Weight-to-Tibial Baseplate Surface Area Ratio Predicts Aseptic Loosening in Total Knee Arthroplasty (TKA)

Nathan Alexander Huebschmann, Jonathan L Katzman[1], Joseph Xavier Robin, Morteza Meftah[2], Joshua Craig Rozell, Ran Schwarzkopf[3]

[1]NYU Langone Health, [2]NYU Langone Orthopedic Hospital, [3]NYU Langone Orthopedic Hospital, Hospital For Joi

INTRODUCTION: High body mass index (BMI) is a risk factor for tibial component loosening following total knee arthroplasty (TKA), but may not adequately correlate to stresses at the tibial baseplate. This study aimed to determine an optimal cutoff of a weight-to-baseplate surface area ratio (weight/SA) for predicting aseptic tibial loosening. We further examined if tibial stem extensions have a protective effect.

METHODS: We identified 16,690 patients who underwent primary, elective TKA from June 2011-March 2023. Patient demographics, implants, and revisions were extracted. Revisions were manually reviewed to confirm indication. The exact distal surface areas of tibial baseplates were obtained from manufacturers. Receiver operator characteristic (ROC) analysis in patients without tibial stem extensions was utilized to examine the utility of BMI and weight/SA for predicting rates of aseptic tibial loosening. An optimal weight/SA cutoff predicting loosening was determined. The effect of tibial stem extensions on loosening was then examined in patients above (n=7,962 4.1% stem extension) and below (n=8,728, 1.8% stem extension) the determined cutoff.

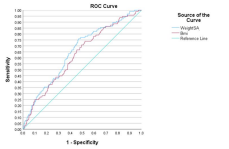
RESULTS:

Weight/SA (AUC=0.654, p<0.001) was a better predictor of aseptic tibial loosening requiring revision compared to BMI (AUC=0.624, p<0.001). Optimal weight/SA cutoff for predicting loosening was 0.0161 kg/mm^2 (sensitivity=0.760, specificity=0.530). Multivariable logistic regression demonstrated weight/SA above the cutoff (Odds Ratio=3.01, 95% Confidence Interval 1.65-5.52, p<0.001) but not BMI (p=0.822) was a significant predictor of tibial loosening in patients without stem extensions. No cases of aseptic tibial loosening in patients with stem extensions occurred either above or below the cutoff. The association between tibial loosening and lack of a stem extension approached significance for patients above (p=0.077), but not below (p=0.502) the weight/SA cutoff.

DISCUSSION AND CONCLUSION:

A ratio of weight-to-tibial baseplate surface area is more predictive of aseptic tibial loosening following TKA than BMI. For obese patients with small tibial baseplate sizes, utilization of a tibial stem extension may protect against tibial loosening.

Figure 1. Receiver operator characteristic curve for revision due to aseptic tibial loosening with body mass index (BMI) and weight-to-tibial baseplate surface area ratio (weight/SA) as predictors. Both BMI (AUC=0.624, p<0.001) and weight/SA (AUC=0.654, p<0.001) were significant predictors of aseptic tibial loosening. Optimal cutoff value for weight/SA was identified as 0.0161202876 kg/mm² (sensitivity=0.760, specificity=0.530, 1-specificity=0.470).



Diagonal segments are produced by ties.

Table 1. Baseline Characteristics for Patients Below Weight-to-Tibial Baseplate Surface Area Ratio* Undergoing Elective Total Knee Arthroplasty

	No Tibial Stem (n = 8,374)	Tibial Stem (n = 354)	*P* Value
Sex, n (%)			0.015
Men	2724 (32.5)	84 (23.8)	
Women	5650 (66.8)	269 (71.4)	
Mean Age (years) [range]	69.0 [24 to 94]	67.0 [24 to 90]	0.071
Race, n (%)			0.002
White	6773 (51.7)	168 (64.4)	
Latinx	943 (13.0)	8 (5.2)	
Black	1129 (14.7)	31 (26.1)	
Asian	735 (8.0)	9 (3.9)	
Other	864 (10.1)	9 (2.9)	
Smoking Status, n (%)			0.141
Current	444 (5.2)	15 (8.4)	
Former	2967 (34.8)	47 (30.3)	
Never	5145 (60.0)	54 (61.3)	
Insurance Status, n (%)			0.000
Medicare	5249 (60.8)	91 (39.1)	
Medicaid	509 (5.9)	16 (11.7)	
Commercial	2776 (32.4)	42 (27.3)	
Worker's Compensation	70 (0.8)	3 (2.9)	
ASA score, n (%)			0.153
1	284 (3.3)	3 (3.9)	
2	3448 (40.3)	80 (58.4)	
3	4744 (55.4)	44 (39.6)	
4	91 (1.2)	0 (0)	
Mean CCI [range]	3.0 [0 to 10]	3.1 [0 to 17]	0.185
Mean BMI (kg/m2) [range]	28.2 [13.3 to 55.4]	27.5 [15.6 to 57.8]	**<0.001**
Mean Follow-Up Time (Years)	3.4 [0.02 to 12.8]	3.0 [0.01 to 10.2]	0.186

