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Original Research

Isolated Medial Incisional Approach to Subtalar and Talonavicular Arthrodesis

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A R T I C L E I N F O

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A B S T R A C T

Triple arthrodesis is commonly used to correct complex deformity with hindfoot valgus. The authors use an isolated medial incisional approach for subtalar and talonavicular joint arthrodesis to correct hindfoot deformity, including high degrees of hindfoot valgus. To assess outcomes achieved with this approach, we reviewed the records of 45 patients from the practices of 5 surgeons. Independent variables evaluated included patient age, primary pathology, use of biologic agents, operative time, time to union, and complications. The median patient age was 57 years (range, 14-78 years). Pathology leading to fusion included 27 (60%) posterior tibial tendon dysfunction, 6 (13.3%) tarsal coalition, 7 (5.5%) degenerative joint disease, 2 (4.4%) rheumatoid arthritis, and 1 (2.2%) each, with Charcot neuroarthropathy, multiple sclerosis, and poliomyelitis. Orthobiological materials were used in 27 (60.0%) of the patients. The median duration of surgery was 87 minutes (range, 65-164 minutes), and the median time to successful arthrodesis was 8 weeks (range, 6-20 weeks). A complication was observed in 6 (13.3%) of the patients, including 1 each of the following: painful calcaneal-cuboid joint, talar fracture, incision dehiscence, poor exposure that required abandonment of the procedure, elevated first ray, and painful fixation. None of the patients experienced a nonunion or an adverse event related to the medial neurovascular structures. Based on our experience with the procedure, the single medial–incision subtalar and talonavicular joint arthrodesis is a useful alternative to triple arthrodesis for the correction of hindfoot valgus deformity.

In 1923, Ryerson described an arthrodesis of the "subastragaloid" (subtalar) and "medio-tarsal" (calcaneocuboid and talonavicular) joints, first coining the term "triple arthrodesis" (1). Ryerson's procedure was based on the insight of Gwilym Davis' article in 1913, which described resection of the talonavicular joint (TNJ) and subtalar joint (STJ) to allow ankylosis and stabilization of the TNJ and STJ in cavus feet (2). The procedure was intended to correct deformity, relieve pain, and stabilize and achieve a plantigrade foot (3). Today, this operation remains the preferred method to treat complex hindfoot pathology. Indications for triple arthrodesis include post-traumatic arthritis, tarsal coalition, severe flexible flatfoot deformity, rigid flatfoot deformity, congenital or neuromuscular deformity, and inflammatory arthritis (4). The traditional approach involves the use of 2 incisions: one medial incision to visualize the TNJ and one lateral incision to visualize both the STJ and calcaneocuboid joints (CCJ) (3). Over the years, a number of variations to this procedure have been described, including isolated fusions of the TNJ and STJ, and published studies suggest that the combination of isolated TNJ and STJ fusions yields results that are similar to those achieved with triple arthrodesis, primarily because of the fact that fusion of the TNJ dramatically reduces motion at the STJ (5–7). Astion et al (8) found that fusion of the TNJ limited motion in the CCJ and the STJ to about 2° in each joint. Furthermore, the single medial incision approach to combined TNJ and STJ fusion has been said to reduce operative time by eliminating lateral dissection (9). Additionally, complications including nonunion of the CCJ and lateral wound dehiscence in severe valgus hindfoot are also avoided with the aforementioned procedure (3). Our hypothesis is that single-incision medial approach for TNJ and STJ arthrodesis provides a viable alternative to correction of the severe valgus

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hindfoot with additional possible benefits to include no residual CCJ symptoms, less surgical time, possible cost savings, and minimal risk to the medial neurovascular elements.

Patients and Methods

Inclusion criteria included all patients undergoing combined STJ and TNJ arthrodesis using a single medial incisional approach between January 2006 and January 2009. Patients came from the practices of 5 of the authors. Data were obtained retrospectively from the medical record. Data collection included the patient's age, primary pathologic diagnosis, time to union, adjunctive use of osteobiologics, type of fixation, total surgical time, and presence of postfusion calcaneal-cuboid pain. Multivariate analysis was performed to compare both surgical time and time to union by procedure, age, and complications.

