The Non-surgical and Surgical Treatment of Tarsal Navicular Stress Fractures

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The purpose of this paper is to provide a statistical analysis of previously reported tarsal navicular stress fracture studies regarding the outcome and effectiveness of conservative and surgical management. A systematic review of the published literature was conducted utilizing MEDLINE through Ovid, PubMed, ScienceDirect, and EBSCOhost. Reports of studies that provided the type of tarsal navicular stress fracture, i.e. complete or incomplete, type of treatment, result of that treatment, and the amount of time required to return to full activity were selected for analysis. Using a Mixed Generalized Linear Model with study as a random effect and treatment as a fixed effect, cases were separated and compared based on three different types of treatment: Conservative, weight-bearing permitted (WBR); Conservative, non weight-bearing (NWB); and Surgical treatment. The outcome of the treatment was recorded as either successful or unsuccessful based on radiographic and/or clinical healing of the fracture and time from onset of treatment to return to activity There was no statistically significant difference between non-weight bearing (NWB) conservative treatment and surgical treatment regarding outcome (P=.6441). However there is a statistical trend favoring non- weight bearing management over surgery.WBR as a conservative treatment was shown to be significantly less effective than either NWB (P=0.0001) or surgical treatment (P<0.0003). Non- weight bearing conservative management should be considered the standard of care for tarsal navicular stress fractures. We could show no advantage for surgical treatment compared with non- weight bearing immobilization. Rest or immobilization with weight bearing was inferior to both other treatments analyzed.

Introduction

The stress fracture of the tarsal navicular was first described in humans in a 1970 case study by Towne et al[1]. Early studies showed that it was a rare injury, accounting for only 0.7 to 2.4 percent of all stress fractures[2]. However, as awareness of the injury has increased, so have the reported number of cases, with tarsal navicular stress fractures currently representing up to 25 percent of stress fractures in some series[3-7]. Heightened awareness and increased participation in athletics has resulted in more frequent diagnosis and more aggressive treatment of this entity. The vascular supply of the tarsal navicular results in a relatively avascular zone in the central one-third, which experiences high compressive forces during explosive maneuvers such as jumping and sprinting. Repetitive activities can result in stress reactions or even fracture. Patients often initially complain of vague midfoot pain localized to the lateral medial border of the foot. The pain is usually exacerbated by activity and relieved with rest. The diagnosis of tarsal navicular stress fracture is challenging due to the high false negative rate of plain radiographs. Additional diagnostic testing with bone scan, computed tomography (CT), and magnetic resonance imaging (MRI) is often required for diagnosis. The proper treatment of tarsal navicular stress fractures has become a topic of debate, as surgical intervention for these injuries has increased. In a recent meta-analysis, Torg et al. found that 96% of tarsal navicular stress fractures treated with non-weight bearing conservative treatment for six weeks went on to successful outcomes. However, only 44% of patients treated with weight bearing conservative treatment had successful outcomes. Surgical treatment resulted in successful outcome in 82% of patients. Interestingly, the meta-analysis also found that fracture type did not correlate with outcomes, regardless of treatment. The meta-analysis also found no difference in time to return to activity between patients treated surgically and those who underwent non-weight bearing conservative treatment. The recent literature suggests that patients are undergoing surgery or are receiving weight bearing conservative management as a first line treatment option with the expectation that they will return to their activity more quickly. Although surgical treatment seems increasingly common, the results remain largely underreported in the literature. Conservative non- weight bearing management is the standard of care for initial treatment of both partial and complete stress fractures of the tarsal navicular. Weight bearing conservative treatment and surgical intervention are not recommended.

Diagnosis of tarsal navicular stress fractures is challenging as routine radiographs often fail to demonstrate the fracture. One must maintain a high index of suspicion for this injury, especially in athletes with foot pain, given the vague complaints and potential for considerable delay in diagnosis.[8]

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Anatomy

The "boat-shaped" tarsal navicular represents the base of the medial column of the foot, articulating with the talus proximally, and the cuboid and all three cuneiforms distally[8,9]. It has several important ligamentous attachments, including the posterior tibial tendon on the medial tuberosity and the spring ligament on the plantar surface[8,9]. The tarsal navicular derives its dorsal blood supply from a branch of the dorsalis pedis artery while the plantar surface receives its supply from branches of the medial plantar artery[9]. These branches form a rich anastomosis, but leave the central one-third relatively avascular[8,9]. The tarsal navicular is subjected to intense compressive forces over its middle one-third during the foot-strike phase of gait when it is compressed between the talus and the cuneiforms[10]. Torg proposed that repetitive cyclical loading of the tarsal navicular could lead to stress fracture over the central one-third[11].

