INTRA-OPERATIVE MEASURMENTS OF THE DISTAL FEMUR GEOMETRY DURING TOTAL KNEE REPLACEMENT AND DIFFERENCES BETWEEN MALE AND FEMALE IN ARAB POPULATION

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Intra-operative Measurements of The Distal Femur Geometry During Total Knee Replacement And Differences Between Male And Female In Arab Population (prospective study)

Abstract

Gender differences in distal femoral morphology may affect femoral component fit using a standard range of prostheses. The clinical relevance of this is controversial.

Standardised measurements were taken from the distal femora of 50 males and 50 females during total knee replacement (TKR). Corresponding measurements were taken from the respective gender specific and standard femoral components. No demographic differences were noted.

Significant differences in both frequency and magnitude existed in medial–lateral femoral component overhang between the sexes.

In females, standard implants overhung at the anterior flange width (AFW) by >2mm in 24/50 (48%) and by >3mm in 17/50 (34%) [i](p<0.001). Also at the anterior medial-lateral width (MLA) 29/50 (58%) overhung by >2mm and 24/50 (48%) by >3mm (p<0.001).

In males, standard implants overhung by >2mm in 1/50 (2%). In females, gender specific implants overhung by >2mm in 3/50 (6%). Females had a mean aspect ratio of 1.02 (0.82 to 1.35) and men 0.98 (0.79 to 1.19).

Femoral component overhang can occur in females undergoing TKR and a gender specific implant would reduce the potential for medial-lateral overhang. Long term studies are awaited to quantify the clinical implications of overhang.

Introduction

There has been an increasing level of public and professional interest in the concept of a gender specific knee replacement and much consequent debate[1-4]. A Google internet search for 'gender knee' in October 2007 yielded 545,000 hits, with subsequent searches in January 2008 and August 2010 producing 1,910,000 and 3,110,000 hits respectively[5]. The rising profile of gender specific knee replacement has no-doubt been driven by both commercial-interests and publications citing morphological gender related differences between the knees of male and female subjects[6-12]. Advocates of implant modifications in gender specific knee prostheses have therefore taken into account the three reported differences in the female knee: an increased Q-angle, less observable prominence of the anterior condyle and a reduction in the medial-lateral to anterior-posterior femoral condylar aspect ratio[9,13]. Interestingly however, Merchant et al examined 19 peer reviewed articles and concluded that not only was there insufficient evidence to support the first two anatomical considerations, but also that the difference in aspect ratio is so small it may have little clinical effect[14]. Concerns that using gender specific implants may actually undercover the femoral resection and lead to higher peri-operative blood loss have also been reported recently[15,16].

We therefore designed a prospective study to measure any potential differences in the intra-articular morphology of the distal femur between sexes and to examine the medial-lateral fit of both gender specific and standard femoral components. (NexGen standard and gender-specific posterior-stabilised high-flexion knee, Zimmer, Warsaw, Indiana) shown in **(Fig. 1).**