A successful arthrodesis was defined as unequivocal bony bridging across the fusion site as determined by the operating surgeon. Clinically, patients were determined to be fused by absence of pain at the fusion mass and lack of clinical motion with applied stress and weight bearing. Surgical time was defined to start at the time of the initial incision and to end at the time of the final closure. Forty-five patients met the inclusion criteria (G. M. W. 16 patients; J. M. S. 14 patients; M. L. 8 patients, S. M. R. 6 patients, and L. F. 1 patient).

Operative Technique

Patients were positioned supine under general or spinal anesthesia, and a thigh tourniquet was used for hemostasis in most cases. A gastrocnemius recession or percutaneous tendo Achillis lengthening was performed initially when needed. A 6- to 8-cm curvilinear incision was placed over the medial hindfoot extending from just posterior and inferior to the medial malleolus distally to the naviculocuneiform joint. Careful dissection to the deep fascia was performed and the posterior tibial tendon identified. A Gelpi retractor was placed with one tine on the medial malleolus and the other on the posterior tibial tendon. Neurovascular elements were maintained inferior to the surgical field. Initial deep dissection began at the TNJ, and sharp dissection continued proximally with care being taken to precisely follow the inferior surface of the talar head and neck so as to lead directly onto the anterior and middle facet of the STJ (Figure 1). At this point, visualization was enhanced by sharply transecting the interosseous ligaments. Both intraarticular and extraarticular joint retractors were placed to yield adequate exposure for joint preparation, which was performed in a standard fashion. Provisional fixation was applied to maintain the calcaneus in a neutral position and the TNJ in a coaxial position to reestablish a normal talo-first metatarsal angle and talar declination angle. Position was confirmed with intraoperative fluoroscopy. Fixation of the STJ then consisted of either 1 or 2 large fragment lag screws. The TNJ was fixated with 2 small or large fragment screws and, in some cases, with a medially applied locked plate (Figure 2).

Rarely did angular deformity need to be addressed by wedging, because the calcaneus was usually easily translated medially during the procedure. Orthobiologics were used at the surgeon's discretion to fill any defects in the fusion site or as an adjunct in those patients with biologic healing deficits. Postoperative care consisted of a non-weight bearing below-the-knee splint until sutures are removed. The patient was then transitioned to a short leg cast until radiographic evidence of healing was observed. Weight bearing as tolerated in a removable cast boot and passive range of motion of the ankle commenced once the cast was removed.

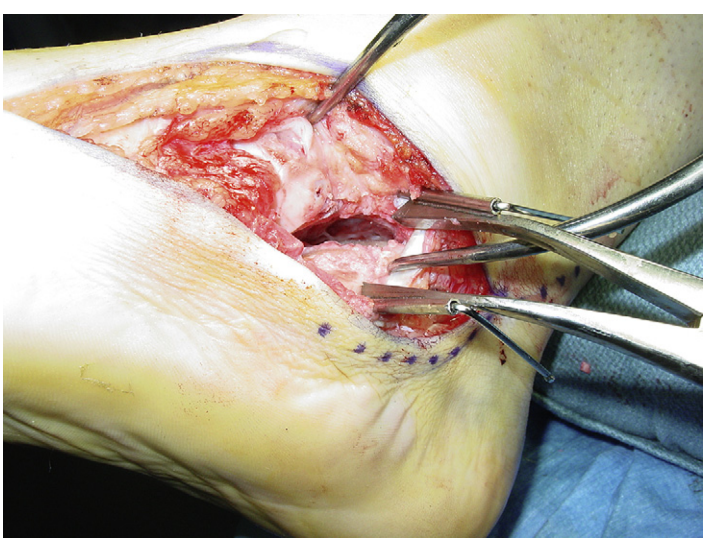

Fig. 1. Gelpi retractor protects the posterior tibial tendon and the neurovascular structures inferior to the surgical field.

Fig 2. Lateral radiographic view of fixated combined talonavicular and subtalar joint arthrodeses.

