Establishing Acceptable Leg Length Discrepancy and Hip Offset following Total Hip Arthroplasty Using Anatomic Variation in Patients at Risk of Developing Osteoarthritis

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Leg length and hip offset are fundamental surgical principles in total hip arthroplasty (THA). Postoperative THA patients may endorse the sensation that one leg feels longer than the other, known as patient-perceived leg length difference (LLD). Preoperative LLDs have also been associated with poor postoperative patient-perceived LLD and functional outcomes. However, there are no large-scale studies that establish acceptable anatomic variation in leg length differences or hip offset. The primary objective of this study was to determine normal anatomic variation in preoperative LLD in patients at-risk of hip osteoarthritis. Second, we aimed to determine anatomic variation of parameters which determine biomechanics of the hip and contribute to the development of hip osteoarthritis, including hip femoral offset. METHODS:

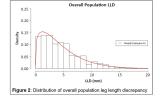
A retrospective study was conducted using data of 543 pre-osteoarthritic patients from a multicenter, ten-year longitudinal study focused on osteoarthritis (OA). The study population consisted of patients aged 45-79 with early or at-risk of developing hip osteoarthritis. Exclusion criteria included history of inflammatory arthritis (e.g., rheumatoid arthritis), bilateral Kellgren-Lawrence >2 OA, or previous history of THA. Radiographic evaluation was conducted using baseline full limb length weight-bearing AP radiographs of bilateral lower extremities. Measurements were conducted using ImageJ software. T-test and ANOVA were used to compare normally distributed data. Shapiro-Wilk test of normality was used to verify the normality of distribution. Multiple linear regression models controlling for sex, age category, height category, and BMI were employed to predict whether there were side-to-side differences in LLD, Δ femoral offset, Δ abductor muscle length (AML), Δ abductor lever arm (ALA), and Δ AP pelvic offset (APO). RESULTS:

The mean anatomic LLD for the population was 5.5mm (range 0 - 19.1mm), and 95% of the population had a LLD of less than 12mm. No significant differences were observed in LLD with regard to sex, age, BMI, or height. The median anatomic difference in femoral offset, abductor muscle length, abductor lever arm, and AP pelvic offset for the population were 3.2mm (0 - 17.2mm), 4.8mm (0-27.7mm), 3.6mm (0-18.8mm), and 3.3mm (0-18.4mm), respectively. In total, 95% of the population had a difference of less than 11mm, 17.5mm, 11.7mm, and 11.5mm, respectively for femoral offset, AML, ALA, and APO. Regression model significantly predicted Δ femoral offset (p=0.007). With regard to femoral offset, height categories of 160-175 and 175-190 were significant predictors of Δ femoral offset (p=0.03, p=.02, respectively). With regard to AML, height category of 175-190 and age category of 60-70 were significant predictors of Δ AML (p=0.002, p=0.003, respectively).

DISCUSSION AND CONCLUSION:

There is a paucity of data available on normal variation in leg length and hip offset. Normal anatomic variation in patients at risk of developing osteoarthritis can be used to help establish acceptable differences in these values. With a study population comprised of pre-osteoarthritic patients with minimal symptoms, our results reveal a mean LLD of 5.5mm and imply a postoperative LLD up to 12mm are within 95% of the pre-osteoarthritic population, respectively. Normal LLD is not affected by age, gender, BMI, and height. Hip-offset is dependent on patient characteristics, especially height. These normal anatomic variations can assist in discussing postoperative perceived LLD and functional versus absolute LLD.