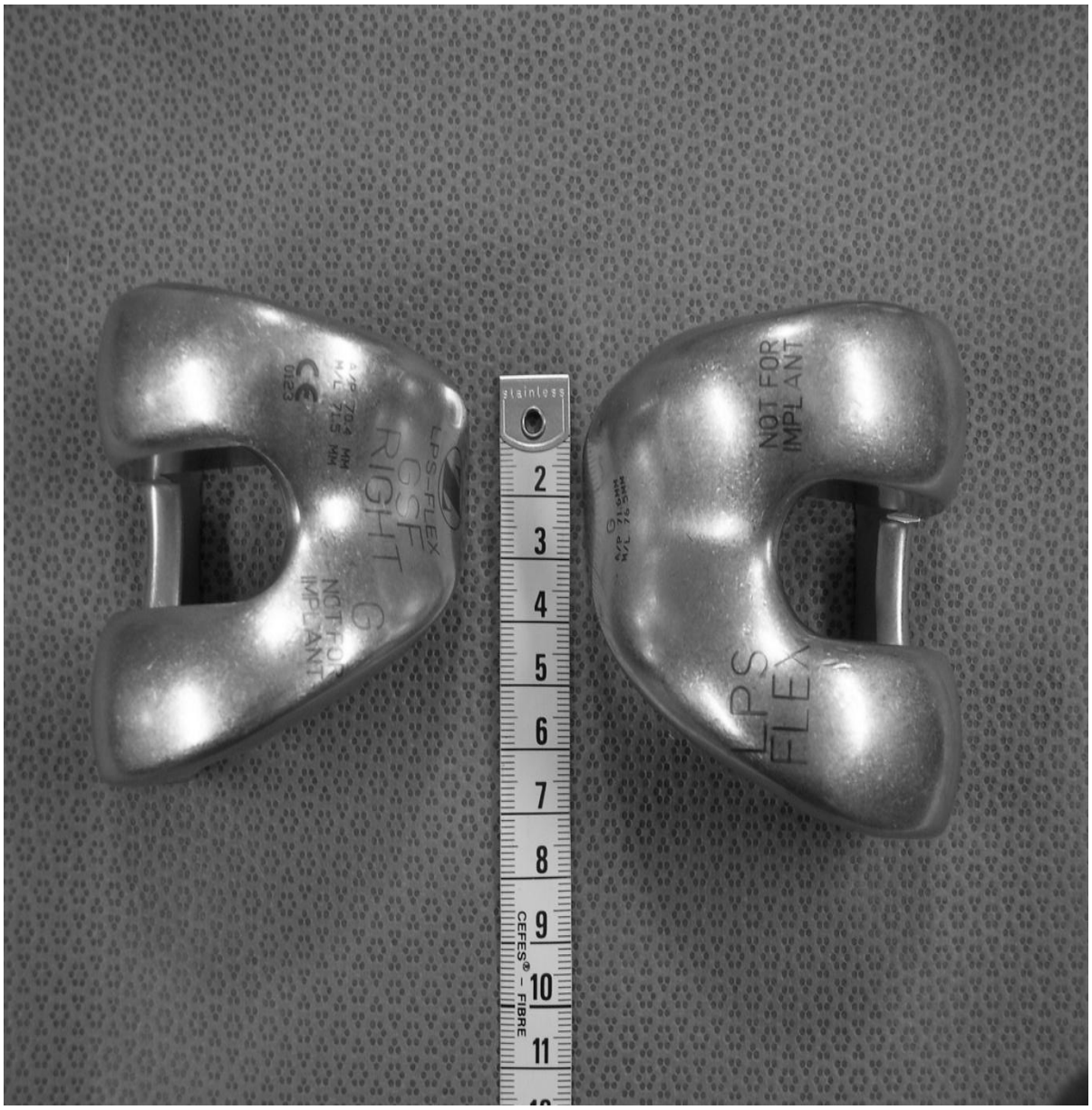

Fig. 1

Patients and Methods

Regional ethics committee and local approval was granted for the study. A consecutive series of 50 consenting females and 50 consenting males were recruited to participate. Excluded were patients with previous distal femoral fractures

and substantial bone loss requiring augmentation. Recruitment was undertaken between September 2007 and March 2008. The standard surgical technique recommended by the manufacturer was performed by the senior author or senior knee fellow. The anterior-posterior measurement was taken of the largest femoral condyle. The following medial-lateral measurements were taken from both the standard and gender specific femoral implant trials; the anterior flange width (AFW), the anterior medial-lateral width (MLA), the mid medial-lateral width (MLM) and the posterior medial-lateral width (MLP) shown in **(Fig. 2).**