Results

A total of 45 patients met the inclusion criteria and were included in the review. Their mean age was 52.8 years (range, 14-78; median, 57 years) (Table 1). The prevalence of etiologies of pes valgus and hindfoot pain included: 27 (60%) posterior tibial tendon dysfunction, 6 (13.3%) tarsal coalition, 7 (5.5%) degenerative joint disease, 2 (4.4%) rheumatoid arthritis, and 1 (2.2%) each with Charcot neuroarthropathy, multiple sclerosis, and poliomyelitis. Of the 45 patients, 4 (8.9%) underwent STJ/TNJ arthrodesis, 14 (31.1%) underwent STJ/TNJ arthrodesis with tendo Achillis lengthening, and 27 (60.0%) underwent an STJ/TNJ arthrodesis with gastrocnemius recession. Orthobiological materials were used in 27 (60.0%) of the patients (Table 2). The mean surgical time was 87 minutes (range, 65-164 minutes; median, 87 minutes). The mean time to successful arthrodesis was 8.5 weeks (range, 6-20 weeks; median, 8 weeks). Six patients (13.3%) experienced a complication that included one each of a painful CCJ, talar fracture, incision dehiscence, poor exposure that required abandonment of the procedure, elevated first ray, and painful fixation (Table 3). There were no nonunions observed in the cohort.

When we examined the effect of patient age on surgical time, there was a general trend with the youngest ($\leq$ 35 years or $>$ 65 years) and oldest patients having a shorter mean surgical time than the middle-aged patients (36-65 years). This trend, however, was not statistically significant ($P = .09$). The presence of a complication was also found to not have an effect on the mean surgical time ($P = .35$) (Table 4).

Multiple variable Kaplan-Meier survival estimates were used to compare the median time with union (in weeks) by procedure, age, and the presence of a complication. When we compared healing time by procedure, the STJ/TNJ fusion alone took slightly longer to heal compared with the other 2 procedures (8.5 weeks vs. 8 weeks). This difference, however, was not statistically significant ($P = .52$). When we compared healing time by age, the youngest age group had the quickest median healing time (7 weeks), whereas each of the other age groups displayed a median healing time of 8 weeks. This difference was also not found to be statistically significant ($P = .23$). For the

Table 1
The dataset (N = 45 operations in 45 patients)

