The effect of implant size difference on patient outcomes and failure after bilateral simultaneous total knee arthroplasty

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ABSTRACT

Background: Proper sizing of femoral and tibial components has been associated with long-term outcomes and survivorship in simultaneous bilateral total knee arthroplasty (SBTKA) and may be a reason for differences in outcomes between knees. The aim of this study compares post-operative outcomes and revision rates in patients undergoing SBTKA with different component sizes.

Methods: A retrospective review was conducted at a single academic institution identifying patients who underwent SBTKA from 2011 to 2019. Inclusion criteria included: primary osteoarthritis, similar pre-operative deformity, and same implant manufacturer. The primary outcome compares pre- and post-op (Δ) Knee Society Score-Knee Score (KSS-KS) and range of motion (ROM) between knees. Secondary outcome measures were all-cause revisions rates, including manipulations under anesthesia and arthroscopy with or without lysis of adhesions.

Results: 149 patients were identified who met the inclusion criteria: 128 patients had femoral size difference (FSD) of 0, 138 patients had tibial size difference (TSD) of 0, 21 patients with FSD of 1, and 11 patients with TSD of 1. There was no difference in Δ KSS-KS or Δ ROM in patients for any FSD or TSD. Revisions for aseptic loosening were greater for TSD 1 compared to TSD 0 ($p < 0.001$). No other differences in cause of revision were identified.

Conclusion: A TSD of 1 may be associated with increased revision rates for aseptic loosening in both smaller and larger sized implants. Surgeons may achieve optimal patient outcomes in SBTKA with proper sized implants through increased awareness of component asymmetry and repeat intraoperative evaluation when asymmetrical measurements occur.

1. Introduction

Degenerative joint disease (DJD) has been determined to be one of the leading causes of disability in the world, affecting nearly half of individuals over the age of 65.^{1–3} While DJD of the knee typically affects the joint unilaterally, 20% of the population experience severe DJD in both knees, prompting the need for bilateral total knee arthroplasty (BTKA).^{4,5} BTKA is performed through one of two approaches: simultaneous or staged. The decision for simultaneous BTKA is largely based on individualized patient indications, physical conditions, and surgeon's experience and preference.⁶ While studies have demonstrated simultaneous BTKA to be associated with increased risk for gastrointestinal, cardiac, pulmonary, and thromboembolic complications when compared to the traditional unilateral TKA, other sources note simultaneous BTKA to be a safe and effective procedure with

comparable survivorship and patient satisfaction levels to a unilateral replacement.^{4,5,7,8}

One critical factor that affects long-term outcomes of all patients undergoing TKA, is the proper sizing of implant components.⁹ Most commonly in BTKA, components are sized equally in both knees, with differences in implant size reportedly occurring in 5.1–8.7% of cases.^{10,11} Implant size is chosen based on both pre-operative radiographic templating which predicts tibial and femoral size correctly 50–60% of the time and within 1 size 90–95% of the time, and intraoperative measurements and evaluation.¹² However, component asymmetry can arise as a result of errors in preoperative templating, intraoperative sizing measurements, and anatomical variations of the knee.^{9–13} Moreover, the asymmetry rates for each component are reported to range between 6.7 and 9.3% (femoral) and 1.1–8.6% (tibial).^{9–11}

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While differences in implant size occur infrequently, they can have a major negative effect on knee outcomes.^{14–16} Oversizing the femoral component can cause decreased flexion range of motion (ROM), increased anterior knee pain due to patella overstuffing and stiffness, and reduced functional outcomes, while undersizing negatively affects flexion stability, pain, and increases the risk of premature component loosening.^{9,12} Proper sizing of the tibial component allows optimal load transfer to the cortical bone, avoids the potential complication of subsidence, and enhances osseointegration when necessary (cementless implants) for implant fixation and survivorship.¹⁶ Oversizing the tibial component is associated with poorer functional outcomes, loss of flexion, and residual pain whereas undersized tibial components can lead to subsidence and failure.^{15–17}

There is currently limited data regarding the functional outcomes and revision rates of patients who undergo a BTKA procedure with different component sizes. The aim of this study was to determine if implant size difference affects the functional outcomes and failure rates of patients who undergo simultaneous BTKA while controlling for external variables. We hypothesize that patients with asymmetrical implants will experience worse functional outcomes and greater failure rates than patients with symmetrical implants.

