Pre- and Post-Operative Analysis of Flatfoot Reconstruction Sparing the Talonavicular Joint.

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Abstract

Surgical correction of a flatfoot deformity is controversial. The purpose of our study was to evaluate the structural radiographic changes of the flatfoot deformity while maintaining the mobile adapter of the foot. We conducted a retrospective analysis of 56 patients that underwent this procedure comparing their pre to post-operative angular changes during follow-up. The mean age of our study cohort was 53.6 (range 20 to 77) years and mean follow-up period was 23 months (range 4-73). Radiographic union was achieved in 48 patients (86%). Forty-six patients (82%) had all required radiographs completed through final follow-up. We illustrated statistically significant changes to the talonavicular, Meary's, talocalcaneal, calcaneal inclination, and talar declination angles, and navicular height at 3 months and final follow up. This study suggests surgical correction of the flatfoot deformity that fused the subtalar but spared the talonavicular joint appears to achieve and maintain radiographic angular changes, and achieve union.

Purpose

To evaluate the effect on the Talonavicular joint on patients with obvious talonavicular subluxation with a flatfoot reconstruction which includes a subtalar joint arthrodesis

Level of Evidence

Level III (3)

Literature Review

Adult acquired flatfoot, or dorsolateral peritalar subluxation, is a complex multi-planar deformity that involves multiple joints. Historically, this subluxation's definitive treatment has included a triple arthrodesis. Fusion of the subtalar, talonavicular, and calcaneocuboid joints is a proven method for improving radiographic alignment of the foot with patients that have stage III posterior tibial tendon dysfunction (1).

The TNJ provides most of the mobility for the medial column and tarsal complex. Astion et al., showed that fusing the TNJ eliminates motion of the subtalar and calcaneal-cuboid joints (2) because it acts like a ball and socket joint allowing rotation in three dimensions (3). Avoiding fusion of this joint allows for added mobility in the foot and prevents stiffness. In another study, Wulker et al., demonstrated with an isolated STJ or calcaneal-cuboid joint fusions, the TNJ could retain from one third up to all its motion (4).

Further stabilization of the tarsal complex and medial column can be accomplished by fixating other medial column joints distal to the talonavicular joints. The rearfoot and midfoot operate together as a triplane complex to determine alignment (5). Greisberg et al. illustrated that fusions to the naviculocuneiform and/or 1st tarsometatarsal joints improved hindfoot alignments without any arthrodesis directly to the hindfoot (6). They accomplished this by carefully selecting patients who did not have arthritic or symptomatic hindfeet..

Methods

The medical charts for patients that underwent flatfoot reconstruction while sparing the talonavicular joint between January 1, 2007 and December 31, 2017 were analyzed. The patient population was from the Kaiser Permanente Northern California (KPNC) and a private practice in the greater Albuquerque area. Criteria for inclusion in this study were as follows: (1) preoperatively, patients had painful flatfoot; (2) surgical correction of flatfoot was required (3) subjects must have had pre and post-operative weight-bearing radiographs ideally follow-up roentgenographic evaluation were at 3-6 and 9-12 months post-surgery. Patients that had other operative adjunctive procedures or comorbidities were not excluded. Paired t-tests were used to test the mean change for all the pre to post-operative angular measurements. All analyses were carried out in SAS 9.3. Two of the authors (SK and YP), both of whom had not participated in any of the operative procedures or associated patient care, assessed all the weight-bearing pre- and post-operative radiographs. The measurements were completed with electronic angles and lengths through the STENTOR and Tigerview systems for all KPNC and greater Albuquerque area patients, respectively. Specifically, the radiographic measurements were determined using the techniques described by Shereff (7), Saltzman et al. (8), Chada et al. (9), and Haddad and Mann (10). Indices of flatfoot reconstruction morphology included the following:

AP radiographs -
- **Talonavicular coverage angle**
- **Talar-1st metatarsal angle**
- **Talocalcaneal angle**