Case	Age (years)	Diagnosis	Duration of surgery (minutes)	Weeks to union	Fixation	Orthobiologicals	Complication	CCJ pain	Procedure
1	77	PTTD	67	7	Screws	None	None	No	STJ/TNJ/Gastroc
2	67	PTTD	71	8	Screws	PRP	None	No	STJ/TNJ/Gastroc
3	44	PTTD	69	8	Screws	None	None	No	STJ/TNJ/Gastroc
4	70	PTTD	65	8	Screws	None	Painful fixation	No	STJ/TNJ/Gastroc
5	45	PTTD	76	9	Screws	None	None	No	STJ/TNJ/Gastroc
6	68	PTTD	67	10	Screws	PRP/DBM	Lateral column pain	Yes	STJ/TNJ/Gastroc
7	67	PTTD	72	10	Screws	PRP	None	No	STJ/TNJ/Gastroc
8	43	PTTD	68	7	Screws	PRP/DBM	Elevated 1st ray	No	STJ/TNJ/Gastroc
9	71	PTTD	73	8	Screws	PRP/DBM	None	No	STJ/TNJ/Gastroc
10	69	DJD	80	7	Screws	DBM	None	No	STJ/TNJ/TAL
11	66	DJD	65	8	Screws	DBM	None	No	STJ/TNJ/TAL
12	72	DJD	80	6	Screws	DBM	None	No	STJ/TNJ/TAL
13	54	PTTD	90	8	Screws	DBM	None	No	STJ/TNJ/TAL
14	74	DJD, PTTD	98	8	Screws	PGC	None	No	STJ/TNJ/TAL
15	39	Coalition	164	20	Screws	BMP	Poor exposure	No	STJ/TNJ
16	17	Coalition	91	7	Screws	PRP	None	No	STJ/TNJ
17	65	Charcot	100	8	Ex fix/Screws	PRP/DBM	None	No	STJ/TNJ/TAL
18	26	PTTD	85	8	Ex fix/Screws	PRP	None	No	STJ/TNJ/Gastroc
19	61	PTTD	103	8	Screws/Plate	PRP	None	No	STJ/TNJ/Gastroc
20	23	DJD	72	6	Screws	PRP	None	No	STJ/TNJ
21	66	PTTD	93	8	Screws/Plate	PRP/SC	None	No	STJ/TNJ/TAL
22	58	PTTD	98	8	Screws	PRP	None	No	STJ/TNJ/TAL
23	35	DJD	102	10	Screws	PRP/DBM	None	No	STJ/TNJ
24	56	PTTD	98	8	Screws/Plate	DBM	None	No	STJ/TNJ/Gastroc
25	63	PTTD	88	10	Screws/Plate	BA glass	None	No	STJ/TNJ/TAL
26	44	PTTD	101	8	Screws/Plate	BA glass	None	No	STJ/TNJ/TAL
27	61	PTTD	91	10	Screws/Plate	DBM/SC	None	No	STJ/TNJ/TAL
28	57	PTTD	110	8	Screws/Plate	BA glass	None	No	STJ/TNJ/TAL
29	59	PTTD	80	8	Screws	PRP/DBM	None	No	STJ/TNJ/TAL
30	22	Coalition	96	8	Screws	BA glass	None	No	STJ/TNJ/Gastroc
31	45	MS	93	10	Screws	None	Fracture talus	No	STJ/TNJ/Gastroc
32	14	Coalition	79	6	Screws	None	None	No	STJ/TNJ/Gastroc
33	78	PTTD	101	8	Screws	None	None	No	STJ/TNJ/Gastroc
34	74	PTTD	93	9	Screws	None	None	No	STJ/TNJ/Gastroc
35	68	RA	97	12	Screws	None	Deshiscence	No	STJ/TNJ/Gastroc
36	57	PTTD	82	8	Screws	None	None	No	STJ/TNJ/Gastroc
37	58	PTTD	98	8	Screws	None	None	No	STJ/TNJ/Gastroc
38	37	Coalition	81	7	Screws	None	None	No	STJ/TNJ/Gastroc
39	31	Poliomyelitis	78	7	Screws	None	None	No	STJ/TNJ/Gastroc
40	45	DJD	82	8	Screws	None	None	No	STJ/TNJ/Gastroc
41	54	RA	100	12	Steinmann pins	None	None	No	STJ/TNJ/Gastroc
42	37	PTTD	69	6	Screws	None	None	Yes	STJ/TNJ/Gastroc
43	51	PTTD	87	8	Screws	None	None	No	STJ/TNJ/Gastroc
44	37	Coalition	76	10	Screws	None	None	No	STJ/TNJ/Gastroc
45	52	PTTD	101	8	Screws/Plate	BA glass	None	No	STJ/TNJ/TAL

CCJ, calcaneocuboid joints; PTTD, posterior tibial tendon dysfunction; STJ, subtalar joint; TNJ, talonavicular joint; Gastroc, gastrocnemius; PRP, platelet-rich plasma; DBM, demineralized bone matrix; TAL, tendo Achillis lengthening; DJD, degenerative joint disease; MS, multiple sclerosis; RA, rheumatoid arthritis; PGC, platelet gel concentrate; BA, bioactive; SC, stem cell; BMP, bone morphogenetic protein.

5 patients who experienced complications, compared with those patients without a complication, the median healing time was 10 weeks versus 8 weeks, respectively, and this difference was found to be statistically significant ($P = .01$) (Table 5).