2. Methods

2.1. Study design and patient population

After receiving approval from our Institution Review Board (IRB), a retrospective chart review was conducted at a single tertiary academic medical center identifying patients who underwent simultaneous BTKA completed by the same surgeon from June 2011 to May 2019. Patient inclusion criteria included: primary diagnosis of osteoarthritis, similar pre-operative varus or valgus deformity, identical implant manufacturer, constraint type and constraint design. Patients who did not meet these criteria were excluded. Pre-operative deformities were determined by the anatomical alignment of each knee as per radiographic measurement on weight-bearing plain films (Fig. 1). By convention, varus and valgus alignment were designated as negative and positive values, respectively. Radiographic measurements were performed by three research fellows who were trained to collect these measurements by a senior fellowship-trained adult joint reconstruction surgeon. All measurements were reviewed by the senior surgeon for quality assessment.

Pre-operative and post-operative Knee Society Scores-Knee Score (KSS-KS) and ROM for each patient were also collected and their differences were calculated as a delta (Δ). A Δ KSS-KS of 5.3 was considered to be the minimal clinically important difference (MCID).¹⁸ Baseline patient demographics including age, body mass index (BMI), gender, race, and American Society of Anesthesiologists (ASA) score, were collected. Surgical data such as operative time and pre-operative joint stability were collected as well. All-cause revisions such as revisions for aseptic loosening and instability, manipulation under anesthesia (MUA) and arthroscopy with or without lysis of adhesion were documented for each knee. The primary outcome analyzed the relationship between implant size difference with knee outcomes determined by Δ KSS-KS and Δ ROM. The secondary outcome measured the relationship between implant size differences and revision rates.

Multiple institutional protocols were placed to minimize any intra-operative or post-operative factors affecting functional outcomes and revision rates reported in this study. To reduce infection rates, an intraoperative lavage consisting of 0.35% povidone-iodine (17.5 mL in 500 mL saline) solution is irrigated into the surgical wound followed by 2 g of vancomycin powder during wound closure.¹⁹ Multimodal opioid-sparing pain management protocols were used to optimize pain control and reduce postoperative complications, improve patient satisfaction, and expedite recovery, rehabilitation, and discharge in patients undergoing TKA at our institution.²⁰ This includes the use of perioperative non-steroidal anti-inflammatory drugs (NSAIDs), intraoperative intravenous acetaminophen, and periarticular infiltration with liposomal bupivacaine. These methods have been shown to reduce postoperative opioid consumption and improve analgesia with less side effects, facilitate rapid rehabilitation, and decrease length of stay and discharge to skilled nursing facilities.

2.2. Statistical analysis

A post-hoc power analysis ($\alpha = 0.05$ and power of 80%) was conducted using G*Power version 3 (Erdfeiler, Faul, & Buchner, Germany) to determine the sample size needed for each cohort to identify a MCID in the Δ KSS-KS between cohorts. Assuming an equal distribution, a sample size of 59 patients (59 BTKAs per cohort) was deemed necessary to identify a MCID in the Δ KSS-KS for patients in the FSD 0 group, 60 patients for the TSD 0 group, 42 patients for the FSD 1 group, and 69 patients for the TSD 1 group.

Further statistical analyses were performed using SPSS v25 (IBM

Fig. 1. Pre-operative anteroposterior (AP) radiograph of a patient with severe bilateral osteoarthritis (A). Post-operative AP radiograph demonstrating a bilateral TKA with a FSD and TSD of 0 after deformity correction (B). Post-operative AP radiograph of another patient with a similar pre-operative deformity demonstrating a bilateral TKA with the larger femoral component (FSD 1) on the right knee (C). Post-operative AP radiograph of another patient with a similar pre-operative deformity demonstrating a bilateral TKA with the larger tibial component (TSD 1) on the left knee (D).

