A Novel Radiographic Predictor for Dehiscence after Total Ankle Arthroplasty

Andreas Kaikis, DPM; William Wolfe, DPM; D. Scot Malay, DPM, MSCE, FACFAS
University of Pennsylvania Health System-Penn Presbyterian Medical Center, Philadelphia, Pennsylvania

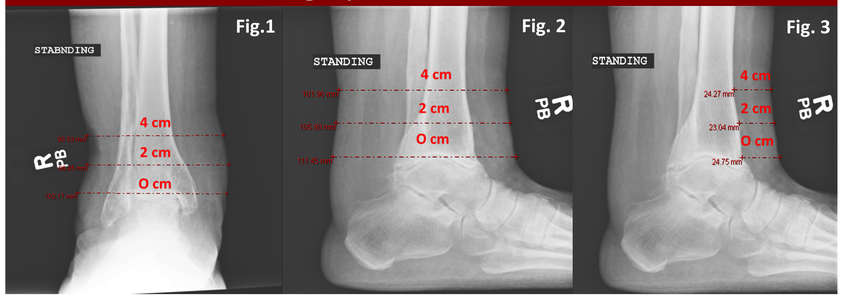
Statement of Purpose

The purpose of this study was to determine if certain preoperative radiographic soft tissue measurements predicted wound dehiscence after total ankle arthroplasty (TAA). This retrospective cohort study aimed to calculate the incidence of anterior wound dehiscence, and to identify risk factors associated with dehiscence following TAA. The authors believe that it is important to recognize patients at risk for soft tissue wound complications after TAA, since the procedure is prevalent and dehiscence and infection can lead to substantial morbidity.

Methodology and Hypothesis

The medical records of 56 consecutive primary TAA patients, having surgery between June 1, 2014 and June 30, 2017, were reviewed with attention paid to the first 90-day postoperative period. We used the University of Pennsylvania Health System (UPHS) electronic medical record to identify patients who underwent TAA (CPT 27702) during the observation period, in whom an anterior, longitudinal, linear incision was used. Six different surgeons performed the operations. Demographic and radiographic measurements were obtained for patients that met our inclusion criteria, and preoperative anteroposterior (AP) and lateral weight bearing radiographs were assessed using the measuring tool in the UPHS radiograph viewing software. On the AP radiograph, we identified the level of the tibiotalar joint (TTJ) as the tangent to the talar dome, and measured the length of the medial-to-lateral soft tissue silhouette **(Fig. 1)**. We then measured this same distance at 2 and 4 cm proximal to the TTJ. On the lateral radiograph, we measured the length of the anterior-to-posterior soft tissue silhouette at the TTJ and again at 2 and 4 cm proximal to the TTJ **(Fig. 2)**. Also on the lateral radiograph, a measurement of the anterior soft tissue depth (ASTD, tibial cortex to the anterior soft tissue silhouette) was made at the level of the TTJ and at 2 and 4 cm proximal to it **(Fig. 3)**. From these measurements we extrapolated circumference of the extremity at the TTJ and at 2 and 4 cm proximal to it. The measurements were made by two assessors (ACK, WMW), and Pearson's product moment correlation coefficients confirmed the inter- and intra-rater reliability of these radiographic measurements. We also procured data from the records and used the CPT codes for wound debridement, split thickness skin graft, delayed primary closure, local soft tissue re-arrangement, and free flap, to identify dehiscence and/or surgical site infection observed during the first 90 days postoperative. The data were described in statistical terms with attention to type and distribution, and the incidence of anterior wound dehiscence was calculated. Tests of the null hypothesis and logistic regression were used to identify statistically significant associations between risk factors and dehiscence. To determine the potential influence of an unmeasured confounder a Greenland sensitivity analysis (1) was undertaken. We used receiver operating characteristic (ROC) analyses and the Youden index (2) to determine the ASTD cut point that maximized diagnostic sensitivity and specificity for dehiscence. Statistical analyses were performed by one author (DSM), and statistical significance was defined at the 5% ($p \leq 0.05$) level (and $p \leq 0.1$ for inclusion in the adjusted logit model). We hypothesized that a smaller diameter and less depth of the soft tissues about the ankle and lower leg, as measured using standard preoperative radiographs, would be associated with anterior wound dehiscence following TAA.

