Two-Screw Fixation Construct for Subtalar Joint Fusion Revisited: A Retrospective Review

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STATEMENT OF PURPOSE

Subtalar joint (STJ) fusion has been reported to yield generally favorable outcomes for the surgical management of many rearfoot conditions. Various fixation constructs may be used, based on surgeon preference. We previously described the divergent screw (delta configuration) fixation technique for STJ fusion with a retrospective case series of 15 early cases. We now report on the outcomes of STJ fusion using this same fixation approach in consecutive cases from 2012-2016.

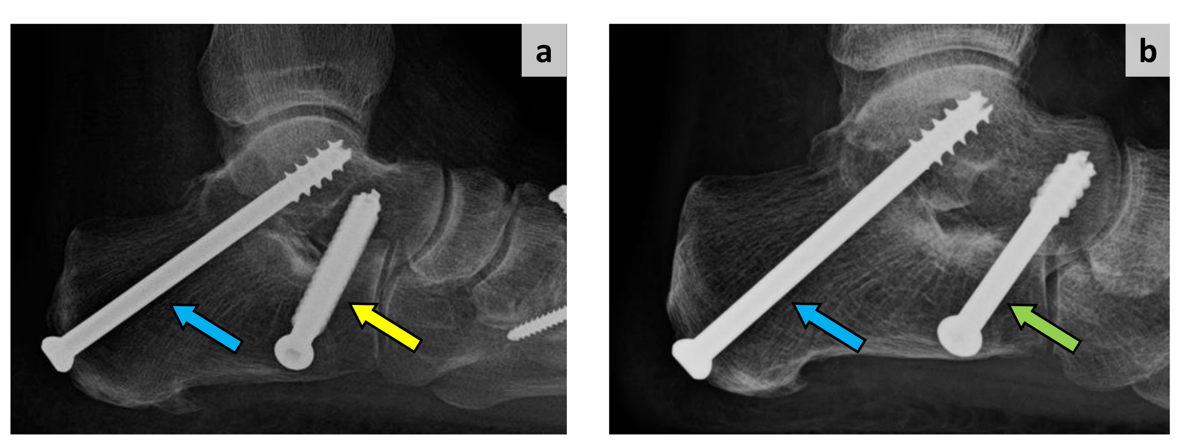
METHODOLOGY AND HYPOTHESIS

An institutional review board-approved retrospective review was performed on consecutive patients who underwent STJ fusion by author T.J.B. from February 2012 to November 2016. Consecutive cases were evaluated to minimize selection bias. Seventy-four cases involving STJ fusion were identified based on use of the Current Procedural Terminology (CPT®) code 28725. Inclusion criteria were primary fusion of the STJ using our divergent screw fixation technique with at least 10 week postoperative follow-up **(Fig. 1)**. Cases involving revision of STJ fusion or an alternate fixation construct were excluded in an effort to focus on the results of our standard protocol **(Fig. 2)**.

A total of 51 cases (49 patients) met inclusion criteria, with 2 patients undergoing bilateral procedures. Electronic medical records for each of the 51 cases were reviewed to identify presence or absence of osseous union at 10 weeks, as documented by author T.J.B. and the radiologist assigned to read each respective radiograph. Osseous union was defined as radiographic evidence of trabecular bridging across the posterior facet fusion site as identified on lateral foot and calcaneal axial views. We have chosen to focus on a descriptive analysis with an emphasis on union rate at 10 week follow-up, represented as a percentage. Additional review included identification of postoperative complications, and rate of hardware removal with attention to which screw(s) required removal.

