varus–valgus laxity in patients with osteoarthritis. Whereas some studies have reported more joint and ligamentous laxity in women,[14,15] attributing this difference to free circulating estrogen and progesterone,[15] others found no difference.[16] Some of the recent implant designs are aimed to address the different anatomic dimensions, namely the decreased prominence of the anterior femoral condyles, femoral condylar height–width relation and Q angle.[11–13,17–19]

Women tend to delay TKA for arthritic knees and may wait until their symptoms are more severe then men.[20,21] This could partly be attributed to a gender bias, with physicians more likely to recommend TKA to a male patient than to a female patient.[22] Consequently, women tend to have lower preoperative knee scores, yet their clinical outcomes are better, resulting in less stiffness and improved function and implant longevity.[23]

We examined the influence of sex on the technical difficulty of TKA. The use of a tourniquet and overall TKA surgical time were used as surrogates for complexity of exposure, soft-tissue balancing and implantation. Our goal was to determine if significant differences exist between a matched group of male and female patients. To the best of our knowledge, such data has not been previously documented and may be of value for improved planning and use of surgical time.

Table 1. Patient data collected before total knee arthroplasty

Characteristic	Group; mean (SD)* Men, *n* = 54	Women, *n* = 48	*p* value
No. of TKAs	58	58	
Age, yr	67.1 (9.3)	66.2 (11.9)	0.63
Height, m	1.7 (0.09)	1.6 (0.1)	0.046
Weight, kg	94.9 (22.1)	85.9 (22.4)	0.031
Body mass index	32.2 (6.7)	33.7 (7.6)	0.28
Preoperative ROM, °	109 (16.9)	100 (22.6)	0.028
Fixed flexion contracture, no. (%) of knees	35 (60.3)	33 (56.9)	0.71
Preoperative knee score			
Oxford	42.7 (4.1)	43.4 (4.9)	0.49
Modified	26.2 (12.7)	23.8 (13.3)	0.32
Radiographic knee OA			
Kellgren	3.7 (0.5)	3.7 (0.5)	0.86
Ahlbäck	2.2 (1.0)	2.4 (1.2)	0.44

OA = gonarthrosis; ROM = range of motion; SD = standard deviation; TKA = total knee arthroplasty.
*Unless otherwise indicated.

METHODS

We included patients who had primary knee osteoarthritis without previous knee surgeries, excluding knee arthroscopy (e.g., high tibial osteotomy, tibial plateau fracture repair). Because the procedural complexity of TKA for valgus knees is generally accepted to be greater and somewhat more variable than varus knees, only knees with mild to moderate varus axial alignment were included.

Approval was granted by Mount Sinai Hospital's research ethics board. We completed a retrospective database review that included 58 consecutive male knees (54 patients) and female knees (48 patients) that underwent primary TKA between 2004 and March 2008 by a single surgeon at an academic hospital. Preoperative demographic data and functional and radiographic scores were recorded from the patient database.

All TKAs were performed using a medial parapatellar surgical approach without patellar eversion by the senior author and a team comprised of a junior orthopedic resident and an arthroplasty fellow. The role of the junior resident was primarily as a surgical assistant.

All TKAs were posterior stabilized and cemented. All men received the Zimmer Nexgen LPS Flex-Fixed Bearing Knee, and all women received the Zimmer Gender Solutions NexGen High-Flex Knee. The Gender model was designed specifically to accommodate the smaller transcondylar width of the distal femur in women. In all patients, the patella was resurfaced and an intra-articular drain was applied at the end of the procedure.

We obtained intraoperative data from the operative notes and the information recorded by the operative nursing staff. Surgical time was defined as the time that elapsed between skin incision and wound closure. In all patients,

Table 2. Patient data collected during total knee arthroplasty

Characteristic	Group; mean (SD)* Men, *n* = 54	Women, *n* = 48	*p* value
No. of TKAs	58	58	
AP femur size, mm	65.5 (4.0)	60.2 (3.8)	< 0.001
ML femur size, mm	71.0 (3.8)	63.8 (3.1)	< 0.001
Formal release, no. (%) of knees	43 (74.1)	35 (60.3)	0.11
Additional cuts, no. (%) of knees	1 (1.7)	2 (3.4)	0.56
Osteophyte excision, no. (%) of knees	27 (46.6)	21 (36.2)	0.26
Surgical time, min	108.2 (17)	96.8 (14.8)	0.001
Tourniquet time, min	75.9 (11.7)	65.9 (11.8)	< 0.001
Wound closure time, min	32.2 (11.5)	30.9 (12.0)	0.45

AP = anterior–posterior; ML = mediolateral; SD = standard deviation; TKA = total knee arthroplasty.
*Unless otherwise indicated.

the tourniquet was inflated immediately before skin incision and was deflated after component implantation. Thus, tourniquet time was the time required for the surgical approach, bone cuts, soft-tissue balancing and component implantation. Wound closure time was the time required for hemostasis after tourniquet deflation and wound closure. Wound closure time was calculated by subtracting tourniquet time from the surgical time.