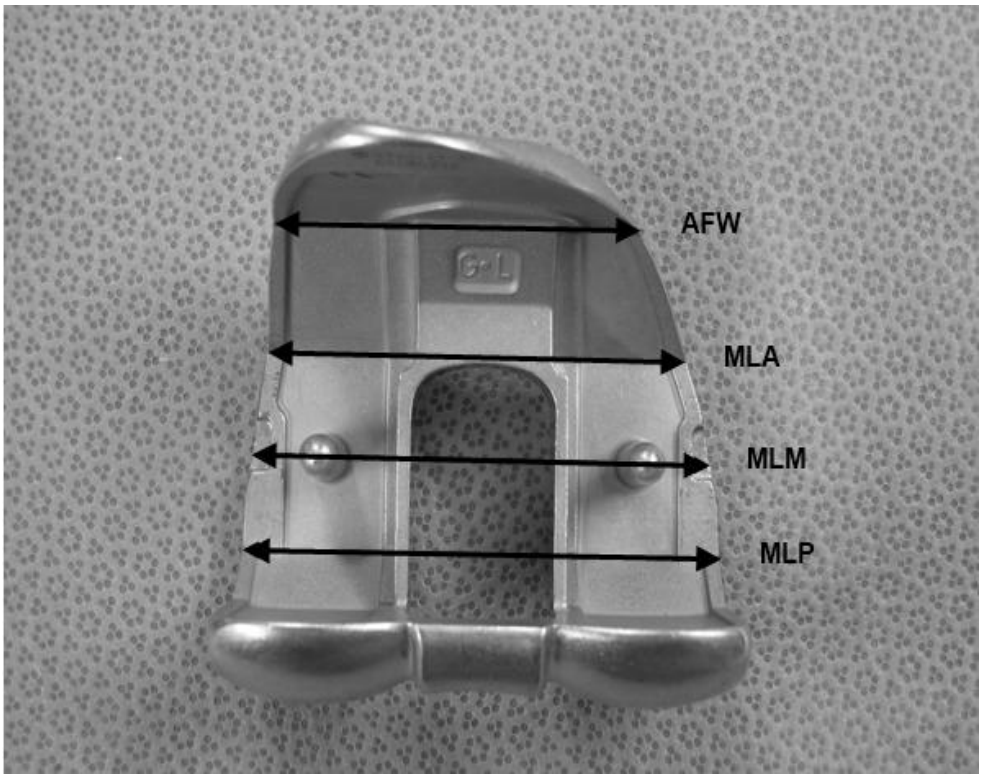

Fig. 2

Corresponding morphological data from the distal femur was collected after the bony cuts had been made, using a sterile vernier scale calliper. An identical calliper was used in each case. The aspect ratio was calculated using the mid medial-lateral

dimension (MLM) divided by the anterior-posterior dimension. To avoid bias the measurements of the knee trial implants were only taken after the complete dataset corresponding to the distal femoral resections had been obtained. The measurements obtained in each individual following completion of the distal femoral cuts was then referenced to the measurements obtained from both the standard and gender specific trials and the site and magnitude of any potential medial-lateral overhang noted.

Statistical Analysis

An a priori power analysis was conducted to determine the required number of patients to evaluate the medial-lateral to anterior-posterior aspect ratio. A minimal sample size of 29 in each group would provide 80% power to detect a difference in means of 0.03 assuming a common standard deviation (SD) of 0.03 and 5% significance. All measurements were tested for normality using Kolmogorov-Smirnov test and all had a normal distribution. Two-tailed Student's *t*-test was used to analyse the parametric data with significance taken at 5% ($p<0.05$). All statistical analysis was performed on SPSS v19 (SPSS Inc., Chicago, Ill).

Results

No significant differences in the range of demographic data were identified between groups. Males had a mean age of 70.8 years (range 50 to 83yrs), height of 177.0cm (164 to 190cm), weight of 89.6kg (64 to 120kg) and body mass index of 28.3 (21 to 38). Females had a mean age of 70.5 years (47 to 87yrs), height of 161.0cm (149 to 170cm), weight of 75.7kg (54 to 130kg) and a body mass index of 28.8 (22 to 45).

