Introduction
Injury to the plantar calcaneonavicular (spring) ligament rarely occurs in isolation [1]. It most commonly occurs in conjunction with posterior tibialis tendon (PTT) dysfunction or injury. Studies have found that between 82-92% of patients with PTT dysfunction also sustained an injury to the spring ligament [2-4]. The spring ligament is one of the primary static stabilizers of the medial arch of the foot, while the PTT is the primary dynamic stabilizer [5-11]. The spring ligament serves two primary functions: 1) supports the head of the talus and 2) stabilizes the longitudinal arch of the foot with the PTT [9]. Spring ligament tears may also occur secondary to a deficient PTT with adult-acquired flatfoot deformity [1]. Damage to either of these structures can result in flat foot deformity [6,9,11,12]. When injury to the spring ligament occurs, it is most often the superomedial calcaneonavicular ligament (SMCNL) portion that is affected.

The severity of a spring ligament tear and its related dysfunction determine the course of treatment [9]. Conservative treatment is commonly reserved for partial and acute tears [9].
The patient will be non-weight bearing (NWB) for approximately six weeks with immobilization. Once pain and inflammation decrease, the patient begins therapy and is guided through a progressive rehabilitation program [9]. A chronically injured spring ligament will commonly occur in conjunction with posterior tibialis tendinopathy (PTT), often requiring surgery for patients who are competitive athletes [2,13,4,9]. However, spring ligament tears leading to flat foot deformity can occur in isolation [14,15]. If they are diagnosed prior to arch collapse, they can be reconstructed in an attempt to prevent a more significant flat foot deformity. Surgical treatment is determined by the extent of the tear and the function of the surrounding structures.

Reconstruction surgeries of the spring ligament have been performed with autograft and allograft techniques using the flexor digitorum longus tendon, and more commonly, the peroneus longus and flexor hallucis longus tendons [16-18,11].

Despite the lack of evidence-based and objective guidelines on spring ligament reconstructions, the goal of rehabilitation in an athlete is to return to previous activity and function as quickly as possible [19]. The rehabilitation process should focus on, but is not limited to, range of motion, proprioception, strength and conditioning, speed and agility, and performance based activities. The purpose of this case report is to summarize the findings, surgery, rehabilitation, and outcomes of an elite athlete who suffered an isolated spring ligament tear.

Materials and Methods

A healthy 21 year-old male Division I collegiate track athlete (long and high jump competitor) was injured during take-off during the long jump. The subject reported immediate pain in the medial hindfoot. After competing in two subsequent track meets, he continued to have significant pain while jumping.

The subject was evaluated by an Orthopaedic Surgeon when he did not respond to rest and conservative measures. On examination tenderness and swelling were isolated to the spring ligament region of the hindfoot. Weight bearing radiographs revealed no arch collapse. MRI revealed a tear of the spring ligament without associated pathology to the posterior tibial tendon (Figure 1). Further conservative treatment was initiated by the Orthopaedist.

Preoperative

The surgeon instructed the subject to maintain toe-touch weight bearing (TTWB) with crutches in a CAM walking boot. After 6 weeks of immobilization, the subject still presented with pain and an inability to advance his activity level without significant symptomatology. In an effort to prevent eventual arch collapse in a high level athlete, surgical intervention was elected.

Surgical intervention

The subject underwent a left spring ligament repair with allograft reconstruction using an allograft peroneus longus tendon. The surgery was performed under a regional block in the supine position with tourniquet control.

An incision was made from posterior to the tip of the medial malleolus to distal to the navicular. The PTT and the flexor digitorum longus tendon were found to be normal in appearance. The spring ligament was noted to have very good tissue proximally; however, a few millimeters proximal to the insertion of the navicular, there was full thickness tearing noted (Figure 2). The spring ligament was repaired primarily with sutures and was then augmented with the allograft (Figure 3). The augmentation was performed to assist with stability and healing in the setting of intense strain that was expected to occur in this collegiate athlete. The pre-tensioned allograft was placed into a tunnel created in the sustentaculum-tali and then anchored into a tunnel running from plantar to dorsal through the navicular. Fixation was obtained with interference screws. The ankle...
was immobilized for 2 weeks in a splint. A timeline of relevant events is described in Table 1.

Rehabilitation

Phase 1: Immediate postoperative phase: restrictive motion (weeks 0–4): The goals of this phase were to protect the anatomic reconstruction, prevent the negative effects of immobilization, and restore/maintain full ROM at the knee and hip. The subject was instructed to remain NWB with crutches for 2 weeks. During weeks 3–4, the subject was TTWB with crutches in a fiberglass short leg cast (Table 2).

Phase 2: Intermediate phase: moderate protection phase (weeks 5–11): This phase focused on protecting the anatomic reconstruction, continuing to diminish pain and inflammation, achieving satisfactory muscle strength, gaining full active plantarflexion and dorsiflexion, and normalizing gait. During this phase, no impact activities were performed and postoperative swelling was managed. The short leg cast was removed and replaced with a CAM boot at week 5 with partial (25%) weight bearing. Weight bearing was advanced to full as tolerated with the use of the CAM walking boot and crutches week 6. During postoperative week 7, the subject discontinued use of the crutches but continued in the CAM walking boot only for longer distances until week 12. The subject used a regular sneaker with an over-the-counter arch support while walking around his dorm room during this time.