Lateral radiographs -
- **Talonavicular angle**:
- **Talar-1st metatarsal angle**
- **Calcaneal Inclination Angle**
- **Talar Declination Angle**
- **Navicular Height**

The pre- and post-operative angular measurements were analyzed using the paired *t* tests, with statistical significant defined at $p \leq .05$. Along with the radiographic data, other post-operative findings included: chronic wounds, infection, malalignment, union, or any further unexpected procedures. Infection was broken up into three categories: none, minor, or major. Minor was defined as a superficial infection that resolved with oral antibiotics, while major was a deep wound or required intravenous antibiotics. Union was also separated into three categories involving yes, delayed or non-union.

Figure 1: Pre and Post Operative Changes with Angular Measurements on AP View

Left image is preoperative AP xray and right image is postoperative xray. On the left image the evaluated AP angles are labeled. A) Talonavicular Angle B) Talo-1st Met Angle C) Talocalcaneal Angle.

Figure 2: Pre and Post Operative Changes with Angular Measurements on Lateral View

Left image is preoperative lateral xray and right image is postoperative xray. On the left image the evaluated lateral angles are labeled. A) Talonavicular Angle B) Talo-1st Met Angle C) Calcaneal Inclination Angle D)Talar Declination Angle E) Navicular Height.

Results

We evaluated 58 patients total that met our inclusion criteria, of which two were lost to follow up allowing 56 patients for analysis. The mean age of the patients was 53.6 (range 20 to 77) years. The mean BMI was 31.8 (range 18 to 52.14) kg/m2. The patients included 40 females (71%) and 16 males (29%). Six patients (11%) were active smokers, who smoked at least one cigarette per day, at the time of surgery. Patient comorbidities included diabetes mellitus (n = 9, 16%), peripheral vascular disease (n= 2, 4%), rheumatoid arthritis (n = 2, 4%) and peripheral neuropathy (n = 3, 5%). Table 1 illustrates the total description of our data set.

Superficial wound infection occurred in 3 (5%) patients, requiring only oral antibiotics for treatment. Three patients (5%) developed chronic wounds that were managed with local wound care and did not require any surgical debridement. One patient (2%) had both a chronic wound and a minor infection. The most common concomitant procedure completed with the subtalar joint arthrodesis was a gastroc recession (n= 39, 70%).

The overall non-union rate was 8 (14%) patients. Of these half (4/8) were subtalar joint non-unions, the others were related to concomitant procedures: naviculo-cuneiform and first met-cuneiform joints, 3 patients (3/29, 10%) and 1 patient (1/18, 6%) respectively. Delayed union occurred in 4 (7%) patients who went onto union without surgical intervention. Of the 6 (11%) active smokers, one developed a non-union and one developed a delayed union.

The pre- and post-operative, as well as the mean difference between the pre- and post-operative, measurements are shown in Tables 2 and 3. The mean change for each pre to post-operative measured radiographic angle was statistically significant at the 3-6 month follow up and at the final follow up. Ten patients were lost to follow up between the 3 month and final follow up. The data illustrate significant changes to the angles measured that are maintained at the time of final follow up.

Data

Table 1: Description of the data set (N= 56 overall)

Variable	All Patients n (%)
Age	
Mean	*53.6*
Range	*20 to 77*
BMI	
Mean	*31.8*
Range	*18-52.14*
Gender	
Male	*16 (29)*
Female	*40 (71)*
Follow-up (mo)	
Mean	*20*
Min-Max	*2-73*
Active Smokers	*6 (11)*
Comorbidities	
DM	*9 (16)*
PVD	*2 (4)*
RA	*2 (4)*
PN	*3 (5)*
Complications	
Additional procedure	*15 (27)*
Wounds	*3 (5)*
Minor infection	*3 (5)*
Non-union rate	*8 (14)*
Delayed union	*4 (7)*
Concomitant Procedures	
Gastroc recession	*39 (70)*
NC fusion	*29 (52)*
1st met-cuneiform fusion	*18 (32)*
Achilles tendon lengthening	*9 (16)*