The anterior-posterior to medial-lateral aspect ratio was larger in women than men can be seen in **Fig .3**

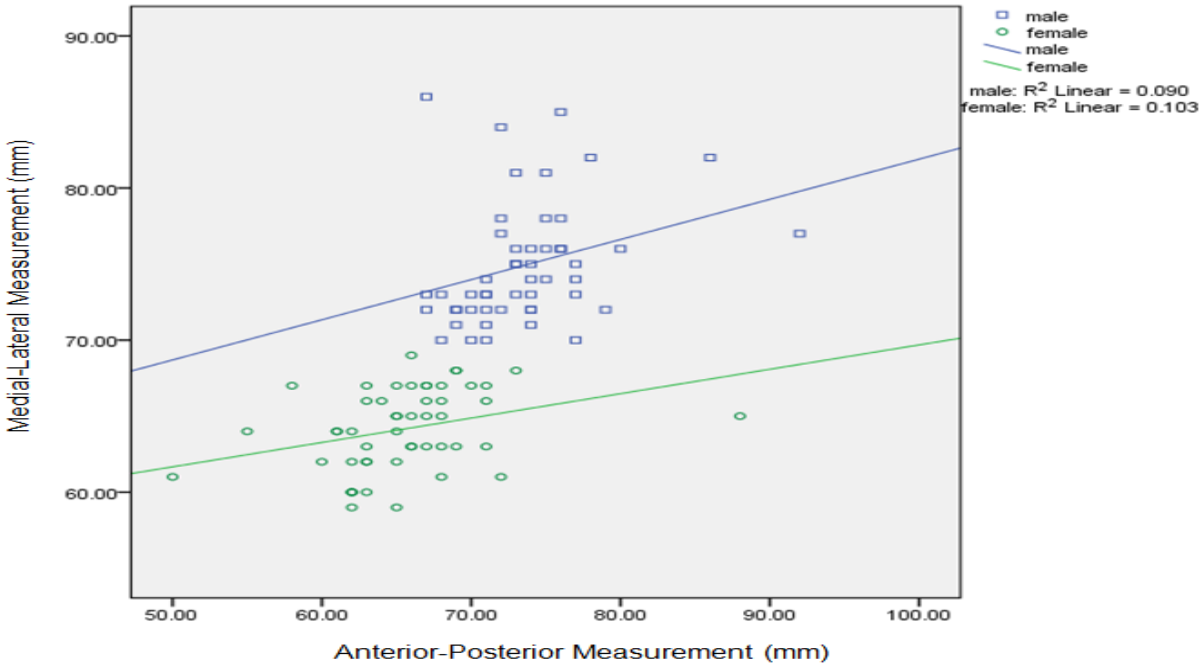

Fig.3

Women had a mean ratio of 1.02 (0.82 to 1.35) and men of 0.98 (0.79 to 1.19)can be seen in **Table 1.**

Summary table of aspect ratio, medial-lateral measurements and the p value (paired t test).

	Gender	Average	Min	Max	S.D.	Significance.
Ratio (AP/ML)	Male	0.98	0.78	1.19	0.64	p=0.005
	Female	1.02	0.82	1.35	0.80	
AP (mm)	Male	73.56	67	92	4.54	p<0.001
	Female	65.54	50	88	5.32	
MLA (mm)	Male	66.54	55	83	4.12	p<0.001
	Female	57.84	50	65	3.10	
MLM (mm)	Male	74.92	70	86	3.98	p<0.001
	Female	64.16	59	69	2.66	
MLP (mm)	Male	79.38	72	90	4.06	p<0.001
	Female	67.60	62	74	2.94	
AFW (mm)	Male	53.44	45	67	4.01	p<0.001
	Female	48.20	42	58	3.45	