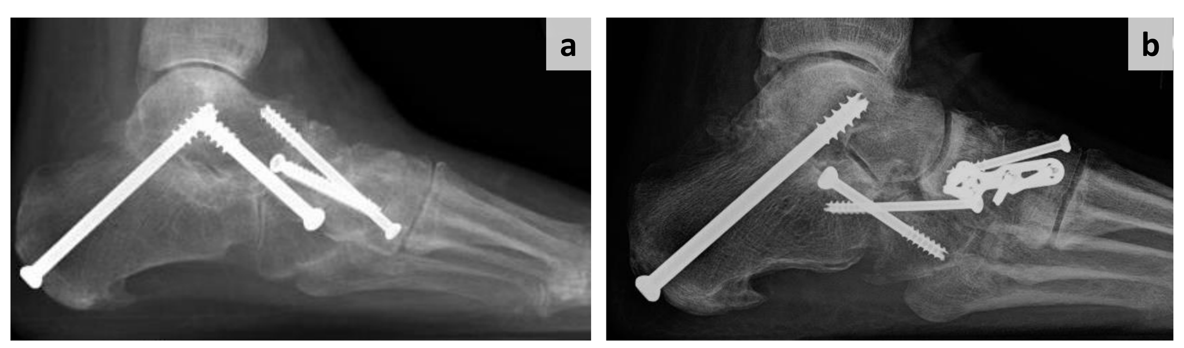
We hypothesize that STJ fusion using the divergent screw fixation construct we describe yields a high rate of fusion by 10 weeks and a low rate of complications or hardware removal.

Figure 1. Divergent screw fixation construct for subtalar joint fusion



Primary compression at the subtalar joint fusion site is provided by the posterior screw (blue arrow). (a) The fully threaded anterior screw (yellow arrow) does not compress but provides stability to protect against rotational forces that could compromise healing. (b) If the middle and anterior subtalar joint facets are prepared, a partially threaded anterior screw (green arrow) can be used to provide compression in addition to stability.

Figure 2. Excluded STJ fusion fixation constructs



The anterior screw for subtalar joint fusion is not used in cases with concomitant (a) talonavicular joint or (b) calcaneocuboid joint fusion, due to interference with and anterior stabilization provided by midtarsal joint fixation. Twenty-two cases were excluded for this reason.

PROCEDURE

Surgical technique involved open preparation of the STJ surfaces for fusion. Preparation of the anterior and middle facets was only performed if accessible, based on incisional approach and rearfoot attitude. Our standard protocol for joint preparation begins with removal of articular cartilage using a flexible osteotome, followed by curettage. The subchondral plates are thinned and contoured with a rotary burr to expose bleeding bone. Finally, the joint surfaces are fenestrated with a 2.0 drill todraw autograft into the fusion site and promote healing. Additional products such as bone graft substitutes, bone marrow aspirate, and bone graft extenders are not routinely used. The rearfoot was then positioned to correct deformity followed by placement of the primary cannulated compression screw (headed) across the posterior facet, directed from the posterior calcaneus to the body of the talus. A secondary cannulated screw (headed) was placed from the anterior calcaneus to the neck of the talus. As shown in **Figure 3**, small longitudinal lateral incision was placed approximately 3 cm proximal to the calcaneocuboid joint and plantar to the calcaneus to avoid injury to the sural nerve and peroneus longus tendon. Blunt dissection was made to bone followed by placement of a guide pin through the incision for the secondary screw. The guide pin was then driven from the anterior calcaneus to the neck of the talus at a 45° angle from plantar lateral to dorsomedial **(Fig. 4)**. The angle of insertion is based on talocalcaneal anatomy which varies depending on pronated vs. supinated foot position after correction of deformity. When the goal of secondary screw placement was only stability, a fully threaded screw was used. A partially threaded screw was used for compression in cases that involved preparation of the middle and anterior facets. Complete intraoperative fluoroscopic imaging was utilized to confirm adequate position cannulated screws **(Fig. 5)**. Patients were placed in a removable below knee brace with recommendations for ankle range of motion (ROM). Non-weight bearing (NWB) status was recommended for all patients until 6 weeks after surgery, which was followed by 4 weeks of protected weight bearing in a below knee fracture boot.