Corporation, Armonk, New York). Descriptive data was reported as means $\pm$ standard deviation for continuous data and counts (%) for categorical variables. Both paired and unpaired, two-tailed t-tests and chi-squared tests were used to compare demographic data between patient populations within each implant cohort. Simple bivariate comparisons for Δ KSS-KS and Δ ROM were done using paired-sample, two-tailed t-tests. Chi-squared tests were used to compare revision rates between cohorts of different implant sizes. A p-value < 0.05 was deemed to be statistically significant.

3. Results

A total of 149 eligible simultaneous BTKA cases (298 knees, and 298 total femoral and tibial implants) were identified and evaluated for knee outcomes and revision rates. Patients were separated into cohorts by implant size which were categorized by size differences of 0 (total n = 128 femoral implants and 138 tibial implants) or 1 (total n = 21 femoral implants and 11 tibial implants) between both knees in the same patient. Average follow-up was 12.3 ± 9.5 months (range: 0.5–45 months). There were no patients identified with a size difference greater than 1 in either the femoral or tibial component. There were no demographic or surgical differences found in both the femoral size difference (FSD) or tibial size difference (TSD) cohorts (Table 1).

Simple bivariate comparisons between Δ KSS-KS and Δ ROM in same patients by FSD showed no clinical or statistical differences in Δ KSS-KS or Δ ROM (Table 2). Patients with a FSD of 0 had an average Δ KSS-KS of 51.6 ± 10 and 51.8 ± 11 ($p = 0.84$) and Δ ROM of $7.4^\circ \pm 16^\circ$ and $5.4^\circ \pm 19^\circ$ ($p = 0.17$) between knees. Patients with a FSD of 1 had an average Δ KSS-KS of 53.9 ± 9.5 in the smaller implant and 53.9 ± 7.6 in the larger implant ($p = 0.84$) and Δ ROM of $7.4^\circ \pm 14.5^\circ$ in the smaller implant and $5.4^\circ \pm 14.9^\circ$ in the larger implant ($p = 0.17$). Similar comparisons were conducted by TSD, which revealed no difference in Δ KSS-KS and Δ ROM in patients with TSD of 1 (KSS: 55.5 ± 7.9 in the larger implant vs 45.2 ± 13.5 in the smaller implant, $p = 0.08$; ROM: $5.7^\circ \pm 20.3^\circ$ in the larger implant vs $0^\circ \pm 14^\circ$ in the smaller implant, $p = 0.13$) (Table 3). There was no difference detected for Δ KSS-KS ($p = 0.52$) or Δ ROM ($p = 0.17$) in patients with a

TSD of 0.

The overall revision rates for FSD 0 and 1 were found to be 0.8% and 0%, respectively. There were no differences detected in any causes of revision for aseptic loosening, instability, MUA, or arthroscopy with or without lysis of adhesions (Table 4). The overall revision rates for TSD 0 and 1 were found to be 1.4% and 18%, respectively. Revision for aseptic loosening occurred more frequently in patients with TSD 1 in both the smaller and larger sized implants compared to those with TSD 0 (18% vs. 0.7%, $p < 0.001$). No other differences were found for any other cause of revision.

4. Discussion

Implant size is known to be a major factor in long-term outcomes and survivorship in TKA as improper component sizing is potentially associated with poor functional outcomes and pain following TKA.^{12,14,15} However, there is limited evidence regarding the degree of component sizing and its effect on outcomes and revision rates in simultaneous BTKA, especially when controlled for patient and surgery-specific factors.

The limitations of our study are mainly inherent to its retrospective design and small sample size. Due to retrospective chart review, our results are susceptible to selection bias and other confounding variables that we could not control for had we prospectively collected our data such as accounting for anthropometric measurements in our study population, which is known to affect implant size.¹³ However, we have attempted to minimize these variables using a strict inclusion criterion, which we believe yielded us higher quality data. Additionally, our results are reported from a single center with a small sample size, which may limit its applicability to the general BTKA population. Last, we acknowledge that our minimum follow-up for our outcomes may be too short to assess any clinical significance (0.5 months). However, when comparing our data using a 2-month and 1-year minimum follow-up period, we found similar trends with the cohort using the 0.5-month minimum follow-up period and decided to include this larger cohort for the purposes of this study.