Table .1

. In males only 1 out of 50 (2%) had any measurable medial-lateral component overhang with a standard implant. In females more than 2mm of overhang was seen in only 3 out of 50 (6%) with gender specific knee implants. Overhang in females if a standard implant of the appropriate size had been employed was statistically significant both for incidence and magnitude. In females 29/50 (58%) of standard implants would have overhung more than 2mm at the MLA measurement compared

to only 3/50 (6%) with the gender specific knee prosthesis of the same size ($p<0.001$). In 30/50 (60%) females a theoretical mean AFW overhang was seen of 3.23mm (1 to 7mm) and in 34/50 (68%) females at MLA a mean overhang of 4.12mm (1 to 11mm). At the MLM 30/50 (60%) females had a mean overhang of 3.13mm (1 to 8mm) and at the MLP measurement 23/50 (46%) females had a mean overhang of 2.59mm (1 to 8mm). The graphical representation in females of the amount and site of medial-lateral overhang and frequency can be seen in **Fig 4**

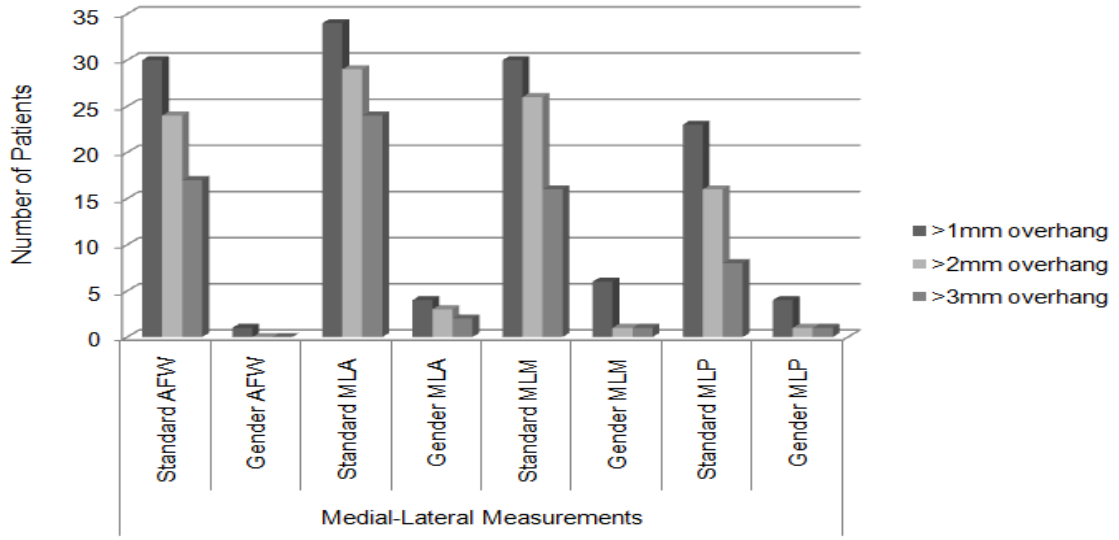

Fig.4

Discussion

We have shown that in our sample population that there is a difference in the aspect ratio seen between male and female knees, in keeping with the literature[7,9,11,12,17]. What is not clear is what this difference may mean clinically. One can argue that if there is a need for a gender specific knee then we must historically have data

available that shows women doing worse than men with traditional non-gender knee replacements. On the contrary, there is a magnitude of evidence suggesting that women do better than men when looking at implant survival[18-25], patient satisfaction[25], wear related failure[21,26], revision risk and revision rates[24,27], range of motion[28], and patient satisfaction[27]. Studies also show women achieving similar or equal results as men when looking at implant survival[5,29-33], pain[5,34], outcome scores[5,24,35-37], stiffness[38] and range of motion[5]. The lack of peer-reviewed justification for the purported anatomical differences in Q angle and prominence of the anterior condyles has led to Merchant et al concluding that there is not sufficient evidence to support their existence[14].-We chose to focus therefore on the aspect ratio and evaluation of femoral component medial-lateral overhang. We found that 58% of females would have had greater than 2mm of overhang ($p < 0.001$) and that 48% would have had greater than 3mm overhang ($p <0.001$) had they been given a standard femoral component. This contrasts with Kim et al. who reported that only 10% of NexGen standard CR-flex femoral components overhung in females and in fact suggested that the distal femur was under covered in 89.1% using a NexGen gender CR-flex knee[15]. In a further study comparing NexGen LPS Flex knees, they noted an overhang in 12% of females given a standard knee compared to apparent under coverage in 84% of females in whom a gender specific prosthesis was implanted[16]. Both publications recognised that their study may be of limited applicability to a Western population. Indeed, anatomical studies have shown there are racial differences in the bony anatomy of the knee[39-44]. More recently, the concept of knee morph type has been suggested to be of particular significance[45].