We analyzed the data using SPSS 15 (SPSS Inc.). The data were not normally distributed; thus, we used nonparametric tests for statistical analysis. We determined sex differences with respect to pre- and intraoperative data using the Mann–Whitney *U* test. A χ^2 test was used to test the differences between the sexes with respect to pre- and intraoperative data that had a calculated incidence (e.g., presence of a fixed flexion contracture [FFC], osteophyte excision). We used 1-way analysis of variance to assess the annual temporal relation between mean surgical times for each sex. We performed multiple regression analyses to analyze the impact of pre- and intraoperative variables on overall surgical time. A p value of 0.05 or less was considered significant.

Results

Preoperative data from 58 consecutive male and 58 female primary TKAs were available (Table 1). The average age of the men (67.1 [SD 9.3] yr) and women (66.2 [SD 11.9] yr) was similar ($p = 0.63$). The men were taller (1.7 [SD 0.09] m v. 1.6 [SD 0.1] m; $p = 0.046$) and heavier (94.9 [SD 22.1] kg v. 85.9 [SD 22.4] kg; $p = 0.031$) than the women. The mean body mass index (BMI) was similar between the sexes (32.2 [SD 6.7] in men v. 33.7 [SD 7.6] in women; $p = 0.28$). However, the women had significantly higher rates of morbid obesity (BMI ≥ 40; 20.75% v. 10.29%; $p = 0.047$).

We compared the patient data according to preoperative range of motion (ROM), presence of a preoperative FFC, knee function and pain using the Oxford and modified knee scores (MDKS) and preoperative radiographic grade of gonarthrosis using the Kellgren and Ahlbäck classifications.[24,25] Men had a higher preoperative ROM (109° [SD 16.9°] v. 100° [SD 22.6°]; $p = 0.028$) and rate of FFCs 10° or greater (60.3% v. 56.9%; $p = 0.71$). Preoperative Oxford knee scores were similar in men and women (42.7 [SD 4.1] v. 43.4 [SD 4.9]; $p = 0.49$). In both sexes, Oxford knee scores at the latest follow up were significantly higher than at the preoperative visit (22.7 [SD 4.5] in men, $p < 0.001$; 24.8 [SD 5.5] in women, $p < 0.001$). Preoperative MDKS was similar in both sexes (26.2 [SD 12.7] in men v. 23.8 [SD 13.3] in women; $p = 0.32$). In both sexes, MDKS at latest follow-up was significantly higher than at preoperative testing (65.5 [SD 6.9] in men, $p < 0.001$; 63.3 [SD 5.4] in women, $p < 0.001$). Because the follow-up in some patients was less than 2 years, we did not compare the postoperative knee scores between the groups.

The radiographic grade of gonarthrosis was similar in both groups according to the Kellgren (3.67 [SD 0.5] in men v. 3.7 [SD 0.5] in women; $p = 0.86$) and Ahlbäck (2.2 [SD 1.0] in men v. 2.4 [SD 1.2] in women; $p = 0.44$) scores.

Intraoperative data were calculated for TKA component size, additional events that occurred during the surgical case and surgical times (Table 2). Men had significantly higher anteroposterior (65.5 [SD 4.0] mm v. 60.2 [SD 3.8] mm; $p < 0.001$) and mediolateral (71.0 [SD 3.8] mm v. 63.8 [SD 3.1] mm; $p < 0.001$) distal femoral measurements. There were similar rates of formal soft-tissue releases (74.1% v. 60.3%; $p = 0.11$), additional cuts (1.7% v. 3.4%; $p = 0.56$) and osteophyte excision (46.6% v. 36.2%; $p = 0.26$) among men and women, respectively.

Mean surgical time among men (108.2 [SD 17, range 77–193] min) was significantly ($p = 0.001$) longer than among women (96.8 [SD 14.8, range 65–125] min). Similarly, mean tourniquet time among men (75.9 [SD 11.7, range 50–123] min) was significantly longer ($p < 0.001$) than among women (65.9 [SD 11.8, range 40–87] min). However, wound closure times were similar ($p = 0.45$) in men (32.2 [SD 11.5, range 11–70] min) and women (30.9 [SD 12.0, range 5–66] min).

We examined the temporal relation between mean annual surgical times for each sex. Among men, there was no significant difference in the mean surgical time between the years for which data were collected ($p = 0.57$). However, among women, there was a significant difference between the years ($p < 0.001$). The mean surgical times from the 3 years that TKAs were recorded for women improved annually from 2006 (105.96 [SD 9.5] min) to 2007 (93.0 [SD 15.0] min) to 2008 (82.5 [SD 9.8] min).