Patient Count	543				
Average BMI s ad (kg/m2)	29.4 ± 4.0				
Average Age ± sd (years)	616±9.0				
Average Height ± sd (on)	195.7 ± 8.8				
	LLD	ΔPO	A AVL	AALA	A APO
Median [interquartile range] (mm)	3.9[1.9-6.2]	3.2 [1.3-5.5]	4.8 [2.1-8.9]	3.6[1.8-6.4]	3.3 [1.4-5.1
Plantae (mm)	0 - 19.1	0 - 17.2	0 - 27.7	0 - 18.6	0 - 15.4
Median [interquartile range] (mm) by Gender					
Male (184)	3.9[1.8-7.0]	3.9 (1.7-5.9)	6.2 (2.7-10.8)	4.1 (2.2-6.5)	3.8 [1.6-5]
Female (359)	3.6(1.9-6.0)	2.9 (1.2-5.2)	4.3 (2.0-7.9)	3.511.6-6.21	3.111.2-5
median [interquantle range] (mm) by Age Group (years)					
40-80 (71)	3.4 [1.7-5.4]	2.8 [1.2-5.2]	3.9 (1.9-7.2)	3.512.2-6.61	3.1(1.4-6)
50-60 (187)	4.0[1.0-6.4]	3.6 (1.5-6.1)	4.1 (2.0-0.1)	3.611.5-6.11	3.4 (1.3-6)
60-70 (176)	3.5[1.8-6.9]	2.9 [1.1-5.2]	5.3 [2.3-9.7]	3.7 [1.8-6.5]	3.4 [1.5-5]
70-80 (109)	4.2 (2.0-5.9)	3.111.6-5.98	4.8 (2.4-10.4)	3.812.3-6.41	3.3 (1.2-5)
Median [interquantle range] (mm) by BMI Group (kg/m2)					
15-20 (6)	5.4 [3.6-10.6]	24[1.14.8]	3.6 30.9-5.51	3.1 [1.8-5.0]	3.2 [1.6-4.
20-25 (104)	3.4 [1.7-5.6]	3.111.6-5.38	4.7 (2.8-0.4)	3.7 (1.7-5.9)	3.6 (1.2-5)
25-30 (206)	3.6[1.7-6.2]	3.0 [1.0 - 5.1]	5.1 [1.9-9.4]	3.7 [1.9-6.4]	
30-35 (156)	4.112.3-6.71	3.3 (1.4-6.0)	4.1 [1.9-8.0]	3.5 [1.8-6.7]	3.3 [1.3-6]
35-40 (56)	3.3[1.7-6.2]	3.6 [1.4-7.3]	5.3 [3.0-0.5]	35[12-67]	43 22-7
40.45 (11)	42[13-73]	4.3 [1.6-7.0]	9.0 [4.9-12.5]	62[2969]	26 17-4
Median [interquartite range] (mm) by Height Oroup (om)					
145-160 (135)	3.2[1.6-6.1]	2.6 [1.0-4.5]	4.6 [1.5-8.2]	3.7 (1.8-5.7)	26[11:5
190-175 (291)	4.0[2.0-6.0]	3.2 [1.4-5.6]	4.3 (2.2-7.9)	3.3 [1.6-6.2]	
		4.111.6-6.11	7.6 (3.3-12.2)	4.5 (2.3-7.0)	4.111.8-6.

	FO	AML	ALA	APO
Mean ± sd (mm)	46.5 ± 6.8	98.3 ± 15.8	52.6 ± 6.7	55.4 ± 6.0
Range (mm)	22.3 - 68.9	55.4 - 152.9	30.8 - 72.5	31.3 - 79.7
Mean ± sd (mm) by Gender				
Male	49.3 ± 6.7	100.8 ± 14.9	54.7 ± 6.5	58.9 ± 5.8
Female	45.1 ± 6.4	97.0 ± 16.1	51.6 ± 6.6	53.7 ± 5.3
Mean ± sd (mm) by Age Group (years)				
40-50	45.4 ± 6.4	98.7 ± 16.0	51.9 ± 7.2	55.1 ± 5.5
50-60	46.4 ± 7.0	100.8 ± 16.7	52.7 ± 7.0	55.5 ± 6.3
60-70	46.4 ± 6.2	97.0 ± 14.9	52.9 ± 6.5	55.3 ± 5.7
70-80	47.5 ± 7.6	95.6 ± 15.0	52.7 ± 6.1	55.8 ± 6.4
Mean ± sd (mm) by BMI Group (kg/m2)				
15-20	48.0 ± 5.7	94.8 ± 11.7	54.8 ± 6.4	55.8 ± 5.2
20-25	45.3 ± 7.4	97.8 ± 18.6	51.6 ± 6.8	55.1 ± 6.7
25-30	46.9 ± 6.3	99.3 ± 16.0	53.1 ± 6.8	56.5 ± 5.9
30-35	46.6 ± 7.3	98.5 ± 13.4	52.7 ± 6.4	54.5 ± 5.7
35-40	46.7 ± 6.0	96.7 ± 16.2	52.7 ± 6.3	54.6 ± 5.6
40-45	46.7 ± 8.1	90.6 ± 14.3	50.4 ± 8.6	54.9 ± 6.8
Mean ± sd (mm) by Height Group (cm)				
145-160	44.1 ± 6.5	96.6 ± 15.1	50.7 ± 6.3	52.0 ± 5.0
160-175	46.5 ± 6.5	97.2 ± 16.1	52.5 ± 6.5	55.4 ± 5.4
175-190	494+69	103 1 + 15 1	55.5 + 6.9	59.7 ± 6.0