Our study found no differences in KSS-KS or ROM by FSD or TSD,

Table 1
Patient demographics and surgical characteristics by femoral and tibial component.

Variables	FSD 0 (n = 128)	FSD 1 (n = 21)	p-value*	TSD 0 (n = 138)	TSD 1 (n = 11)	p-value*
Demographic data						
Age	61.8 $\pm$ 6.8	63.2 $\pm$ 5.5	0.28	61.7 $\pm$ 6.7	65.1 $\pm$ 5	0.06
BMI	31.4 $\pm$ 4.2	31.4 $\pm$ 5.2	0.97	31.4 $\pm$ 4.4	31 $\pm$ 4.2	0.73
ASA	2.02 $\pm$ 0.27	2.05 $\pm$ 0.5	0.83	2.04 $\pm$ 0.3	1.9 $\pm$ 0.3	0.2
Gender	49 (38%)	10 (48%)	0.42	53 (38%)	7 (64%)	0.1
Male	79 (62%)	11 (52%)		85 (62%)	4 (36%)	
Female						
Race	74 (58%)	18 (86%)	0.050475	85 (62%)	7 (64%)	0.92
White	22 (17%)	1 (5%)		21 (15%)	2 (18%)	
African American (Black)	32 (25%)	2 (9%)		32 (23%)	2 (18%)	
Other Race (including Asian)						
Surgical Data						
Operation Time (minutes)	174.3 $\pm$ 44.9	188.2 $\pm$ 36.3	0.13	175.1 $\pm$ 44	190.5 $\pm$ 42.6	0.28
Varus/Valgus Alignment (degrees)	$-1.25^\circ \pm 6.9^\circ$	$-1.88^\circ \pm 8.1^\circ$	0.63	$-1.25^\circ \pm 7.0^\circ$	$-2.41^\circ \pm 8.2^\circ$	0.53
A-P Stability	< 5 mm	< 5 mm	1.0	< 5 mm	< 5 mm	1.0
	128 (100%)	21 (100%)		138 (100%)	11 (100%)	
	> 5 mm	> 5 mm		> 5 mm	> 5 mm	
	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
M-L Stability	< 5°	< 5°	0.68	< 5°	< 5°	0.78
	127 (99%)	21 (100%)		137 (99%)	11 (100%)	
	> 5°	> 5°		> 5°	> 5°	
	1 (1%)	0 (0%)		1 (1%)	0 (0%)	
Constraint Type	12 (9%)	2 (10%)	0.92	14 (10%)	0 (0%)	0.51
Cruciate Retaining	115 (90%)	19 (90%)		123 (89%)	11 (100%)	
Posterior-Stabilized	1 (1%)	0 (0%)		1 (1%)	0 (0%)	
Constrained						
Mean Follow-Up Time for Outcomes (in months)	12.3 $\pm$ 9.5	–	–	12.3 $\pm$ 9.5	–	–

*p-values derived from two-tailed, paired and unpaired t-tests or chi-squared test.

Table 2Bivariate comparison between Δ KSS-KS and Δ ROM by femoral size difference (FSD) in same patients.

