Incidence and Predictors of Valgus Tibiotalar Tilt after Progressive Collapsing Foot Deformity Reconstruction using Subtalar Fusion

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INTRODUCTION:

Subtalar fusion is a powerful option for correcting hindfoot deformity in progressive collapsing foot deformity (PCFD). It has traditionally been used to treat rigid and arthritic subtalar joints; however, it is being increasingly employed to address severe deformity or as a definitive procedure for PCFD correction in obese or elderly patients.

Despite successful PCFD correction through subtalar fusion, the development of valgus tibiotalar tilt at the ankle joint has been documented as a significant complication. This can be detrimental to patients as eccentric force at the ankle joint can lead to cartilage wear and subsequent ankle arthritis over time. Moreover, the optimal salvage method for this complication has not yet been established. Despite its importance, the incidence of valgus tibiotalar tilt following subtalar fusion for PCFD reconstruction has not been extensively studied. One study reported a 27.3% incidence of valgus ankle malalignment after subtalar fusion in elderly patients; however, conclusions from this are limited because this study included patients with preoperative valgus tilt as well.

Furthermore, little is known about factors associated with the development of valgus tibiotalar tilt after subtalar fusion. One study identified that preoperative abduction of the foot predisposed patients for postoperative valgus tibiotalar tilt, but was not limited to PCFD patients. Under correction of heel alignment and excessive foot stiffness from multiple arthrodesis of the foot have also been suggested as contributing factors from anecdotal experience; However, there are no studies in the literature evaluating predictors of valgus tibiotalar tilt following subtalar fusion in PCFD correction.

The purpose of this study was 1) to define the incidence of valgus tibiotalar tilt after PCFD reconstruction using subtalar fusion and 2) to identify the demographic and radiographic predictors of patients who were more likely to develop postoperative valgus tibiotalar tilt. To accomplish this, we analyzed preoperative weight-bearing computed tomography (WBCT) and magnetic resonance imaging (MRI) as well as standard radiographs, all of which are commonly used in surgical planning for PCFD patients. We hypothesized that those with greater preoperative deformities would be more likely to develop postoperative valgus tibiotalar tilt.

METHODS:

This study reviewed 59 patients (median age: 59 years) who underwent PCFD reconstruction with subtalar fusion and had pre-and postoperative weight-bearing anteroposterior radiographs of the ankle in the registry. Patients with a tibiotalar tilt prior to surgery were excluded. On standard weight-bearing radiographs, the talonavicular coverage angle, talo-1st metatarsal angle, calcaneal pitch, and hindfoot moment arm (HMA), and medial distal tibial angle were measured. Weight-bearing computed tomography (WBCT) was used to determine the presence of preoperative sinus tarsi or calcaneofibular bony impingement. A radiologist evaluated the superficial and deep deltoid ligaments using magnetic resonance imaging (MRI). Postoperative valgus tibiotalar tilt was defined as tilt >2 degrees. Univariate regression analysis was used to identify the factors associated with development of postoperative valgus tibiotalar tilt. These factors included age, gender, BMI, as well as concomitant procedures, radiographic parameters, lateral bony impingement on WBCT, and deltoid ligament status on MRI.

RESULTS:

Among 59 ankles, a total of 17 patients developed valgus tibiotalar tilt, resulting in an incidence of 28.8%. The mean postoperative tibiotalar tilt was 5.4 degrees (range, 3.8-8.1), with eight patients having a tilt of between 2 and 5 degrees and nine having a tilt of between 5 and 10 degrees. The mean time to develop valgus tibiotalar tilt was 7.7 months (range, 2-31), with eight (47.1%) patients developing valgus tibiotalar tilt within three months after surgery on their first postoperative weight-bearing ankle AP radiographs. Bivariate analysis demonstrated that patients with postoperative valgus tibiotalar tilt had significantly larger preoperative HMA (mean ± standard deviation [SD], 35.52 ± 11.45) compared to those who did not (mean ± SD, 32.84 ± 12.89, $P < 0.05$). Preoperative CP was smaller in patients with postoperative valgus tibiotalar tilt (mean ± SD, 9.81 ± 4.47 versus 12.41 ± 5.18 degrees), but this difference was not significant, ($P = 0.075$). No other radiographic parameters differed between groups (**Table 1**). Univariate logistic regression was then conducted for preoperative HMA and CP since they met the criteria of $P < 0.1$, which demonstrated that preoperative HMA was associated with postoperative valgus tibiotalar tilt. With an increase in preoperative HMA by 1 millimeter, there was a 6% increase in risk for developing postoperative valgus tibiotalar tilt. The proportion of additional procedures, the incidence of lateral bony impingements in WBCT, and the deltoid ligament stages in MRI did not differ between groups in the current study and were not associated with the development of valgus tibiotalar tilt.