Clinical Presentation and Physical Examination

Patients most often present with dorsal foot pain of insidious onset. Patients may initially describe the pain as soreness or cramping along the dorsomedial border of the foot that is exacerbated with activity[8,10]. As many patients who sustain tarsal navicular stress fractures are athletes, they initially may complain of pain only during athletic activities and not with other activities of daily living[8,10]. Specifically, explosive activities such as jumping, sprinting, and rapidly changing direction may exacerbate symptoms[8,10]. Physical examination is often unremarkable. Patients may have tenderness to palpation over the tarsal navicular. Provocative testing includes having the patient hop on the affected foot to determine if it reproduces the symptoms experienced during athletic play[8,10].

Diagnosis

The diagnostic work-up should begin with standing plain radiographs of the foot and ankle. The radiographs may demonstrate a visible fracture line, however, several authors have found a high rate of false negative radiographs[3,11,12]. If there remains a high index of suspicion after negative plain radiographs, further work-up with bone scan, CT, or MRI is indicated. Although bone scan has been found to have a high sensitivity, it is also non-specific and requires additional diagnostic testing in the event of a positive test, further delaying the definitive diagnosis[11]. Bone scans are unable to differentiate tarsal navicular pathology from other possible etiologies, including painful accessory tarsal navicular, posterior tibial tendonitis, tarsal coalition, anterior tibial tendonitis, and osteochondral defects of the talus[8]. Bone scans carry a relatively high radiation burden and while a negative result reliably rules out a stress fracture, a positive result is nonspecific and requires clinical correlation[10]. CT has been found to be the most sensitive and specific test for diagnosis of tarsal navicular fractures, although MRI is better suited for tarsal navicular stress fractures[8,11]. MRI evaluation provides a sensitive method of evaluation with more specificity than bone scan or CT and has the advantages of showing more anatomic detail and bone edema in non-displaced and partial fractures[10].

Classification

Saxena *et al*[13] proposed a CT based classification system for tarsal navicular stress fractures. Type I is a break in the dorsal cortex; type II is a break in the dorsal cortex and navicular body; and type III is a fracture into another cortex. Fractures are further sub classified by avascular, cystic, and sclerotic changes. Although this classification has been used to describe tarsal navicular stress fractures, a meta-analysis by Torg[7] found no correlation between outcomes (specifically fracture union) and the type of fracture.

Treatment

The proper treatment of tarsal navicular stress fractures has been a recent topic of debate. Historically (see Table 1), conservative treatment in a non-weight bearing cast has been the treatment of choice[1,3,8,11]. More recently, authors have described open reduction and internal fixation for tarsal navicular stress fractures[7,8,12,14,15].

Torg *et al* reported on 21 cases of tarsal navicular stress fracture and demonstrated that the fractures heal well with conservative treatment[11]. Because routine radiographs failed to show the fracture, the interval between the onset of symptoms and diagnosis ranged from less than one month to thirty-eight months (mean of 7 months). Conservative treatment in this series consisted of non-weight bearing cast immobilization for 6-8 weeks, followed by gradual weight bearing in a boot for 2-6 weeks until pain free. The efficacy of this treatment protocol has been confirmed by several authors[5,12,16]. Even in patients who have failed treatment in a weight-bearing cast, non-weight bearing cast treatment compares favorably with surgical treatment[12]. There is strong evidence supporting the effectiveness of proper conservative management for both partial and non-displaced, complete stress fractures of the tarsal navicular. Case series or reports from Ostlie[17], Alfred[18], Murray[19], Towne[1], Goergen[20], Ariyoshi[21], Miller[22], and Ting[23] all reported a 100% success rate when non-weight bearing management of at least six weeks was utilized. The data also strongly reaffirms that weight bearing rest or limited activity as a conservative treatment often leads to an unsuccessful outcome, including: delayed or non-union, re-fracture, fracture progression, or recurrence of symptoms[1,5,11,12,16,24,25].