Phase 3: Advanced strengthening phase (weeks 12–20): During this phase, the subject discontinued bracing, began jog-run-sprint progressions, initiated higher-level strengthening and athletic maneuvers, and returned to full weight room activities. During postoperative week 12 weight bearing radiographs were performed, confirming adequate maintenance of arch alignment. At this time, no significant pain or tenderness was reported. The subject approached full, pain-free ankle range of motion and strength. The subject was also prescribed a custom fit orthotic. During postoperative week 19, the subject reported painless running during short sprints and 400m runs.

Phase 4: Return-to-sport phase (months 4–6): During postoperative week 28 the subject was cleared by the physician to return to all activities as tolerated. Rehabilitation focused on returning to full activity, continuing to progress weight room activities, and educating the subject on a maintenance program.

### Table 1: Timeline of Events.

<table>
<thead>
<tr>
<th>Time</th>
<th>Relevant Events</th>
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<tbody>
<tr>
<td>Week(s) 0-2</td>
<td>- Left spring ligament reconstruction with peroneus longus tendon allograft - Subject placed in a well-padded posterior and short leg U-splint - NWB with axillary crutches</td>
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<tr>
<td>Week(s) 3-4</td>
<td>- Subject instructed to wear a short leg cast using TTWB with crutches</td>
</tr>
<tr>
<td>Week(s) 5-12</td>
<td>- Week 5: Transitioned PWB with a CAM walking boot and crutches; Initial FADI scores taken - Week 6: Transitioned WBAT with a CAM walking boot and crutches - Week 7-11: Transitioned WBAT with a CAM walking boot without crutches for long distances; for short distances used regular sneaker with over-the-counter arch support</td>
</tr>
<tr>
<td>Week 12</td>
<td>- Discontinued use of CAM walking boot - Radiographs showed continued growth and healing - Full, pain-free strength (5/5) throughout available ankle range of motion without palpable tenderness - Approaching full ROM, pain-free with minimal tenderness at operative site - Arches maintained and alignment adequate</td>
</tr>
<tr>
<td>Week 19</td>
<td>- Subject received custom orthotic - Full ankle and foot AROM - Minimal swelling medially</td>
</tr>
<tr>
<td>Week 28</td>
<td>- Subject cleared to return to all activity as tolerated</td>
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### Outcome measure

The FADI is a subjective self-report measure of function with two components [20]. The traditional FADI consists of 26-items related to activities-of-daily living (ADL); in addition, the FADI Sport (S) subscale consists of 8-items that are specifically designed for an athletic population [21]. It is scored for activity and pain items on a 0 to 4 scale: 0 representing unable to do or unbearable pain and 4 representing no difficulty or no pain, respectively. The scores for the FADI and FADI-S are calculated into separate percentages with 100% representing no dysfunction. The FADI (ICC = 0.89) and FADI-S (ICC = 0.84) have both been shown to be reliable outcome measures used to detect functional limitations in patients with CAI [21,22]. The FADI-S is more sensitive in detecting limitations among high-functioning individuals and therefore may be more practical for use in an athletic population. Construct validity has been demonstrated as these measures were found to have good sensitivity to detect change in function between healthy subjects and patients with CAI [21,22]. Both measures have demonstrated responsiveness to improvements in function following rehabilitation. Minimal clinically important difference (MCID) has yet to be determined for both the FADI and FADI-S.

### Results and Discussion

The subject initially presented with significant pain in his medial hindfoot without visible collapse of the arch. After 6 weeks of conservative treatment without improvements, reconstructive surgery was performed. The subject’s early rehabilitation consisted of exercises focusing on achieving normal ankle ROM and muscle strength while maintaining normal mobility at proximal joints. As goals were met, the program advanced, consisting of more sport-specific exercises. Once the subject was cleared by the physician and there were sufficient improvements with the FADI and FADI-S, the subject was able to return to sport pain-free. At the subject’s 30 month follow-up evaluation, he was noted to be competing at an elite level as a college track athlete. He reported no pain at the operative site, exam demonstrated normal strength without atrophy, full range of motion, and a maintained arch. He was subjectively pleased with the result.

Implementation of a rehabilitative protocol that incorporated a criterion-based progressive plan of care was key in the subject’s recovery and ultimately in his return to sport. Caution was taken throughout the course of his care to avoid overly tensioning the reconstruction while still providing adequate stresses for soft tissue.
Table 2: Rehabilitation Protocol.