Radiographic Measurements



Literature Review

TAA is a common treatment for end-stage ankle arthrosis, and innovations in preoperative guides, instrumentation and prosthesis design facilitate a more patient-specific approach to this intervention. Despite technical advancements, wound complications continue to be a prevalent postoperative problem, and have been reported to affect 16-28% of cases (3). Whalen et al (4) showed that 25% of patients with a post-TAA wound healing complication require removal of the prosthesis. Meticulous dissection, careful retraction, close incision monitoring, incisional negative pressure wound therapy, and immobilization techniques have been proposed to decrease soft tissue complications. In the preoperative period, no risk factor has been shown to predict development of an anterior incision wound complication other than patient co-morbidities (5). Patton et al (6) found wound healing problems at >14 days after surgery, as well as diabetes, to be predictive for postoperative dehiscence and infection, and Raikin et al (7) showed that a history of inflammatory disease and diabetes were associated with major and minor wound complications post-TAA. In general, it is thought that any preoperative strategy aimed at minimizing the risk of postoperative wound complications could promote more favorable outcomes. Interestingly, however, the use of prophylactic or simultaneous soft tissue coverage and preoperative oxygen tensiometry measurements failed to reduce the incidence of postoperative wound complication after TAA (3,8).

Results

Statistical descriptions of the cohort are shown in **Tables 1 and 2.** The incidence of dehiscence was 21.43% in the 56 TAAs performed by six surgeons over the observation period. Those that dehisced were younger, 61 ± 6.22 *v.* 65.02 ± 10.93 years ($p = 0.0384$); and, they had less anterior soft tissue depth at the joint line, 15.87 ± 5.26 *v.* 20.05 ± 6.02 mm ($p = 0,0295$) **(Table 3)**. Unadjusted logistic regression showed only the anterior soft depth at the joint line to be statistically significantly associated with dehiscence (odds ratio (OR) 0.8855 (95% confidence interval (CI) 0.7883, 0.9946), and this remained significant in the fully adjusted model (OR = 0.864 (95% CI 0.7591, 0.9833) **(Table 4)**. The Greenland sensitivity analysis, wherein the unmeasured exposure ranged from 1% to 99% in its association with our exposures (demographic and radiographic measurements) and anterior wound dehiscence, showed that our effect estimates never changed more than 10% up to an OR of 9 for the unmeasured variable by the outcome. ROC analyses showed the area under the curve for the anterior soft tissue depth to be 0.7064 (95% CI 0.5502, 0.8627), and its Youden index was 0.47, indicative of an ASTD cut point of 19.5 mm as a predictor of anterior wound dehiscence.

Table 1 Statistical description of the cohort* (N = 56 TAAs in 56 patients)

Age (years)	Male sex	BMI	RA	NIDDM	Smoker	Dehiscence
64.16 ± 10.2 65 (20, 85)	21 (37.5)	31.35 ± 5.31 30.1 (21.29, 46)	3 (5.36)	4 (7.14)	4 (7.14)	12 (21.43)

*There were no patients with end-stage renal disease, venous insufficiency, or peripheral arterial disease, and none that were status post solid organ transplant.
Results presented as mean ± standard deviation and mean (minimum, maximum) for continuous data, and count (%) for categorical data.
Abbreviations: BMI = body mass index, RA = rheumatoid arthritis, NIDDM = non-insulin dependent diabetes mellitus.

Table 2 Statistical description of the radiographic measurements (N = 56 TAAs in 56 patients)

Measurement	Anatomic level of measurement		
	Joint line	2 cm proximal	4 cm proximal
Anteroposterior (mm)	84.79 ± 8.68 84.82 (71.27, 118.34)	76.01 ± 8.9 77.07 (61.86, 107.27)	72.42 ± 9.35 71.69 (57.7, 100.47)
Lateral (mm)	102.96 ± 7.4 103.12 (88.81, 118.12)	92.14 ± 7.81 91.73 (76.78, 109.06)	87.44 ± 7.34 87.93 (68.52, 104.25)
ASTD (mm)	19.15 ± 6.07 19.94 (6.85, 33.63)	12.37 ± 4.11 12.51 (3.35, 22.48)	11.33 ± 3.9 11.63 (3.83, 24.58)
Area (mm^2)	6891.51 ± 1133.38 6689.34 (5081.19, 10977.76)	5540.77 ± 1060.64 5565.87 (3810.77, 9188)	5012.12 ± 1015.7 4966.06 (3422.31, 8226.02)

Abbreviation: ASTD = anterior soft tissue depth

Results Continued

Table 3 Prevalence of risk factors by outcome (N = 56 TAAs in 56 patients [mean ± standard deviation and median (minimum, maximum), or count (%)])

