Preoperative Valgus Alignment Does Not Predict Inferior Outcome of Total Knee Arthroplasty

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Abstract *Background:* Preoperative valgus deformity is present in an estimated 10–20% of patients undergoing total knee replacement (TKR). *Questions/Purposes:* The objective of this study was to compare the Western Ontario and McMaster Universities Arthritis Index (WOMAC) scores after TKR in a matched cohort of patients with preoperative valgus and varus deformities. *Methods:* This is a matched cohort study of 162 patients with varus native knees and 162 patients with valgus native knees who underwent TKR and were prospectively followed in our institutional registry. Patients matched were based on age, BMI, sex, and severity of preoperative knee deformity, which was classified as mild, moderate, severe varus or valgus, or no deformity. Outcomes were evaluated using the WOMAC preoperatively and at 6 weeks, 3 months, 6 months, and 1 year postoperatively. *Results:* No significant difference was found between the matched varus and valgus cohorts in all WOMAC subdomain scores except for a marginally worse stiffness at 1 year in patients with valgus deformity (WOMAC stiffness, 75.1 varus vs. 70.1 valgus; $P = 0.049$). This is below the minimal clinically important difference for WOMAC scores. There was no significant difference in postoperative varus/valgus alignment between

the two groups ($P = 0.092$). *Conclusion:* We found no clinically significant difference in any of the WOMAC domains in patients with preoperative varus deformity versus valgus deformity within the first year after TKR. These findings may allow surgeons to more appropriately counsel patients with osteoarthritis with valgus deformity that they can expect similar outcomes compared to patients with varus deformity.

Keywords valgus · varus · tibiofemoral alignment · total knee arthroplasty · alignment

Introduction

Preoperative valgus deformity is present in an estimated 10–20% of patients undergoing total knee replacement (TKR) [3, 5, 7, 14]. Many surgeons consider valgus alignment to be a uniquely challenging issue which is less routinely encountered compared to varus alignment [6, 11, 15]. Technical challenges related to TKR for valgus deformity include obtaining proper component rotational alignment due to worn or hypo-plastic posterolateral femoral condyles and soft tissue balancing in the coronal plane in both flexion and extension.

Valgus deformity in the native knee has been associated with rheumatoid arthritis [1], and prior studies of valgus knees have generally reported aggregate outcomes of TKR for patients with both osteoarthritis and inflammatory arthritis [5, 15]. Stern et al. reported the outcomes of TKR in 110 knees with valgus alignment at a mean of 4.5 years follow-up and found an average improvement in HSS Knee Score from 49 to 86 postoperatively with 71% excellent outcomes [15]. Ranawat et al. demonstrated a mean modified Knee Society clinical score of 93 and a mean functional score of 81, with 110 degrees of motion in 35 knees with valgus deformity, at a minimum of 5 year follow-up after TKR [14]. While several reports exist on outcomes of TKR in small patient cohorts using a variety of techniques for coronal

Level of Evidence: III: Retrospective Cohort Study.

Investigation was performed at Hospital for Special Surgery.

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balancing, the literature is lacking in data on the outcomes in large cohorts of patients who have undergone TKR for osteoarthritis with preoperative valgus alignment.

The primary objective of this study was to compare the 1-year Western Ontario and McMaster Universities Arthritis Index (WOMAC) scores in a matched cohort of patients with preoperative valgus and preoperative varus deformities who underwent total knee arthroplasty. We hypothesized that patients with valgus deformity would have worse WOMAC scores compared to a matched cohort of patients with varus deformity.

Patients and Methods

This is a matched cohort study of 162 patients with preoperative varus knees and 162 patients with preoperative valgus knees who underwent TKR. Using our institution's prospective joint replacement registry which includes patients from 2007 to present, we identified 1171 patients who underwent primary total knee arthroplasty for a diagnosis of osteoarthritis of the knee and had at least 1 year of follow-up data. Seventy-eight patients (6.66%) were excluded because they did not have plain radiographs available. Coronal degree of knee deformity for the remaining 1093 patients was evaluated on plain x-ray short radiographs of the knee for all patients. All measurements were made by a single trained research assistant (MT). Within this cohort, we identified 173 patients (15.8%) with preoperative valgus deformity. We matched these patients to patients with varus deformity based on the following criteria: age within ± 7 years, BMI ± 3.5 , exact sex, and category of severity of deformity. Inclusion criteria for the valgus knee cohort were patients aged > 18 years with a valgus aligned native knee who underwent primary total knee arthroplasty for a diagnosis of osteoarthritis with at least 1 year of follow-up. Exclusion criteria were prior high tibial osteotomy or other bony procedure for alignment of the knee joint, diagnosis of

inflammatory arthritis or other cause of deformity besides osteoarthritis, and unicondylar knee replacement.