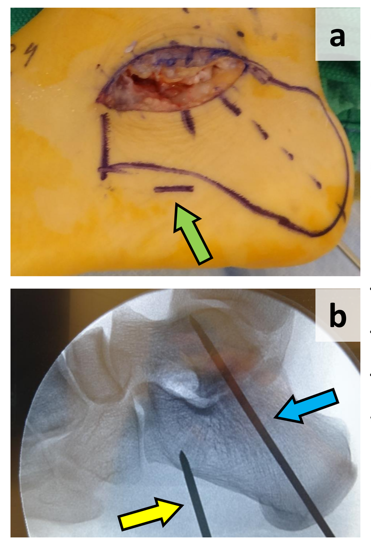
LITERATURE REVIEW

STJ fusion has been described for the surgical management of many painful rearfoot conditions, congenital and acquired. Examples include end-stage osteoarthritis of the STJ, post-traumatic arthritis, STJ instability, pathologic pronation, posterior tibial tendon dysfunction (PTTD), cavus deformity, and tarsal coalition (1). Non-union rates from 0% up to 23.8% have been reported, with certain risk factors found to negatively impact fusion rate (2-3). Many reports have focused on fusion rates associated with specific fixation constructs. Examples of constructs described include one, two, and three screw fixation with headed or headless screws in various arrangements, staples, external fixation, and bone dowels (4-5). In 2012, Boffeli and Reinking described a divergent 2-screw fixation construct with a retrospective case series involving 15 patients (3). A 100% fusion rate was reported based on review of lateral and axial radiographs at 10 weeks. This construct has been subsequently reported to be biomechanically superior to a single posterior screw across the STJ and two posterior screws across the STJ, in both parallel and divergent orientations (6-7).

Table 1. Summary of results (n=51 cases in 49 patients)

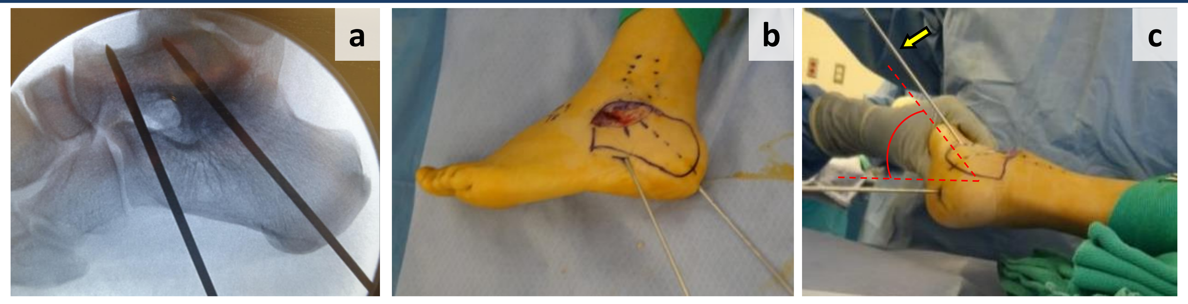
Variable	Value
Age	Mean: 53.8 years (range 20-79)
Gender	Male: 13/49 (26.5%), Female: 36/49 (73.4%)
Radiographic union of STJ fusion at 10 weeks	51/51 cases (100.0%)
Cases requiring revision	1/51 (2.0%)
Cases requiring hardware removal	4/51 (7.8%)
Both (anterior and posterior screw removal)	2/51 (3.9%)
Posterior screw alone	2/51 (3.9%)