There is no clinical evidence available to date in the peer-reviewed literature to support the concepts that overhang of the femoral prosthesis in the medial-lateral

plane causes symptoms. We would suggest that the lack of current evidence is not sufficient justification to assume that there is no cause for concern. Proposed consequences from implant overhang range from soft tissue irritation to compromised soft tissue balancing[4,11] .There does not seem to be much logic in the standard practice of remove overhanging medial-lateral osteophytes to assist with soft tissue balancing if these are then replaced with a prosthesis that may overhang due to dimensional mismatch and potentially recreate the problem. Similarly the prospect exists intra-operatively (using AP referencing) of being faced with the decision as to whether to downsize the femoral component if significant overhang is considered an appreciable risk. This compromise may result in either femoral notching anteriorly or increasing the flexion gap (depending upon the use of anterior or posterior referencing system) with consequent difficulty in achieving balanced flexion and extension. With the option to choose an implant with a narrower medial-lateral ratio implant this may be less likely to happen, though under sizing may allow more cancellous bone to be exposed, leading to higher blood loss postoperatively[11,15,16] and may allow increased osteolysis from wear debris in the longer term[11].

The strengths of this study relate primarily to the prospective reproducible collection of comparative datasets with adequate statistical power. A potential weakness may lie in inter and intra-observer errors incurred during measurement collection.

We conclude that the female distal femur is different to the male distal femur and that in our cohort there would have been significant measured overhang with a standard component in a significant proportion of female knees. It is not known whether this is clinically relevant and further long-term research should be concentrated in this area. In an age when there is apparent burgeoning interest and sophisticated marketing

campaigns concerning individual custom made implants and jigging systems, perhaps gender specific knee implants offer an economically viable alternative in sizing options. In the absence of any current clinical evidence it is important for the orthopaedic surgeon to have a selection of implants that most accurately match their own patient populations. This may mean utilising a specific gender design, proposing to the manufacturer to increasing the number of sizes (or half sizes) available or using their own tried and tested intra-operative strategies of downsizing, lateralising and /or flexing the femoral component to accommodate a less extensive range of implant options.

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References

1. Barrett WP. The need for gender-specific prostheses in TKA: does size make a difference? *Orthopedics*. 2006;29(9 Suppl):S53-S55.
2. Booth RE Jr. Sex and the total knee: gender-sensitive designs. *Orthopedics*. 2006;29(9):836-838.
3. Booth RE Jr. The gender-specific (female) knee. *Orthopedics*. 2006;29(9):768-769.
4. Greene KA. Gender-specific design in total knee arthroplasty. *J Arthroplasty*. 2007;22(7 Suppl 3):27-31.
5. Dalury DF, Mason JB, Murphy JA, Adams MJ. Analysis of the outcome in male and female patients using a unisex total knee replacement system. *J Bone Joint Surg Br*. 2009;91(3):357-360.
6. 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(2):208-211.
7. Poilvache PL, Insall JN, Scuderi GR, Font-Rodriguez DE. Rotational landmarks and sizing of the distal femur in total knee arthroplasty. *Clin Orthop Relat Res*. 1996;331:35-46.
8. Livingston LA. The quadriceps angle: a review of the literature. *J Orthop Sports Phys Ther*. 1998;28(2):105-109.
9. Chin KR, Dalury DF, Zurakowski D, Scott RD. Intraoperative measurements of male and female distal femurs during primary total knee arthroplasty. *J Knee Surg*. 2002;15(4):213-217.

10. Csintalan RP, Schutz MM, Woo J, McMahon PJ, Lee TQ. Gender differences in patellofemoral joint biomechanics. *Clin Orthop Rel Res*. 2002;402:260-269.