Risk factor		No dehiscence (n = 44 [78.57%])	Dehiscence (n = 12 [21.43%])	*p*-value*
Age (years)		65.02 ± 10.93, 65.5 (20, 85)	61 ± 6.22, 61.5 (52, 74)	0.0384
Male sex		14 (31.82)	7 (58.33)	0.0956
BMI		31.61 ± 5.84, 29.98 (21.29, 46)	30.38 ± 2.46, 30.23 (26.8, 34.41)	0.8261
RA		2 (4.55)	1 (8.33)	0.6087
NIDDM		4 (9.09)	0	0.2827
Smoker		3 (6.82)	1 (8.33)	9.8580
AP (mm)	Joint line	85.19 ± 9.14, 85.04 (71.27, 118.34)	83.32 ± 6.87, 83.73 (72.65, 93.59)	0.7494
	2 cm proximal	76.58 ± 9.18, 77.34 (61.86, 107.27)	73.93 ± 7.75, 75.04 (62.14, 85.34)	0.5359
	4 cm proximal	73.26 ± 9.64, 77.71 (57.7, 100.47)	69.32 ± 7.76, 69.2 (58.16, 82.94)	0.1943
Lateral (mm)	Joint line	103.64 ± 7.53, 103.12 (88.81, 118.12)	100.47 ± 6.59, 101.1 (89.06, 110.57)	0.2468
	2 cm proximal	92.8 ± 7.5, 91.73 (76.89, 109.06)	89.73 ± 8.68, 89.87 (76.78, 101.95)	0.3279
	4 cm proximal	88.29 ± 7.1, 88.17 (68.52, 104.25)	84.32 ± 7.72, 84.69 (74.93, 98.53)	0.1058
ASTD (mm)	Joint line	20.05 ± 6.02, 20.41 (6.85, 33.63)	15.87 ± 5.26, 15.73 (7.74, 22.91)	0.0295
	2 cm proximal	12.69 ± 4.12, 12.76 (3.35, 22.48)	11.19 ± 4.02, 11.64 (4.73, 16.78)	0.3181
	4 cm proximal	11.75 ± 3.91, 12.09 (3.83, 24.58)	9.77 ± 3.6, 9.74 (4.96, 17.19)	0.1058
Area (mm)	Joint line	6971.82 ± 1188.47, 6853.21 (5230.91, 10877.76)	6597.02 ± 883.67, 6550.72 (5081.19, 7712.7)	0.46
	2 cm proximal	5620.03 ± 1073.8, 5587.71 (3820.77, 9188)	5250.16 ± 1000.12, 5298.71 (3847.81, 6832.69)	0.3689
	4 cm proximal	5117.41 ± 1029.15, 5059.04 (3425.79, 8226.02)	4625.03 ± 900.53, 4798 (3422.31, 6418.15)	0.1563

*Wilcoxon rank-sum test (Mann-Whitney two-sample statistic) for continuous data, Kruskal-Wallis test for categorical data. Statistically significant results highlighted in yellow.
Abbreviations: AP = anteroposterior, ASTD = anterior soft tissue depth, BMI = body mass index, NIDDM = non-insulin dependent diabetes mellitus, RA = rheumatoid arthritis

Table 4 Association of risk factors with anterior wound dehiscence (N = 56 TAAs in 56 patients)

Model	Risk factor	Odds ratio (95% confidence interval)
Unadjusted	Anterior soft tissue depth at joint line	0.8855 (0.7883, 0.9946)
Adjusted	Surgeon	0.7780 (0.3797, 1.5942)
	Age	0.9304 (0.8605, 1.0061)
	Male sex	3.2479 (0.6896, 15.2957)
	BMI	0.9503 (0.8063, 1.1201)
	Anterior soft tissue depth at joint line	0.864 (0.7591, 0.9833)

Statistically significant results highlighted in yellow

Discussion

The incidence of dehiscence was 21.43%, and the anterior soft tissue depth (ASTD) at the joint line, as viewed on the standard preoperative lateral radiograph, was statistically significantly associated with post-TAA anterior wound dehiscence. We believe that a measurement ≤ 19.5 mm may foretell dehiscence, when a standard longitudinal anterior incision is used. Limitations of this investigation included surgeons making radiographic measurements, although the method of measurement showed inter- and intra-rater reliability; hence, the information was likely valid. Moreover, the findings were resistant to the potential influence of an unmeasured exposure. To our knowledge, the anterior soft tissue depth is the first radiographic predictor for dehiscence when using a longitudinal anterior ankle incision for TAA. In conclusion, preoperative measurement of the anterior soft tissue depth on the lateral radiograph may be useful in predicting dehiscence, and future investigations are needed to further refine the predictive value of this readily available measurement.

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