Multiple regression analysis showed that 20.3% and 45.3% of the variance in surgical time was contributed to by the aforementioned pre- and intraoperative variables in men and women, respectively. In men, when the variables were analyzed independently, there were no statistically significant results. Conversely, age ($p = 0.007$), presence of an FFC ($p = 0.018$) and anteroposterior ($p = 0.040$) and mediolateral ($p = 0.041$) distal femoral measurements were significant variables in women.

Discussion

Total knee arthroplasty aims to provide patients with pain relief and substantial improvement in function. Advancements in surgical techniques and implant designs as well as patients' increased awareness have lead to a tripling of the rate of TKAs performed annually in the US.[1] This has had a substantial effect on the costs for health care systems. If we could better predict the time required for each procedure, depending on data available preoperatively, improved use of health system resources, such as allocated operative time, may be achieved.

Our study population had a comparable distribution of

patient characteristics (including height, weight, morbid obesity and preoperative knee function) to that in a recent report comparing surgical outcomes in both sexes.[23] This study validates our results with respect to the demographics of the participants. The present study indicates that for a consecutive series of male and female TKA patients with similar demographic and preoperative functional and radiographic characteristics, time from skin incision to skin closure was 11.4 minutes (10.5%) longer in men than in women. Similarly, the time required for surgical approach, bone cuts, soft-tissue balancing and component implantation was 10 minutes (13.2%) longer in men.

The time discrepancy between the sexes may be explained by anatomic and physiologic differences. On average, men have a significantly higher percentage of lean muscle mass,[26] which may create a difficult surgical exposure. In our study, men had significantly larger anteroposterior and mediolateral measurements of the distal femur, which is consistent with results in the literature.[11–13] Furthermore, the combination of increased ligamentous and joint laxity[14,15] in women and recent advances in gender-specific TKA components may provide an easier exposure and component implantation. Multiple regression analysis showed that the variance in surgical time was more than twice as likely to be influenced by the pre- and intraoperative variables in women. Therefore, in men, the additional surgical time was likely because of a variable not examined in our study, such as the complexity of exposure and component implantation. Further examination of this issue is required to determine the underlying cause.

All surgeries in this study were performed by a single surgeon with a high-volume, academic practice; this surgeon almost exclusively performs TKAs. Thus, it is reasonable to assume that intraoperative efficiency was maximized in both men and women. However, there was a significant difference in the mean surgical time between the years that the female TKAs were recorded. This discrepancy coincides with a recent provincial initiative to increase total joint replacements. When we compared the mean surgical times between the sexes, men had significantly longer times for each year. Whereas it is true that academic institutions are subject to biases such as residents and fellows in training, each trainee had a specific role within the surgical case and therefore both groups were influenced equally.

Cost-containment strategies play a major role in modern health care. The recent strategies in the field of total joint arthroplasty include performing preoperative evaluation on an outpatient basis, reducing the length of postoperative hospital stays and providing physical therapy services.[27–30] An additional method is to maximize the use of allocated operating room time. Our data may allow a higher resolution of operating room time planning, which may lead to better use of health system resources while providing services to a greater number of patients. Surgeons are encouraged to examine the operative time in their hospitals and evaluate if a better planning of their operating room time for TKAs is possibly based on patient sex.

Competing interests: None declared for Drs. Kosashvili, Trajkovski, Lackstein and Safir and Mr. Mayne. Dr. Backstein has been a paid consultant for Stryker Canada within the past 2 years.

Contributors: Drs. Trajkovski and Backstein designed the study. Mr. Mayne and Drs. Trajkovski and Lackstein acquired the data, which Drs. Kosashvili, Trajkovski, Safir, Lackstein and Backstein analyzed. Dr. Kosashvili and Mr. Mayne wrote the article. All authors reviewed the article and approved its publication.