FSD 0 (n = 128)				FSD 1 (n = 21)		
Variables	Left Knee	Right Knee	p-value*	Smaller Implant	Larger Implant	p-value*
Δ KSS-KS	51.6 $\pm$ 10	51.8 $\pm$ 11	0.84	53.9 $\pm$ 9.5	53.9 $\pm$ 7.6	1
Δ ROM	7.4° $\pm$ 16°	5.4° $\pm$ 19°	0.17	6° $\pm$ 14.5°	7.9° $\pm$ 14.9°	0.38
2-month minimum follow-up						
FSD 0 (n = 118)				FSD 1 (n = 20)		
Variables	Left Knee	Right Knee	p-value*	Smaller Implant	Larger Implant	p-value*
Δ KSS-KS	51.3 $\pm$ 10.2	52.1 $\pm$ 11.1	0.41	54.4 $\pm$ 9.5	54.6 $\pm$ 7.1	0.9
Δ ROM	8.4° $\pm$ 16°	6.8° $\pm$ 18.2°	0.24	7.9° $\pm$ 12.2°	10.1° $\pm$ 11.1°	0.29
1-year minimum follow-up						
FSD 0 (n = 68)				FSD 1 (n = 8)		
Variables	Left Knee	Right Knee	p-value*	Smaller Implant	Larger Implant	p-value*
Δ KSS-KS	52 $\pm$ 9.1	52.5 $\pm$ 12.3	0.74	55.1 $\pm$ 8.6	55.9 $\pm$ 9.2	0.72
Δ ROM	6.4° $\pm$ 15.4°	5.75° $\pm$ 14.3°	0.6	2.75° $\pm$ 8.2°	9° $\pm$ 10.1°	0.24

which agrees with the current literature.^{9–12} Reddy et al. studied femoral and tibial component asymmetry in the Indian population and reported no outcome differences in either cohort.⁹ Additionally, Brown et al. reviewed 268 consecutive simultaneous and staged BTKAs and found no differences in knee scores, pain, function, ROM, or complications in patients with asymmetrical femoral, tibial, and patellar components.¹⁰ Similarly, Capeci et al. compared KSS and ROM in symmetrical and asymmetrical femoral and tibial components of anterior and posterior referenced bilateral TKAs and also found no difference between each cohort.¹¹ Pinsornsak et al. investigated the clinical and post-operative functional outcomes including ROM and KSS in patients with symmetrical and asymmetrical femoral components and also reported no differences between the two groups.¹² While the literature shows no differences between pre- and post-op results for KSS and ROM in BTKAs with femoral or tibial component asymmetry, our study attempts to expand upon the literature by comparing the *degree* of implant size difference and its relationship to patient reported outcome (PRO) scores and ROM. Neither increasing FSD nor TSD was shown to affect PRO scores or ROM. Although there was a trend towards higher KSS favoring the larger tibial implant between the two knees at a difference much greater than the MCID in our TSD 1 group, our results were not statistically significant possibly due to our small sample size. These results may suggest that undersizing implants in simultaneous BTKA leads to poorer outcomes, however future studies are needed to

determine whether this difference is true using either a larger sample size or including greater implant size differences of 2 or more.

In addition to implant size *difference*, analyses examining implant size's effect on knee outcomes were conducted using simple linear plot and regression models. The regression model found no significant differences between femoral or tibial size for ROM ($p = 0.613$ for femoral size and 0.729 for tibial size), but found a difference in KSS-KS at an unstandardized beta coefficient of -0.840 for femoral size ($p = 0.033$) and -1.052 for tibial size ($p = 0.006$). These data may suggest that oversizing implants in simultaneous BTKA is also associated with poorer outcomes. There are mixed findings in the literature that discuss the impact of implant size on knee outcomes.^{12,15–17,21} Pinsornsak et al. did not find any differences in KSS or post-op ROM when comparing different femoral component size in posterior referenced bilateral TKAs.¹² Abram et al. also found no difference in their outcome scores [Oxford Knee Score (OKS), Western Ontario and McMaster Universities Arthritis Index (WOMAC), and Short-Form Health Survey (SF-12)] with differing tibial sizes in uncemented unilateral TKA.¹⁶ However, several other studies report differences with larger implant sizes.^{15,17,21} Kawahara et al. found that upsizing the femoral component increases anterior offset, anterior overstuff, and patellofemoral contact force, which may influence outcomes related to pain and ROM.²¹ Moreover, the findings of Bonnin et al. found that tibial oversizing was associated with lower ROM and functional scores measured by the Knee Injury and

Table 3Bivariate comparison between Δ KSS-KS and Δ ROM by tibial size difference (TSD) in same patients.