<table>
<thead>
<tr>
<th>Rehabilitation Following Surgical Reconstruction of the Spring Ligament</th>
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<td><strong>Phase I: Immediate Postoperative Phase: Restrictive Motion</strong></td>
</tr>
</tbody>
</table>

**Goals**

1. Protect the anatomic repair
2. Prevent negative effects of immobilization
3. Restore/main full ROM of the knee and hip

**Post-Operative Day 1 to Week 2**

**Weight Bearing:** Placed in a well-padded posterior and short leg U-splint; NWB with crutches

**Week 3 to Week 4**

**Weight Bearing:** Placed in a fiberglass short leg cast; TTWB with crutches

1. Knee/hip range of motion (A/A/A/PROM)
2. Proximal hip proprioceptive neuromuscular facilitation (PNF) D1/D2 strengthening
3. Gentle knee and hip strengthening
4. Upper body ergometer

**Progression Criteria to Enter Phase 2**

1. Satisfactory clinical examination by surgeon

**Phase 2: Intermediate Phase: Moderate Protection**

**Goals**

1. Continue to protect the anatomic repair
2. Continue to diminish pain and inflammation
3. Satisfactory muscle strength and eliminate arthrogenic muscle inhibition at the ankle
4. Active dorsiflexion 0-10°; full active plantarflexion
5. Normalize gait and return to ADLs

**Precautions**

1. No impact activities
2. Avoid post-activity swelling

**Week 5 to Week 7**

**Week 5 Weight Bearing:** Transitioned to PWB with a CAM (TROM; DJO Global, Vista, CA) with crutches

**Week 6 Weight Bearing:** Transitioned WBAT with a CAM walking boot and crutches

**Week 7-11:** Transitioned WBAT with a CAM walking boot without crutches for long distances; for short distances used regular sneaker with over-the-counter arch support

1. Soft tissue and scar mobilizations
2. Continue ROM exercises (gentle great toe extension ROM)
3. Continue soft tissue and scar mobilizations as indicated
4. Initiate gait training
5. Initiate balance training
6. Initiate proprioception drills
7. Initiate closed chain exercises to 60° knee flexion
8. Initiate non-impact cardiovascular aerobic training
9. Initiate core strengthening and motor control exercises
10. Initiate aquatic exercises
11. Progress hip and ankle strengthening
12. Continue cryotherapy, modalities as indicated

**Week 8 to Week 11**

**Weight Bearing:** Week 7-11: Transitioned WBAT with a CAM walking boot without crutches for long distances; for short distances used regular sneaker with over-the-counter arch support

1. Fabrication of a custom fit orthotic
2. Continue and progress program as above
adaptations. Monitoring signs and symptoms of associated with these stresses was especially important considering the lack of literature concerning spring ligament reconstructions.

The subject’s FADI scores improved from 66.3% to 99% and the FADI-S improved from 0% to 87.5% (Table 3). The FADI and FADI-S were the outcome measures used to assess the subject’s level of dysfunction and responsiveness to treatment. The FADI is an outcome tool because it has a sport component in order to analyze tasks that are more sport specific [21,22]. While it has been found to

<table>
<thead>
<tr>
<th>Progression Criteria to Enter Phase 3</th>
<th>1. Normalized gait</th>
<th>2. Full active and passive ROM at the ankle</th>
<th>3. Muscular strength (good grade or better)</th>
<th>4. No pain or tenderness</th>
<th>5. Single limb stance (SLS) ≥ 30 seconds with minimal postural sway</th>
<th>6. Ability to carry out activities of daily living without compensation</th>
<th>7. Satisfactory Foot Ankle Disability Index scoring (FADI)</th>
<th>8. Satisfactory clinical exam</th>
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<tr>
<th>Phase 4: Return-to-Sport</th>
<th>Goals</th>
<th>1. Full return to activity</th>
<th>1. Continue to progress weight room activities</th>
<th>1. Educate on maintenance program</th>
</tr>
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</table>

| Month 4 to Month 6 | 1. Gradually progress track activities to unrestricted participation | 2. Continue Olympic lifting and strengthening program | 3. Continue plyometric program |
|-------------------------------|----------------|---------------------------------|---------------------------------|-------------------|

Table 3: FADI and FADI-S Scores.

<table>
<thead>
<tr>
<th>Postoperative Outcome Scores</th>
<th>Week 5 Score</th>
<th>Week 28 Score</th>
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<tbody>
<tr>
<td>FADI</td>
<td>66.3%</td>
<td>99%</td>
</tr>
<tr>
<td>FADI Sport</td>
<td>0%</td>
<td>87.5%</td>
</tr>
</tbody>
</table>
be a reliable outcome tool, it was only assessed in one study which analyzed the FADI and FADI-S in patients with CAI [21]. Further research needs to be conducted to assess their reliability with other foot and ankle pathologies.

**Conclusion**

This study outlines a subject’s return to pain-free sport activity following a spring ligament reconstruction. The results suggest that a multimodal approach to rehabilitation will lead to a successful outcome in post-surgical rehabilitation of a spring ligament reconstruction. This may help guide clinicians with their return to sport progressions for patients with similar presentations. Future studies should be conducted following these guidelines in order to confirm successful post-surgical reconstruction outcomes.

**References**