Abbreviations: DM, diabetes mellitus; PVD, peripheral vascular disease; RA, rheumatoid arthritis; PN, peripheral neuropathy; NC, naviculo-cuneiform

Table 2: Comparison of preoperative, three month and final follow-up radiographic measurements

Measurement	Preoperative (N=56)			Follow-up at 3 Months* (N=56)			Final Follow-Up *(N=46)		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max
TA, AP	36.36 ± 17.23	1.0	63.0	15.54 ± 13.13	-5.0	50.0	15.76 ± 13.25	-3.0	48.0
TA, Lat	-2.45 ± 12.02	-38.0	43.0	2.39 ± 6.67	-30.0	13.0	1.72 ± 5.95	-18.0	15.0
Meary's, AP	17.36 ± 10.67	0.0	45.0	4.45 ± 9.37	-15.0	26.0	2.93 ± 8.63	-20.0	26.0
Meary's, Lat	-8.75 ± 16.85	-40.0	26.0	1.39 ± 6.83	-17.0	14.0	0.80± 7.64	-20.0	20.0
TCA	23.82 ± 7.03	0.00	39.0	15.25 ± 7.01	0.0	29.0	15.57 ± 5.90	0.0	27.0
CIA	11.77 ± 5.57	-1.0	25.0	13.80 ± 5.28	0.0	25.0	12.91± 5.37	-4.0	23.0
TDA	33.82 ± 7.94	20.0	55.0	21.38 ± 5.38	12.0	32.0	21.96 ± 6.03	10.0	39.0
NH	22.55 ± 6.46	8.0	37.0	32.28 ± 6.11	23.0	49.5	30.83 ± 5.48	21.4	46.0

Abbreviations: TA, talonavicular coverage angle (º);TA, talocalcaneal angle(º); CIA, calcaneal inclination angle (º); TDA, talar declination angle (º); NH navicular height (mm).
*Follow up at 3 months was anywhere between 3 to 6 months post-operative; Final follow-up was X

Table 3: Comparison of difference between three month and final follow-up radiographic measurements

Measurement	Preoperative - 3 months F/U (N=56)		Preoperative - Final F/U (N=46)	
	Mean (SD)	p-value*	Mean (SD)	p-value*
TA, AP	20.82 ± 11.14	<.0001	21.30 ± 13.14	<.0001
TA, Lat	-4.84, ± 11.44	0.0025	-3.85 ± 11.92	0.0038
Meary's, AP	12.91, ± 9.79	<.0001	13.61 ± 9.77	<.0001
Meary's, Lat	-10.14, ± 16.85	<.0001	-8.91 ± 16.69	0.0007
TCA	8.57, ± 7.53	<.0001	8.57± 7.78	<.0001
CIA	-2.04, ± 2.72	<.0001	-1.30 ± 2.88	0.0036
TDA	12.45, ± 8.02	<.0001	12.17 ± 8.29	<.0001
NH	-9.73, ± 5.97	<.0001	-8.71 ± 6.14	<.0001

Abbreviations: TA, talonavicular coverage angle (º); TA, talocalcaneal angle(º); CIA, calcaneal inclination angle (º); TDA, talar declination angle (º); NH navicular height (mm). *paired *t* test

Conclusion

We identified statistically significant changes to the talonavicular and talo-first metatarsal angles both on AP and lateral, calcaneal inclination, talar declination, medial cuneiform height, and talocalcaneal angle. The results are consistent with previous studies that had smaller patient cohorts. The results of this study may potentially influence patient selection for talonavicular sparing procedures that undergo flatfoot reconstruction with asymptomatic talonavicular joints. This could diminish further osteoarthritic changes to adjacent and promote the longevity of the ankle joint. Further studies should investigate the long-term maintenance of radiographic changes following this surgery.