TSD 0 (n = 138)				TSD 1 (n = 11)		
Variables	Left Knee	Right Knee	p-value*	Smaller Implant	Larger Implant	p-value*
Δ KSS-KS	51.8 $\pm$ 10.2	52.4 $\pm$ 10.2	0.52	45.2 $\pm$ 13.5	55.5 $\pm$ 7.9	0.08
Δ ROM	7.7° $\pm$ 15.6°	5.8° $\pm$ 18.8°	0.17	0° $\pm$ 14°	5.7° $\pm$ 20.3°	0.13
2-month minimum follow-up						
TSD 0 (n = 128)				TSD 1 (n = 10)		
Variables	Left Knee	Right Knee	p-value*	Smaller Implant	Larger Implant	p-value*
Δ KSS-KS	51.6 $\pm$ 10.3	52.8 $\pm$ 10.1	0.17	45.3 $\pm$ 14.2	57.1 $\pm$ 6.3	0.07
Δ ROM	8.6° $\pm$ 15.4°	7° $\pm$ 17.8°	0.25	3° $\pm$ 10.4°	10° $\pm$ 15.3°	0.08
1-year minimum follow-up						
TSD 0 (n = 69)				TSD 1 (n = 7)		
Variables	Left Knee	Right Knee	p-value*	Smaller Implant	Larger Implant	p-value*
Δ KSS-KS	52.2 $\pm$ 9.3	53.3 $\pm$ 11	0.32	43.6 $\pm$ 16.9	58.7 $\pm$ 6.7	0.1
Δ ROM	6.2° $\pm$ 14.6°	5.6° $\pm$ 14°	0.57	2.4° $\pm$ 11.3°	12.4° $\pm$ 17.9°	0.07

Table 4
Reoperation rates in femoral and tibial components by size difference.

Cause of Reoperation	FSD 0 (n = 128)		FSD 1 (n = 21)		p-value*		TSD 0 (n = 138)		TSD 1 (n = 11)		p-value*
	Counts (%)	Mean Time in Months (range)	Counts (%)	Mean Time in Months (range)	Counts (%)	Mean Time in Months (range)	Counts (%)	Mean Time in Months (range)	Counts (%)	Mean Time in Months (range)	
All Cause Revision^a	1 (0.8)	10.8	0 (0)	–	0.13	11.7 (10.8–12.6)	2 (1.4)	11.7 (10.8–12.6)	2 (18)	11.7 (10.8–12.6)	0.33
Aseptic Loosening	0 (0)	–	0 (0)	–	–	12.6	1 (0.7)	12.6	2 (18)	26.1 (20.8–31.4)	< 0.001
Instability	1 (0.8)	10.8	0 (0)	–	0.68	10.8	1 (0.7)	10.8	0 (0)	–	0.79
MUA	10 (8)	8.4 (0.7–25.5)	0 (0)	–	0.18	8.4 (0.7–25.5)	10 (7.2)	8.4 (0.7–25.5)	0 (0)	–	0.38
Arthroscopy ± lysis of adhesions	2 (1.6)	11.8 (7.1–26.6)	0 (0)	–	0.56	11.8 (7.1–26.6)	2 (1.4)	11.8 (7.1–26.6)	0 (0)	–	0.7
2-month minimum follow-up											
All Cause Revision^a	1 (0.8)	10.8	0 (0)	–	0.68	10.8	1 (0.8)	10.8	2 (20)	26.1 (20.8–31.4)	< 0.001
Aseptic Loosening	0 (0)	–	0 (0)	–	–	–	0 (0)	–	2 (20)	26.1 (20.8–31.4)	< 0.001
Instability	1 (0.8)	10.8	0 (0)	–	0.68	10.8	1 (0.8)	10.8	0 (0)	–	0.78
MUA	9 (7)	7.2 (0.7–25.5)	0 (0)	–	0.2	7.2 (0.7–25.5)	9 (7)	7.2 (0.7–25.5)	0 (0)	–	0.39
Arthroscopy ± lysis of adhesions	2 (1.7)	11.8 (7.1–26.6)	0 (0)	–	0.56	11.8 (7.1–26.6)	2 (1.6)	11.8 (7.1–26.6)	0 (0)	–	0.69
1-year minimum follow-up											
All Cause Revision^a	1 (1.5)	10.8	0 (0)	–	0.73	10.8	1 (1.4)	10.8	2 (28.6)	26.1 (20.8–31.4)	< 0.001
Aseptic Loosening	0 (0)	–	0 (0)	–	–	–	0 (0)	–	2 (28.6)	26.1 (20.8–31.4)	< 0.001
Instability	1 (1.5)	10.8	0 (0)	–	0.73	10.8	1 (1.4)	10.8	0 (0)	–	0.73
MUA	7 (10.3)	7.8 (0.7–25.5)	0 (0)	–	0.34	7.8 (0.7–25.5)	7 (10)	7.8 (0.7–25.5)	0 (0)	–	0.34
Arthroscopy ± lysis of adhesions	2 (2.9)	11.8 (7.1–26.6)	0 (0)	–	0.62	11.8 (7.1–26.6)	1 (1.4)	11.8 (7.1–26.6)	0 (0)	–	0.73