11. Hitt K, Shurman JR II, Greene K, McCarthy J, Moskal J, Hoeman T, Mont MA. Anthropomorphic measurements of the human knee: correlation to the sizing of current knee arthroplasty systems. *J Bone Joint Surg Am*. 2003;85-A Suppl 4:115-122.

12. Dargel J, Michael JWP, Feiser J, Roland I, Koebke J. Human Knee Joint Anatomy Revisited: Morphometry in the Light of Sex-Specific Total Knee Arthroplasty. *J Arthroplasty*. 2010 [EPub ahead of print]

13. Conley S, Rosenburg A, Crowninshield R. The female knee: anatomic variations. *J Am Acad Orthop Surg*. 2007;15(Suppl 1):S31-S36.

14. Merchant AC, Arendt EA, Dye SF, Fredericson M, Grelsamer RP, Leadbetter WB, Post WR, Tietge RA. The female knee: anatomic variations and the female-specific total knee design. *Clin Orthop Rel Res*. 2008;466(12):3059-3065.

15. Kim YH, Choi Y, Kim JS. Comparison of standard and gender-specific posterior-cruciate-retaining high-flexion total knee replacement. *J Bone Joint Surg Br*. 2010;92(5):639-645.

16. Kim YH, Choi Y, Kim JS. Comparison of a standard and a gender-specific posterior Cruciate-substituting high-flexion knee prosthesis: a prospective, randomized,short-term outcome study. *J Bone Joint Surg Am*. 2010;92(10):1911-1920.

17. Mensch JS, Amstutz HC. Knee morphology as a guide to knee replacement. *Clin Orthop Relat Res*. 1975;112:231-241.

18. 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(3):397-409.

19. Rand JA, Trousdale RT, Ilstrup DM Harmsen WS. Factors affecting the durability of primary total knee prostheses. *J Bone Joint Surg Am*. 2003;85-A(2):259-265.

20. Vasquez-Vela Johnson G, Worland RL, Keenan J, Norambuena N. Patient demographics as a predictor of the ten-year survival rate in primary total knee replacement. *J Bone Joint Surg Br*. 2003;85(1):52-56.

21. Fehring TK, Murphy JA, Hayes TD, Roberts DW, Pomoroy DL, Griffin WL. Factors influencing wear and osteolysis in press-fit condylar modular total knee replacements. *Clin Orthop Relat Res*. 2004;428:40-50.

22. Himanen AK, Belt E, Nevalainen J, Hämäläinen M, Lehto MU. Survival of the AGC total knee arthroplasty is similar for arthrosis and rheumatoid arthritis. Finnish Arthroplasty Register report on 8,467 operations carried out between 1985 and 1999. *Acta Orthop*. 2005;76(1):85-88.

23. Roberts VI, Esler CN, Harper WM. A 15-year follow-up study of 4606 primary total knee replacements. *J Bone Joint Surg Br*. 2007;89(11):1452-1456.

24. MacDonald SJ, Charron KD, Bourne RB, Naudie DD, McCalden RW, Rorabeck CH. The John Insall Award: gender-specific total knee

replacement: prospectively collected clinical outcomes. *Clin Orthop Rel Res*. 2008;466(11):2612-2616.

25. Robertsson O, Dunbar M, Pehrsson T, Knutson K, Lidgren L. Patient satisfaction after knee arthroplasty: a report on 27,372 knees operated on between 1981 and 1995 in Sweden. *Acta Orthop Scand*. 2000;71(3):262-267.

26. Baker PN, Khaw FM, Kirk LM, Esler CN, Gregg PJ. Randomised control trial of cemented versus cementless press-fit condylar total knee replacement: 15-year survival analysis. *J Bone Joint Surg Br*. 2007;89(12):1608-1614.

27. Robertsson O, Knutson K, Lewold S, Lidgren L. The Swedish Knee Arthroplasty Register 1975-1997: an update with special emphasis on 41,223 knees operated on in1988-1997. *Acta Orthop Scand*. 2001;72(5):503-513.