Discussion

Historically the triple arthrodesis was the gold standard for patients with symptomatic flatfeet. Monson et al. study of 46 triple arthrodesis demonstrated that 91% (n=46) of the patients had a good or excellent functional result with an average 24 years follow up (11). Then Devries et al. (12) argued that there was no difference in radiographic angles when comparing triple versus a medial double arthrodesis, demonstrating the same level of correction with fewer fusions. Our results continue this trend allowing fusion of only one joint in the tarsal complex, but restoring the tripod of the foot. All the angles evaluated had statistically significant change and were maintained during the monitored post-operative period.

The authors believe that such an effective correction can be made and maintained is because of the STJ's direct involvement of the valgus hindfoot. Taking out the valgus heel during the STJ arthrodesis directly improves the talar angulation because it forces the talus to dorsiflex. Zographos et al. (14) also confirmed the motion of the STJ as a screw like motion that operates through instantaneous axes. This multiplanar motion works in conjunction with the talus affecting its alignment. Other studies confirm our finding. Johnson et al. (16) in 2000 evaluated 16 patients with an average follow up of 27 months who had an improvement of 6º in the AP talo-1st met angle, 17º in the talonavicular coverage, 10º in the lateral talo-first met angle, and an improvement of 6mm in the medial cuneiform height. Our data shows similar results with an improvement of 13.61º, 21.3º, 8.91º, and 8.71 mm respectively.

Once the rearfoot complex is fixed, residual forefoot varus may be revealed and corrected with a medial column procedure that is distal to the TNJ. In our study 49 (%) patients required some type of an osseous medial column procedure to address the residual forefoot varus. Hirose and Johnson (25) looked at the cotton opening wedge osteotomy in 16 feet in conjunction with their flatfoot correction and showed improvement of 7º in the talo-first met angle AP and 14º in the lateral, 15º in the talonavicular coverage, and 7mm in medial cuneiform height. Three patients in our study had a cotton osteotomy. First metatarsal-cuneiform arthrodesis has also been shown to correct forefoot varus and improve the lateral talar-first metatarsal angle. This was shown with a statistical significant dorsiflexion of the talus seen in the cadaveric study completed by Bierman et al. (26) and then completed in vivo with Avino et al. (27) who had a statistically significant talar-first metatarsal angle change pre- to postoperative of 3º.

The radiographic changes were maintained from 3 months to final follow up which is the critical aspect of the procedure (29,30). Our findings were confirmed by Barg et al. (17) who looked at 10 patients with stage 3 PTTD that was corrected with a combination of a subtalar and naviculocuneiform joint arthrodesis. This study demonstrated statistically significant improvements in TN coverage (13º), first talo-metatarsal angles on AP (8º) and lateral (9º), calcaneal pitch (2º) and talocalcaneal angle (5º). It assists in validating the concept of being able to achieve correction of the flatfoot deformity with a subtalar joint arthrodesis with possible medial column procedure to address the remaining residual forefoot varus that could be present after the correction.

Our study demonstrated a nonunion rate of 14% (8/56) which could be due to the increased number of arthrodesis performed. Two of the non-union patients were non-compliant with their weight bearing status and three were asymptomatic with a possible fibrous non-union. Half of the non-unions were medial column procedures (NC or first tarsometatarsal fusions). Using the cotton osteotomy may have helped decrease our non-union rate, but unfortunately the mobility of the first ray, arthritis, and potential faults likely played a part in choosing a medial column fusion rather than a cotton osteotomy to help correct the residual forefoot varus. Furthermore, there was no discrimination against patients who were active smokers. Kim and Patel's (31) literature review showed a negative association from smoking with any desired osseous unions. This could be another reason for the non-union rate. Infections did not appear to have a significant impact, as all were non-surgically managed.

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