^a all-cause revisions include aseptic loosening or instability revisions.

Osteoarthritis Outcome Score (KOOS) and increased pain.^{15,17} Our results reflect the findings of these studies more closely with the exception of pain, which was not assessed in our analysis.

The secondary outcome of our study is, to our knowledge, the first to investigate revision rates by implant size difference in patients undergoing simultaneous BTKA. When comparing component size difference by revision rates, there was no difference in all cause revision rates ($p = 0.13$ in any FSD and $p = 0.33$ in any TSD). However, when comparing varying degrees of size difference, we found that patients with a TSD of 1 had the highest revision rates for aseptic loosening in both the larger and smaller component in our affected patients ($p < 0.001$). A post-hoc analysis for aseptic loosening between TSD 0 and TSD 1 determined these findings to be powered at 62% (assuming $\alpha = 0.05$), 72% ($\alpha = 0.10$), and 82% ($\alpha = 0.15$). It is known that tibial loosening after TKA results from incomplete cementation, poor component alignment, and soft-tissue imbalance.^{22,23} Tibial component loosening of posterior cruciate ligament (PCL)-retaining TKA frequently occurs with more medial placement and varus tilt of the tibial component.^{22,24} Tibial component loosening in PCL-substituting TKA is commonly seen in patients with varus tibial femoral alignment, varus tilt of the tibial component, or excessive tibial resection.²⁵ Tibial component size alone has not been shown to affect aseptic loosening in limited studies, however there is still uncertainty regarding revision rates among varying degrees of tibial size difference in BTKA.²⁶ As asymmetrical rates for the tibial component occur between 1.1% and 8.6% of cases and may arise as a result of errors in preoperative templating, intraoperative sizing measurements, gap balance, and positional errors such as implant rotation, proper surgical technique becomes essential.^{9–13} Thus, surgeons require increased awareness of the incidence of component asymmetry and may choose to repeat intraoperative evaluation when asymmetrical measurements occur to minimize such complications and optimize patient outcomes.

Our study's cohorts demonstrated no significant differences in demographic data including age, gender, race, or BMI between each group. While white race trended towards statistical significance in our FSD 1 group ($p = 0.050475$), there are currently no studies to support any particular race as a risk factor for component asymmetry. Moreover, this characteristic may just be unique to our institution's patient population. Other studies, particularly Yang et al., reported that asymmetrical active ROM, quadriceps strength, and visual analogue scale (VAS) pain score in simultaneous BTKA with component asymmetry are associated with risk factors such as old age, female gender and high BMI.²⁷

5. Conclusion

A tibial implant size difference of 1 between two knees in the same patient may be associated with increased revisions for aseptic loosening without any significant changes in knee scores or ROM when controlled for patient and surgery-specific factors. These findings may suggest that surgeons performing BTKA can achieve optimal outcomes through repeat intraoperative evaluation when asymmetrical measurements occur.

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