Figure 3. Anterior screw incision and guide pin placement



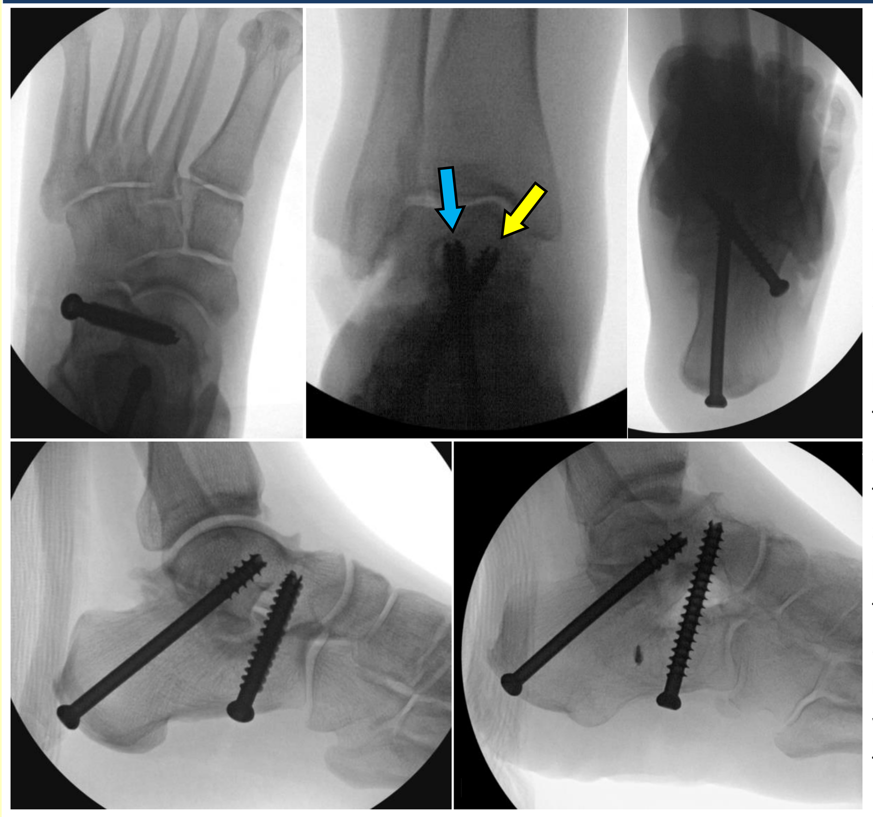
(a) Incision for anterior screw (green arrow) is placed at the lateral heel, inferior to the plantar calcaneal margin and approximately 3 cm proximal to the calcaneocuboid joint. This incision placement avoids iatrogenic injury to the sural nerve and peroneus longus tendon. Following blunt dissection to bone (b) the anterior guide pin (yellow arrow) is inserted, with fluoroscopy used to confirm desired starting point and trajectory. The pin enters the calcaneus off the weightbearing surface and is directed to the talar neck, parallel to the midtarsal joint. Ideal posterior guide pin position is also shown (blue arrow).

Figure 4. Anterior and posterior guide pin orientation



Desired orientation of anterior and posterior guide pins is shown (a) radiographically and (b) clinically. (c) Viewed from posteriorly, angulation between the anterior guide pin (yellow arrow) and the posterior guide pin is shown in red. This angle is typically 45° but may vary with rearfoot alignment after deformity correction.

Figure 5. Intraoperative fluoroscopy following divergent screw placement



Final fluoroscopic imaging following divergent screw placement confirms desired anatomic alignment and optimal hardware placement. AP ankle imaging confirms midline position of the posterior screw in the talar body (blue arrow) and the anterior screw in the talar neck (yellow arrow). Medial oblique imaging is used to assess full seating of the anterior screw. Note multiplanar divergence which adds stability to the construct.

RESULTS

Our review identified 74 cases of STJ fusion. Of these cases, 51 (49 patients) involved primary fusion using the divergent 2-screw construct previously described by Boffeli and Reinking (3). The mean age of the patients who met the inclusion criteria was 53.8 years (range 20-79). Of those who were included, 13 patients (26.5%) were male and 36 patients (73.4%) were female. Preoperative indications for fusion included flatfoot deformity, PTTD, tarsal coalition, cavus deformity, and peroneal tendon dysfunction. Osseous union at 10 week follow-up was identified in 51/51 (100%) of cases. Following successful fusion, 1 case (2%) required positional revision at 3.5 months following the index procedure due to supinated STJ alignment with lateral column overload. Hardware removal was required in a total of 4 cases (7.8%). Both screws were removed in 2 cases (3.9%), one of which was the aforementioned revision case. The other case requiring removal of both screws involved hardware-associated pain. The other 2 hardware removal cases (3.9%) involved only the posterior screw due to hardware-associated pain, while the anterior screw was left intact in both cases. No other complications related to the STJ fusion procedure were identified. Results are summarized in **Table 1**.

ANALYSIS AND DISCUSSION

Each fixation construct for STJ fusion that has been described in the published literature has advantages and disadvantages. DeCarbo et al. found no statistical difference between the fusion rates associated with a single posterior screw and two posterior screws across the subtalar joint (8). However, a concern with the single compression screw across the STJ is that a fall or premature ambulation during the 10 week postoperative healing phase could result in loss of compression and potentially compromise osseous union. While a second screw across the posterior facet has been shown to increase stability, this second screw occupies precious posterior facet surface area for osseous union and can increase the potential for pain with weight bearing. The fixation construct we describe affords the biomechanical stability of two screws, and surface area for osseous union is maximized as only one screw crosses the posterior facet.

