Appendix

Sensitivity Analyses

Three sensitivity analyses were performed whereby alternative modeling approaches were applied. Alternative modeling approaches (other than mixed-effects modeling) included a propensity-score analysis[25] with matching, an instrumental variable analysis[28], and multiple imputation, whereby missing data on surgeon type were addressed.

In the propensity-score analysis, we calculated propensity scores from a mixed-effects model with the outcome of surgeon type (excluding unknown surgeon type) and using the same covariates as in the primary analysis. Cases performed by a podiatrist were matched with up to 3 cases performed by an orthopaedic foot and ankle surgeon. Balance in covariate distribution between the groups in the matched sample was assessed using standardized differences. Effects were then estimated from this newly created, balanced cohort (standardized differences generally of $\leq$0.1).

The second sensitivity analysis was an instrumental variables analysis, an alternative method to account for (unmeasured) confounding, which requires the measurement of a valid "instrumental variable."[28] This is a variable that (1) is independent of unmeasured confounding; (2) affects the treatment variable (in this context, type of surgeon), and (3) affects the outcome only indirectly through its effect on the "treatment." While several types of instrumental variables exist, "preference-based" instrumental variables are increasingly used. We selected the hospital-specific percentage of ankle surgeries performed by a podiatrist as the "preference-based" instrumental variable. The assumption here was that patients undergoing their procedure in hospitals with a higher value of this instrumental variable had a higher probability of being operated on by a podiatrist. Importantly, we assumed that our instrumental variable was not directly associated with our outcomes; it only estimated the outcome through its impact on the type of surgeon. As previously described[28], a 2-stage least-squares regression using the instrumental variable was used to estimate the effect of a podiatrist as the operating surgeon (compared with an orthopaedic foot and ankle surgeon) on our outcomes. All available study variables were included in both stages of the instrumental variable regressions.

The third sensitivity analysis addressed missing data for surgeon type and applied multiple imputation to approximate the missing values under the assumption that data were missing at random[29]. The multiple imputation procedure includes creating multiple copies (generally, 5[40]) of the data set with the missing values replaced by imputed values (based on the observed data). Next, standard statistical methods are used to fit the model of interest to each of the imputed data sets. Separate effect estimates are then averaged together to give an overall effect estimate.

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TABLE E-1 Mean Cost, Length of Stay (LOS), and Percentage of Procedures Performed by Podiatrists by Region

	Mean Cost	Mean LOS *(days)*	Mean % of Procedures Performed by Podiatrist
TAA			
Midwest	$23,411	2.11	21.1%
Northeast	$22,917	2.19	7.2%
South	$25,794	2.11	10.8%
West	$21,903	2.08	33.2%
Ankle arthrodesis			
Midwest	$17,135	3.13	25.3%
Northeast	$17,173	2.62	9.5%
South	$19,924	3.17	15.7%
West	$16,443	2.55	24.6%

The highest percentage of procedures performed by podiatrists was seen in the West and Midwest; this did not coincide with particularly higher cost or length of stay in the West or Midwest, suggesting that differences observed were not due to regional differences. (Of note, we also adjusted for hospital characteristics in our multivariable model, which would have partly adjusted for regional differences if this bias had been present, which our data suggest it was not.)

See also the limitations section in the Discussion of this article: regional differences in cost and length of stay did not coincide with regional differences in the percentage of procedures performed by podiatrists, rendering such an effect unlikely.