Discussion

Triple arthrodesis has been used successfully to treat severe hindfoot angular deformities, and the operation traditionally involves a 2-incision approach that can be associated with lateral wound complications, sural nerve damage, and nonunions of the CCJ (3, 10). In this series, we did not fuse the CCJ, thus obviating a potential source of complications including nonunion (11). Although the lateral approach to STJ arthrodesis provides complete visualization of the posterior facet, it is somewhat limited by difficulty visualizing the middle and anterior facets and increased difficulty correcting valgus deformity, which can typically be readily reduced via the medial approach. In fact, we feel that the single-incision medial approach offers a mélange of benefits to the surgeon and the patient alike. The hallmark advantage of the medial approach is superior exposure that enables effective resaddling of the talus. Taking down the sustentaculum allows ample calcaneal slide and repositioning that is not available via the lateral approach, and we believe that this is a crucial

Table 2
Biologic agents used

Biologic agent	Count (%)
None	18 (40.0)
PRP	7 (15.6)
PRP/DBM	6 (13.3)
BA glass	5 (11.1)
DBM	5 (11.1)
BMP	1 (2.2)
DBM/SC	1 (2.2)
PGC	1 (2.2)
PRP/SC	1 (2.2)
Total	45 (100)

PRP, Platelet-rich plasma; DBM, demineralized bone matrix; BA, bioactive; BMP, bone morphogenetic protein; SC, stem cell; PGC, platelet gel concentrate.

Table 3
Types of complications

Complication	Count (%)
None	39 (86.7)
Inadequate exposure (abandoned)	1 (2.2)
Elevated first ray	1 (2.2)
Talar fracture	1 (2.2)
Lateral column pain	1 (2.2)
Painful fixation	1 (2.2)
Wound dehiscence	1 (2.2)

element in the correction of severe hindfoot valgus deformity. Because the lateral soft tissues are frequently contracted secondary to longstanding calcaneovalgus, the medial approach avoids the potential difficulties that can be associated with a complicated closure of contracted lateral soft tissue structures.

We also believe that, when preparing a joint for fusion, there is a natural tendency to resect more from the side of the approach. This can be particularly problematic if, during use of the lateral approach to subtalar arthrodesis for correction of a valgus deformity, more bone is resected from the lateral side of the joint and the valgus deformity perpetuated. Avoidance of this tendency is optimized with use of the medial approach, and taking more bone from the medial side of the joint, in the case of a valgus deformity, can be helpful, especially when combined with optimal calcaneal translation.

Any incision using a medial approach at the level of the rearfoot draws a natural concern for the possibility of injuring the neurovascular bundle. Such concern is appropriate, because injury to any component of the neurovascular bundle can result in serious morbidity. However, when the anatomy is dissected with care, the danger of such a complication is unlikely and not a contraindication to use of the medial approach. The incision is strategically placed between the neurovascular bundle and the deep deltoid ligament. The authors are more than comfortable using the medial approach for subtalar arthrodesis, without injury to the tibial nerve. Interestingly, aggressive blind dissection and curettage via the lateral approach may put these vital structures at risk, because they reside just posteromedial to the STJ (11).

In 1995, O'Malley et al (5) performed a cadaver study that showed isolated TNJ and STJ fusion to be just as effective as triple arthrodesis. Specifically, they found that restoration of arch height and forefoot rotation could be obtained without fusing the CCJ (5). Sammarco and colleagues (10), in 2006, also demonstrated clinical improvement in 16 patients who had undergone combined TNJ and STJ fusions for correction of severe valgus hindfoot deformities and noted that the average American Orthopaedic Foot & Ankle Society (AOFAS) score significantly ($P < .01$) improved from 44.7 preoperatively to 77.0 postoperatively. Still further, Jeng et al (13) compared the adequacy of joint preparation using the medial approach versus the 2-incisional approach commonly associated with triple arthrodesis and found that the medial approach afforded better preparation of all joint surfaces except the calcaneal aspect of the STJ and the CCJ, where the differences were considered negligible.

Table 4
Multiple variable* results depicting the adjusted duration of surgery (minutes) by procedure, age, and complication

Covariate	Mean time to union (weeks)		
	Mean	95% CI	*P* value
Procedure			
STJ/TNJ fusion	113.9	96.5, 131.2	.01†
STJ/TNJ fusion with TAL	91.7	79.0, 104.3	
STJ/TNJ fusion with GR	84.8	76.5, 93.2	
Age group			
≤ 35 years	89.2	74.0, 104.3	.09
36 to 55 years	100.2	89.9, 110.5	
56 to 65 years	106.2	93.2, 119.1	
>65 years	91.7	81.0, 102.3	
Complication observed			
Yes	93.3	86.7, 99.9	.35
No	100.3	86.2, 114.4	

STJ, Subtalar joint; TNJ, talonavicular joint; TAL, tendo Achillis lengthening; GR, gastrocnemius recession.
* Adjusted means obtained using one-way analysis of variance.
† Statistically significant at $\alpha = 0.05$.