One hundred and sixty-two patients with valgus deformity were matched to 162 patients with varus deformity. Before matching, patients with varus deformity had a significantly higher BMI compared to patients with valgus deformity (31.3 vs. 29.9, respectively; $P = 0.0058$). There were significantly more females in the valgus group compared to the varus group. After matching, there were no significant differences between the two groups. (Table 1)

The categories of deformity were defined as follows: severe valgus, > 15 degrees of femorotibial valgus; moderate valgus, 10.00–14.99 degrees of femorotibial valgus; mild valgus, 7.01–9.99 degrees femorotibial valgus; severe varus, > 4 degrees femorotibial varus; moderate varus, 1.99 degrees femorotibial valgus to 3.99 degrees femorotibial varus; mild varus, 2.00 degrees femorotibial valgus to 4.99 degrees femorotibial valgus; no deformity, 5.00–7.00 degrees femorotibial valgus (Table 2). In the matched cohort, 20% of patients had severe deformity, 47% had moderate deformity, and 33% had mild deformity. The average age was 69 years, the average BMI was 29.5, and 82% of patients were male. Postoperatively, there was no significant difference in varus/valgus alignment between the two groups. The mean postoperative alignment in the valgus knee groups was 3.5 degrees of valgus, while the mean postoperative alignment in the control group was 3.1 degrees ($P = 0.09$).

Outcome was evaluated using the WOMAC preoperatively and at 6 weeks, 3 months, 6 months, and 1 year postoperatively. The WOMAC score is a validated patient-reported outcome measure of pain, stiffness, and function of the hip and knee [2].

Matching variables were compared between varus and valgus cohorts using a Student t test for continuous variables and chi-square test for categorical variables. A Student t test was used to detect differences between the matched varus and valgus cohorts in WOMAC subdomain scores preoperatively and at each follow-up time point. Subsequently, multiple linear regression analysis was performed looking

Table 1 Matching characteristics

Characteristics used for matching	Before matching					After matching				
	Varus <i>n</i> = 623		Valgus <i>n</i> = 173		<i>P</i> value	Varus <i>n</i> = 162		Valgus <i>n</i> = 162		<i>P</i> value
	Mean	Std	Mean	Std		Mean	Std	Mean	Std	
Age	67.4	8.8	69.0	10.1	0.0526	69.0	9.2	69.1	9.5	0.9101
BMI	31.3	6.8	29.9	5.7	0.0058	29.6	5.4	29.5	5.2	0.9393
	<i>N</i>	%	<i>N</i>	%		<i>N</i>	%	<i>N</i>	%	
Gender					< .0001					0.9999
Female	376	60.4	141	81.5		29	17.9	29	17.9	
Male	247	39.6	32	18.5		133	82.1	133	82.1	
Severity of deformity					< .0001					0.9999
Mild	90	14.4	60	34.7		54	33.3	54	33.3	
Moderate	309	49.6	80	46.2		76	46.9	76	46.9	
Severe	224	36	33	19.1		32	19.8	32	19.8	

Table 2 Categories of deformity of femorotibial alignment

Category	Degrees of deformity
Severe valgus	> 15.00 valgus
Moderate valgus	10.00–14.99 valgus
Mild valgus	7.01–9.99 valgus
No deformity	5.00–7.00 valgus
Mild varus	2.00–4.99 valgus
Moderate varus	1.99 valgus to 3.99 varus
Severe varus	> 4.00 varus

at WOMAC scores at 1 year postoperatively as the outcome variable, adjusting for the baseline scores.

Results

No significant difference was found between the matched varus and valgus cohorts in total WOMAC score or in any WOMAC subdomain scores except for a marginally worse stiffness at 1 year in patients with valgus deformity (WOMAC stiffness, 75.1 varus vs. 70.1 valgus; $P = 0.049$) (Fig. 1). This is below the minimal clinically important difference for WOMAC scores.