References

1. Kurtz S, Mowat F, Ong K, et al. Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002. *J Bone Joint Surg Am* 2005;87:1487-97.
2. Ritter MA, Wing JT, Berend ME, et al. The clinical effect of gender on outcome of total knee arthroplasty. *J Arthroplasty* 2008;23:331-6.
3. Tillman MD, Bauer JA, Cauraugh JH, et al. Differences in lower extremity alignment between males and females. Potential predisposing factors for knee injury. *J Sports Med Phys Fitness* 2005;45:355-9.
4. Horton MG, Hall TL. Quadriceps femoris muscle angle: normal values and relationships with gender and selected skeletal measures. *Phys Ther* 1989;69:897-901.
5. Hsu WH, Fisk JA, Yamamoto Y, et al. Differences in torsional joint stiffness of the knee between genders: a human cadaveric study. *Am J Sports Med* 2006;34:765-70.
6. Csintalan RP, Schulz MM, Woo J, et al. Gender differences in patellofemoral joint biomechanics. *Clin Orthop Relat Res* 2002;402:260-9.
7. Woodland LH, Francis RS. Parameters and comparisons of the quadriceps angle of college aged men and women in the supine and standing positions. *Am J Sports Med* 1992;20:208-11.
8. Aglietti P, Insall JN, Cerulli G. Patellar pain and incongruence. I: Measurements of incongruence. *Clin Orthop Relat Res* 1983;176:217-24.
9. Livingston LA. The quadriceps angle: a review of the literature. *J Orthop Sports Phys Ther* 1998;28:105-9.
10. Grelsamer RP, Dubey A, Weinstein CH. Men and women have similar Q angles: a clinical and trigonometric evaluation. *J Bone Joint Surg Br* 2005;87:1498-501.
11. Poilvache PL, Insall JN, Scuderi GR, et al. Rotational landmarks and sizing of the distal femur in total knee arthroplasty. *Clin Orthop Relat Res* 1996;331:35-46.
12. Chin KR, Dalury DF, Zurakowski D, et al. Intraoperative measurements of male and female distal femurs during primary total knee arthroplasty. *J Knee Surg* 2002;15:213-7.
13. Hitt K, Shurman JR, Greene K, et al. Anthropometric measurements of the human knee: correlation to the sizing of current knee arthroplasty systems. *J Bone Joint Surg Am* 2003;85(Suppl 4):115-22.
14. Van der Esch M, Steultjens MP, Lems WF, et al. Gender difference in varus-valgus laxity in osteoarthritis of the knee. *Scand J Rheumatol* 2007;36:157-9.

15. Felson DT, Zhang Y. An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. *Arthritis Rheum* 1998;41: 1343-55.

16. Zalzal P, Papini M, Petruccelli D, et al. An in vivo biomechanical analysis of the soft-tissue envelope of osteoarthritic knees. *J Arthroplasty* 2004;19:217-23.

17. Mensch JS, Amstutz HC. Knee morphology as a guide to knee replacement. *Clin Orthop Relat Res* 1975;112:231-41.

18. Seedhom BB, Longton EB, Wright V, et al. Dimensions of the knee. Radiographic and autopsy study of sizes required by a knee prosthesis. *Ann Rheum Dis* 1972;31:54-8.

19. Yoshioka DS, Siu D, Cooke TD. The anatomy and functional axes of the femur. *J Bone Joint Surg Am* 1987;69:873-80.

20. Karlson EW, Daltroy LH, Liang MH, et al. Gender differences in patient preferences may underlie differential utilization of elective surgery. *Am J Med* 1997;102:524-30.

21. Katz JN, Wright EA, Guadagnoli E, et al. Differences between men and women undergoing major orthopedic surgery for degenerative arthritis. *Arthritis Rheum* 1994;37:687-94.

22. Borkhoff CM, Hawker GA, Kreder HJ, et al. The effect of patients' sex on physicians' recommendations for total knee arthroplasty. *CMAJ* 2008;178:681-7.

23. MacDonald SJ, Charron KD, Bourne RB, et al. The John Insall Award: gender-specific total knee replacement: prospectively collected clinical outcomes. *Clin Orthop Relat Res* 2008;466:2612-6.

24. Kellgren JH. *Atlas of standard radiographs*. Oxford: Blackwell Scientific; 1963.

25. Ahlbäck S. Osteoarthrosis of the knee. A radiographic investigation. *Acta Radiol Diagn (Stockh)* 1968;Suppl 277:7-72.

26. Neder JA, Nery LE, Silva AC, et al. Maximal aerobic power and leg muscle mass and strength related to age in non-athletic males and females. *Eur J Appl Physiol Occup Physiol* 1999;79:522-30.

27. Froimson AI. Rational use of resources in total joint arthroplasty [presentation]. Annual Meeting. American Academy of Orthopaedic Surgeons; 1994 Feb. 24–Mar. 1; New Orleans (LA).

28. Hard R. Hospitals review ortho process to trim costs. *Hospitals* 1992; 66:54,56.

29. Kirschenbaum IH. Impact of a prospectively applied total joint replacement protocol on length of stay, complications, and results [presentation]. Annual Meeting. American Academy of Orthopaedic Surgeons; 1994 Feb. 24–Mar. 1; New Orleans (LA).

30. Sommers LS, Schurman DJ, Jamison JQ, et al. Clinician-directed hospital cost management for total hip arthroplasty patients. *Clin Orthop Relat Res* 1990;258:168-75.