One STJ fusion patient with divergent screw placement identified in our initial review was excluded, as they were referred to author T.J.B. for revision of non-union after STJ fusion by a different surgeon. This was a high-risk patient with history of coronary artery disease who was non-compliant with weight bearing recommendations, and continued to smoke postoperatively. The patient eventually went on to osseous union across the STJ after a second attempt at revision using our divergent screw fixation and augmentation with bone graft. This case highlights the utility of our divergent construct for high-risk patients who require additional stability due to expected premature weight bearing or need long-term stability at the fusion site in cases of anticipated slow union due to diabetes, continued tobacco use, or poor bone health.

Twenty-two additional STJ fusion cases identified in our initial review were excluded as they involved concomitant talonavicular (TNJ) and/or calcaneocuboid joint (CCJ) fusion **(Fig. 2)**. The anterior screw we describe was not used in these cases, as midtarsal joint fixation serves as anterior stabilization. Additionally, the position of hardware for TNJ and CCJ fusion makes anterior screw placement impractical.

We did not identify other complications associated with anterolateral screw placement including sural nerve injury and peroneus longus tendon injury. The location of the incision for this screw is important, as improper placement risks damage to the sural nerve and peroneus longus tendon. **Figure 3** demonstrates markings for incision planning and pearls for placement.

This study is limited by its retrospective design and could be strengthened by a direct comparison of our divergent construct for STJ fusion with other commonly employed fixation constructs allowing more robust statistical analysis. The 100% union rate and low complication rate described here is partly related to what we feel is optimal screw fixation but is also influenced by our overall STJ fusion protocol involving cessation of smoking, bone health assessment, concomitant vitamin D optimization, normalization of Hgb A1c, thorough joint preparation, and strict NWB during the initial healing phase. In conclusion, we have found that STJ fusion using the divergent screw fixation construct we describe yields a high rate of fusion by 10 weeks and is associated with a low rate of hardware removal.

REFERENCES

1. Jastifer JR, Alrafeek S, Howard P, Gustafson PA, Coughlin MJ. Biomechanical Evaluation of Strength and Stiffness of Subtalar Joint Arthrodesis Screw Constructs. Foot Ankle Int 37:419-426, 2016.
2. Mirmiran R, Wilde B, Nielsen M. Retrospective analysis of the rate and interval to union for joint arthrodesis of the foot and ankle. J Foot Ankle Surg 53:420-425, 2014.
3. Boffeli TJ, Reinking RR. A 2-screw fixation technique for subtalar joint fusion: a retrospective case series using a 2-screw fixation construct with operative pearls. J Foot Ankle Surg 51:734-738, 2012.
4. Herrera-Pérez M, Andarcia-Bañuelos C, Barg A, Wiewiorski M, Valderrabano V, Kapron AL, Pais-Brito JL. Comparison of cannulated screws versus compression staples for subtalar arthrodesis fixation. Foot Ankle Int 36:203-210, 2015.
5. Matsumoto T, Glisson RR, Reidl M, Easley ME. Compressive force with 2-screw and 3-screw subtalar joint arthrodesis with headless compression screws. Foot Ankle Int 37:1357-1363, 2016.
6. Eichinger M, Schmölz W, Brunner A, Mayr R, Bölderl A. Subtalar arthrodesis stabilisation with screws in an angulated configuration is superior to the parallel disposition: a biomechanical study. Int Orthop 39:2275-2280, 2015.
7. Jastifer JR, Alrafeek S, Howard P, Gustafson PA, Coughlin MJ. Biomechanical Evaluation of Strength and Stiffness of Subtalar Joint Arthrodesis Screw Constructs. Foot Ankle Int 37:419-426, 2016.
8. DeCarbo WT, Berlet GC, Hyer CF, Smith WB. Single-screw fixation for subtalar joint fusion does not increase nonunion rate. Foot Ankle Spec 3:164-166, 2010.