Similarly, using regression analysis adjusting for baseline WOMAC scores, patients with valgus deformity had a worse WOMAC stiffness score (-5.2 ± 2.5 ; $P = 0.0331$) at 1 year postoperatively compared to patients with varus deformity. For all subgroups of varus or valgus alignment, we could identify no other significant differences in WOMAC scores.

Discussion

This matched cohort study found no clinically significant differences in WOMAC scores between patients with preoperative varus versus valgus knee deformity at 6 weeks, 3 months, or 1 year after TKR. Patients with valgus deformity had a WOMAC stiffness score that was statistically significantly worse than the varus group at 1 year postoperatively, but the difference in mean values was five points, which falls below the minimal clinically significant difference threshold for the WOMAC stiffness score [13].

This study is not without limitations. First, all measurements of knee alignment were made on plain short radiographs of the knee. The gold standard for measurement of knee alignment is the mechanical axis which can

Fig. 1. WOMAC scores legend: patients with valgus deformity had marginally worse stiffness at 1 year compared to patients with varus deformity (WOMAC stiffness, 70.1 valgus vs. 75.1 varus; $P = 0.049$). No other significant difference in WOMAC scores was noted between the two groups at any time points.

only be determined using full-limb radiographs [9]. However, Colebatch et al. reported that standard AP standing radiographs of the knee are just as reliable as full-length hip to ankle films for measurement of knee alignment [4]. Thus, given the ease of access and reliability of standard short radiographs of the knee, short radiographs were used for all measurements in this study. Second, there was a significantly greater number of male patients compared to female patients in each of our cohorts after matching. This is in contrast to the standard distribution of osteoarthritis in the general population. However, given that our cohorts were matched on relevant demographics, there is no evidence to suggest that this variable would change the generalizability of the study. The strengths of this study include a large patient cohort, as well as a matched design comparing groups subdivided by severity of deformity.

Prior studies have described multiple techniques for addressing severe valgus deformities and have reported the outcomes in small cohorts of patients. Clark et al. reported outcomes of 24 patients who underwent TKR for valgus knees using the “pie crust” technique for the release of lateral soft tissues. They reported an average Knee Society score of 97, a mean Knee Society functional score of 74, and a mean range of motion of 121 degrees at 54-month follow-up [3]. Peters et al. presented a series of 1216 consecutive knee arthroplasties in which they recorded the order of releases for balancing in the coronal plane. In looking at both varus and valgus deformities, the authors noted that patients with valgus deformity requiring multiple releases intraoperatively fared worse than patients with a valgus deformity requiring no releases intraoperatively [12]. These prior studies did not compare outcomes for valgus deformity to the more commonly encountered varus deformity in patients with osteoarthritis. Furthermore, these prior studies used rating schemes that were primarily provider-based measures. Our study is the largest matched cohort of patients with varus versus valgus deformity examining a patient-reported outcome measurement before and after TKR.

While previous literature has described valgus knee TKR as uniquely challenging, prior smaller studies have found similar outcomes in TKR for valgus and varus knees. Similar to the present study, Karachalios et al. compared 34 patients with severe valgus deformity to 17 patients with severe varus deformity and found no significant differences on the Bristol Knee Score up to 10 years postoperatively [10].

Patients with valgus deformity in our cohort had a lower score on the WOMAC stiffness component compared to patients with varus deformity, though this difference was below the previously cited minimal clinically important difference [13]. Postoperative stiffness is thought to be multifactorial [8, 16]. In terms of coronal alignment, postoperative stiffness most likely is more related to the soft tissue balancing achieved during surgery rather than the presurgical malalignment [8, 16]. Further research is needed to determine the link between preoperative deformity and postoperative deformity and subsequent impact on clinical outcome.

In conclusion, we found no clinically significant difference in any of the WOMAC domains in patients with preoperative varus deformity versus valgus deformity within the first year after total knee replacement. These findings may allow surgeons to more appropriately counsel patients with osteoarthritis and valgus deformity that they can expect similar outcomes compared to patients with varus deformity.

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Compliance with Ethical Standards

Conflict of Interest: Cynthia A. Kahlenberg, MD; Myra Trivellas, BS; and Yuo-yu Lee, MS have declared that they have no conflict of interest. Douglas E. Padgett, MD, reports other from American Joint Replacement Registry, Journal of Arthroplasty, and The Hip Society and personal fees from PixarBio and DJ Orthopaedics outside the work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was obtained from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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