DISCUSSION AND CONCLUSION:

The incidence of valgus tibiotalar tilt after subtalar fusion in PCFD reconstruction was 28.8% in this study. Preoperative valgus hindfoot alignment rather than the condition of the deltoid ligament was a significant predictor of postoperative valgus tibiotalar tilt. Our findings indicate that surgeons should be cognizant of patients with a greater degree of hindfoot valgus and of their propensity to develop a valgus ankle deformity. Additionally, our relatively high incidence of valgus tibiotalar tilt suggests that weight-bearing ankle radiographs should be included in the initial and subsequent follow up of PCFD patients with hindfoot valgus treated with subtalar fusions.

Table 1. Demographic and Radiographic Bivariate Analysis of Patients with and without Valgus Tibiotalar Tilt

	No postop valgus (n=42)	Postop valgus (n=17)	p value
Age (median [IQR])	59.73 [56.27, 62.89]	59.71 [52.29, 64.22]	0.558
Male (%)	13 (31.0)	11 (64.7)	**0.036***
BMI (median [IQR])	30.55 [26.70, 33.90]	33.90 [28.40, 37.10]	0.357
Lateral column lengthening (%)	9 (21.4)	1 (5.9)	0.254
Talonavicular fusion (%)	11 (26.2)	8 (47.1)	0.213
1st TMT fusion (%)	25 (59.5)	9 (52.9)	0.863
Cotton osteotomy (%)	10 (23.8)	2 (11.8)	0.478
FDL transfer (%)	27 (64.3)	7 (41.2)	0.182
Spring ligament reconstruction (%)	6 (14.3)	2 (11.8)	1
MCO (%)	37 (88.1)	14 (82.4)	0.678
Gastrocnemius recession or Achilles lengthening (%)	35 (83.3)	17 (100.0)	0.096
Preop TNC (mean(sd))	32.84 (15.00)	35.52 (12.64)	0.519
Preop Meary (mean(sd))	33.47 (12.25)	36.76 (9.61)	0.326
Preop CP (mean(sd))	12.41 (5.18)	9.81 (4.47)	0.075
Preop HMA (mean(sd))	23.90 (12.89)	32.59 (11.45)	**0.019***
Preop MDTA (mean(sd))	91.22 (2.80)	90.19 (1.82)	0.168
Preop WBCT sinus tarsi impingement (%)	28 (66.7)	15 (88.2)	0.115
Preop WBCT calcaneofibular impingement (%)	14 (33.3)	10 (58.8)	0.13
MRI Anterior superficial deltoid grade (%)			0.927
Intact	13 (39.4)	5 (35.7)	
Degeneration <50%	5 (15.2)	3 (21.4)	
Degeneration >50%	9 (27.3)	3 (21.4)	
Tear <50%	5 (15.2)	2 (14.3)	
Tear >50%	1 (3.0)	1 (7.1)	
MRI Posterior superficial deltoid grade (%)			0.272
Intact	10 (30.3)	9 (64.3)	
Degeneration <50%	9 (27.3)	2 (14.3)	
Degeneration >50%	8 (24.2)	1 (7.1)	
Tear <50%	5 (15.2)	2 (14.3)	
Tear >50%	1 (3.0)	0 (0.0)	
MRI Deep deltoid grade (%)			0.617
Intact	11 (33.3)	4 (28.6)	
Degeneration <50%	10 (30.3)	4 (28.6)	
Degeneration >50%	7 (21.2)	4 (28.6)	
Tear <50%	5 (15.2)	1 (7.1)	
Tear >50%	0 (0.0)	1 (7.1)	

Abbreviations: IQR, interquartile range; BMI, body mass index; TMT, tarsometatarsal joint; FDL, flexor digitorum longus; MCO, medializing calcaneal osteotomy; TNC, talonavicular coverage angle; Meary, talo-1st metatarsal angle; CP, calcaneal pitch angle; HMA, hindfoot moment arm; MDTA, medial distal tibial angle; WBCT, weightbearing computed tomography; MRI, magnetic resonance imaging