28. Ritter MA, Harty LD, Davis KE, Meding JB, Berend ME. Predicting range of motion after total knee arthroplasty. Clustering, log-linear regression and regression tree analysis. *J Bone Joint Surg Am*. 2003;85-A(7):1278-1285.

29. Scuderi GR, Insall JN, Windsor RE, Moran MC. Survivorship of cemented knee replacements. *J Bone Joint Surg Br*. 1989;71(5):798-803.

30. Font-Rodriguez DE, Scuderi GR, Insall JN. Survivorship of cemented total knee arthroplasty. *Clin Orthop Rel Res*. 1997;345:79-86.

31. Gill GS, Joshi AB. Long-term results of Kinematic Condylar total knee replacement. An analysis of 404 knees. *J Bone Joint Surg Br*. 2001;83(3):355-358.

32. Khaw FM, Kirk LM, Morris RW, Gregg PJ. A randomised, controlled trial of cemented versus cementless press-fit condylar total knee replacement. Ten-year survival analysis. *J Bone Joint Surg Br*. 2002;84(5):658-666.

33. American Academy of Orthopaedic Surgeons. Gender-specific knee replacements: a technology overview. *J Am Acad Orthop Surg*. 2008;16(2):63-67.

34. Whiteside LA. The effect of patient age, gender, and tibial component fixation on pain relief after cementless total knee arthroplasty. *Clin Orthop Rel Res*. 1991;271:21-27.

35. Wright RJ, Sledge CB, Poss R, Ewald FC, Walsh ME, Lingard EA. Patient-reported survivorship after Kinemax total knee arthroplasty. *J Bone Joint Surg Am*. 2004;86-A(11):2464-2470.

36. Kane RL, Saleh KJ, Wilt TJ, Bershadsky B. The functional outcomes of knee arthroplasty. *J Bone Joint Surg Am*. 2005;87(8):1719-1724.

37. Bourne RB, McCalden RW, Macdonald SJ, Mokete L, Guerin J. Influence of patient factors on TKA outcomes at 5 to 11 years followup. *Clin Orthop Rel Res*. 2007;464:27-31.

38. Kim J, Nelson CL, Lotke PA. Stiffness after total knee arthroplasty. Prevalence of the complication and outcomes of revision. *J Bone Joint Surg Am*. 2004;86-A(7):1479-1484.

39. Vaidya SV, Ranawat CS, Aroojis A, Laud NS. Anthropometric measurements to design a total knee prostheses for the Indian population. *J Arthroplasty*. 2000;15(1):79-85.

40. Uehara K, Kadoya Y, Kobayashi A, Ohashi H, Yamano Y. Anthropometry of the proximal tibia to design a total knee prosthesis for the Japanese population. *J Arthroplasty*. 2000;17(8):1028-1032.

41. Yip DK, Zhu YH, Chiu KY, Ng TP. Distal rotational alignment of the Chinese femur and its relevance in total knee arthroplasty. *J Arthroplasty* 2004;19(5):613-619.

42. Ho WP, Cheng CK, Liau JJ. Morphometrical measurements of resected surface of femurs in Chinese knees: correlation to the sizing of current femoral implants. *Knee*.2006;13(1):12-14.

43. Kwak DS, Surendran S, Pengatteeri YH, Park SE, Choi KN, Gopinathan P, Han SH, Han CW. Morphometry of the proximal tibia to design the tibial component of total knee arthroplasty for the Korean population. *Knee*. 2007;14(4):295-300.

44. Shelbourne KD, Gray T, Benner RW. Intercondylar notch width measurement differences between African American and white men and women with intact anterior cruciate ligament knees. *Am J Sports Med*. 2007;35(8):1304-1307.

45. Bellemans J, Carpentier K, Vandenneucker H, Vanlauwe J, Victor J.The John Insall Award: Both morphotype and gender influence the shape of the knee undergoing TKA. *Clin Orthop Rel Res*. 2010;468(1):29-36.