Table 5
Multiple variable* results depicting the adjusted median time to union by procedure, age, and complication

Covariate	Median time to union (weeks)		
	Median	95% CI†	P value‡
Procedure			
STJ/TNJ fusion	8.5	6.0, 20.0	.52
STJ/TNJ fusion with TAL	8.0	—	
STJ/TNJ fusion with GR	8.0	—	
Age group			
≤35 years	7.0	6.0, 8.0	.23
36-55 years	8.0	8.0, 10.0	
56-65 years	8.0	—	
>65 years	8.0	8.0, 9.0	
Complication observed			
Yes	10.0	8.0, 12.0	.01§
No	8.0	—	

STJ, Subtalar joint; TNJ, talonavicular joint; TAL, Tendo Achillis Lengthening; GR, gastrocnemius recession.
* Adjusted median times obtained using Kaplan-Meier estimates.
† Confidence intervals not indicated in 4 of the 9 strata due to low sample size.
‡ *P*-value obtained from stratified log-rank test, testing homogeneity across strata.
§ Statistically significant at $\alpha = 0.05$.

In this era of cost containment, a single-incision approach makes fiscal sense. Our average operating time was about 87 minutes. Bonsell (14), in 2000, was able to show a cost savings of $565.00 for every 23 minutes of time saved in the operating room. Adjusted for inflation, that would be comparable to $706.00 in 2009. Conservatively assuming an operating room time of 150 minutes using the traditional 2-incision approach would translate to an average savings of approximately $1933.00 per case. This crude cost comparison does not further consider the potential additional cost of the procedure due to the use of additional hardware to fuse the CCJ.

Like all retrospective studies, a number of methodological weaknesses could have threatened the validity of our conclusions. Because our sample size was relatively small, we were unable to thoroughly consider healing time as it related to age, procedure selection, and the occurrence of a surgical complication. With a larger sample size, we could estimate the relative differences with respect to surgical time and healing. By estimating relative differences, this could give clinicians a more qualitative (as well as quantitative) idea of the benefits of the single-incision approach. Additionally, there remains uncertainty in regard to all of the variables that may have impacted the reported surgical times. Although our findings support the idea that there is a cost savings associated with use of the single medial–incision approach, we recognize that our cost analysis was very crude and depended on a previously reported historical control. Further studies comparing patients in the same institution undergoing the single versus 2-incision approach could realize the true costs associated with each technique. Still further, our outcomes were measured and determined by the surgeons who performed the operations, and we did not use a valid foot-related quality-of-life outcome measurement to determine the results of the single-medial incision approach to combined TNJ and STJ fusion. Finally, we did not undertake a sensitivity analysis to test the resistance of our results to the potential influence of an unmeasured variable (such as comorbidity, smoking status, or any other demographic factor that could influence the response of a patient to the operation). Despite these shortcomings, we believe that the results of this investigation indicate that the single-medial incision approach to combined TNJ and STJ arthrodesis is safe and effective. Furthermore, the results of this investigation could be used in the development of future prospective cohort studies and randomized controlled trials that focus on repair of advanced hindfoot valgus deformity.

In conclusion, the single-medial incision TNJ and STJ arthrodesis is a useful alternative to triple arthrodesis for advanced adult–acquired flatfoot and hindfoot angular deformities (15). The procedure provides excellent surgical exposure of the posterior, anterior, and middle facet of the STJ, while enabling easy joint resection and manipulation of the calcaneus beneath the talus. Patients with severe hindfoot valgus deformities may also benefit from decreased operating room time, decreased operating room cost, the potential for decreased postoperative complications, and the possibility of decreased postoperative pain when compared with patients who undergo a more invasive 2-incision approach to major hindfoot and midfoot arthrodesis.

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