ASA, American Society of Anesthesiologists; BMI, Body mass index; CCI, Charlson comorbidity index.
*All patients were classified as below the weight-to-tibial baseplate surface area ratio of 0.0161202876 kg/mm² as determined by Receiver Operator Characteristic (ROC) analysis (Figure 1).

Table 2. Baseline Characteristics and Revisions for Patients Above Weight-to-Tibial Baseplate Surface Area Ratio* Undergoing Elective Total Knee Arthroplasty

	No Tibial Stem (n = 7,607)	Tibial Stem (n = 355)	*P* Value
Sex, n (%)			**0.035**
Men	2530 (33.3)	82 (23.2)	
Women	5301 (69.9)	269 (74.8)	
Mean Age (years) [range]	68.7 [27 to 92]	67.2 [21 to 91]	**0.005**
Race, n (%)			
White	3998 (52.4)	147 (42.2)	**<0.001**
Latinx	680 (8.6)	32 (8.8)	
Black	1047 (13.4)	139 (46.6)	
Asian	243 (3.2)	9 (2.8)	
Other	853 (10.5)	28 (8.6)	
Smoking Status, n (%)			0.558
Current	445 (6.0)	21 (8.5)	
Former	2737 (35.8)	107 (32.9)	
Never	4439 (58.1)	197 (60.4)	
Insurance Status, n (%)			**0.006**
Medicare	3247 (42.5)	121 (37.2)	
Medicaid	495 (6.5)	44 (13.5)	
Commercial	3642 (47.7)	158 (48.6)	
Worker's Compensation	110 (1.5)	2 (0.6)	
ASA score, n (%)			**<0.001**
1	63 (0.8)	0 (0)	
2	3720 (48.7)	109 (31.5)	
3	3720 (48.8)	230 (66.4)	
4	130 (1.7)	8 (2.3)	
Mean CCI [range]	2.6 [0 to 10]	3.0 [0 to 15]	0.479
Mean BMI (kg/m2) [range]	37.1 [23.7 to 69.9]	41.9 [27.3 to 85.3]	**<0.001**
Mean Follow-Up Time (Years)	3.5 [0.02 to 11.4]	2.5 [0.04 to 10.0]	**<0.001**

AOA, American Society of Anesthesiologists; BMI, Body mass index; CCI, Charlson comorbidity index.
*All patients were classified as at or above the weight-to-tibial baseplate surface area ratio of 0.0161202876 kg/mm² as determined by Receiver Operator Characteristic (ROC) analysis (Figure 1).

Table 3. Multivariable Binary Logistic Regression for Revision Due to Aseptic Tibial Loosening in Patients Without Tibial Stem Extensions.

Independent Variable	OR (95% CI)	*P* value
Age (years)	0.99 (0.96-1.01)	0.246
Sex (ref=men)	0.88 (0.57-1.35)	0.560
BMI (kg/m²)	1.01 (0.94-1.05)	0.822
Above Weight/SA Cutoff	3.01 (1.65-5.52)	**<0.001**
ASA Score		0.998
CCI Score	0.86 (0.74-0.99)	**0.035**

Weight/SA, Weight-to-Tibial Baseplate Surface Area Ratio; BMI, Body Mass Index; ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index. Cutoff for weight-to-tibial baseplate surface area ratio was 0.0161202876 kg/mm² as determined by Receiver Operator Characteristic (ROC) analysis (Figure 1).

Table 4. Revisions for Aseptic Tibial Loosening in Patients With and Without Tibial Stem Extensions.

		No Tibial Stem n (%)	Tibial Stem n (%)	*P* Value
Total Sample	No Revision	16109 (99.4)	479 (100)	0.124
	Revision	102 (0.6)	0 (0)	
Below Weight/SA Ratio Cutoff	No Revision	8549 (98.7)	154 (100)	0.502
	Revision	25 (0.3)	0 (0)	
Above Weight/SA Ratio Cutoff	No Revision	7560 (99.0)	325 (100)	0.077
	Revision	77 (1.0)	0 (0)	

Weight/SA, Weight-to-Tibial Baseplate Surface Area Ratio. Cutoff for weight-to-tibial baseplate surface area ratio was 0.0161202876 kg/mm² as determined by Receiver Operator Characteristic (ROC) analysis (Figure 1).