It appears, however, that current management of this injury increasingly utilizes surgical intervention[12] both as a first line treatment or following failed treatment with weight-bearing conservative management due to pressure on both the athlete and the physician to have the athlete more quickly return to competition[5,16]. Saxena et al, in 2000, suggested that surgical intervention would decrease the amount of time for an athlete to return to their activity level prior to injury[13]. However, the most recently reported data by Saxena et al, in 2006, demonstrated that there is no significant difference between surgical and conservative management[26]. In their series,

TABLE 1: Summary of published studies comparing treatment options for navicular stress fractures.

Author	Year	Number of Fractures	Successful outcome with NWB-cast for ≥ 6 weeks (n/total)	Average Return to Activity NWB 6 weeks (months)	Successful outcome with NWB-cast for less than 6 weeks (n/total)	Average Return to Activity NWB < 6 weeks (months)	Successful outcome with WB-cast (n/total)	Average Return to Activity WB-cast (months)	Successful outcome with surgery (n/total)	Average Return to Activity with surgery (months)
Torg	1982	21	10/10	3.9			2/9	5.5	2/2	6.0
Fitch	1989	34					13/18	10.0	12/16	8.0
Kahn	1992	86	19/22	5.6	9/13	5.8	9/34	5.8	12/20	5.4
Bojanic	1997	18	18/18	6.0						
Saxena	2000	22					8/13	4.3	9/9	3.1
Burne	2005	20	2/2		4/5		8/13			
Saxena	2006	19	6/6	3.7					8/9	4.1
Others		30	15/15	5.7	4/4	4.2	3/5	3.0	6/6	4.9
Totals		251	70/73 (96%)	4.9	17/22 (77%)	3.7	43/92 (47%)	5.7	54/66 (82%)	5.2

the authors treated all Type II and Type III fractures with immediate ORIF. This incorrectly elevates the healing rates for surgical intervention as historical series have demonstrated high healing rates with non-operative management of these fractures[3,11,12,16]. In support of this view, Burne and colleagues found the clinical outcome of alternative therapies inferior to that which is reported for cast immobilization[5]. The authors stated that "there is limited evidence to support surgical intervention as a first line of management" and suggest that the large variance in different surgical approaches "may reflect a lack of consistently satisfactory outcomes."

Given the small numbers of patient in many series and the heterogeneity in time to diagnosis and classification, a meta-analysis may be the most appropriate way to study outcomes. In a recent meta-analysis by Torg et al, three hundred and thirteen tarsal navicular stress fractures were identified in 23 reports in the peer review literature[7]. The authors created three subsets based on the information contained within each study. Subset I included studies that reported fracture types as partial or complete. Subset II included all reports that documented the fracture without defining if it was partial or complete. Subset III included reports limited to documentation of the fracture and successful/ unsuccessful outcomes without including time to return to activity.

In subset I, 50 incomplete fractures and 12 complete fractures were treated conservatively, compared with 13 incomplete fractures and 12 complete fractures treated surgically. The fracture type, partial or complete, was not statistically significant when comparing NWB conservative and surgical treatment with regard to a successful outcome ($p = 0.994$). Having demonstrated that the type of fracture was not a statistically significant variable regarding success of outcome, subsets I and II were combined to yield 251 tarsal navicular stress fractures for analysis. Seventy (96%) of the 73 fractures initially treated with NWB cast immobilization for 6 weeks had a successful outcome with return to activity on average 4.9 months (Figure 1). Only 43 (47%) of the 92 patients initially treated with weight bearing rest and/or cast immobilization experienced a successful outcome, with return to activity on average 5.7 months. Clearly, non-weight bearing treatment is favored over weight bearing treatment. Fifty-four (82%) of 66 fractures initially treated surgically had a successful outcome with return to activity in an average of 5.2 months. Comparing the modes of treatment, the authors found no statistically significant difference between NWB conservative treatment and surgery ($p = 0.6441$) in regards to outcome and no difference in time to return to activity. However, the authors did demonstrate a statistical trend favoring NWB

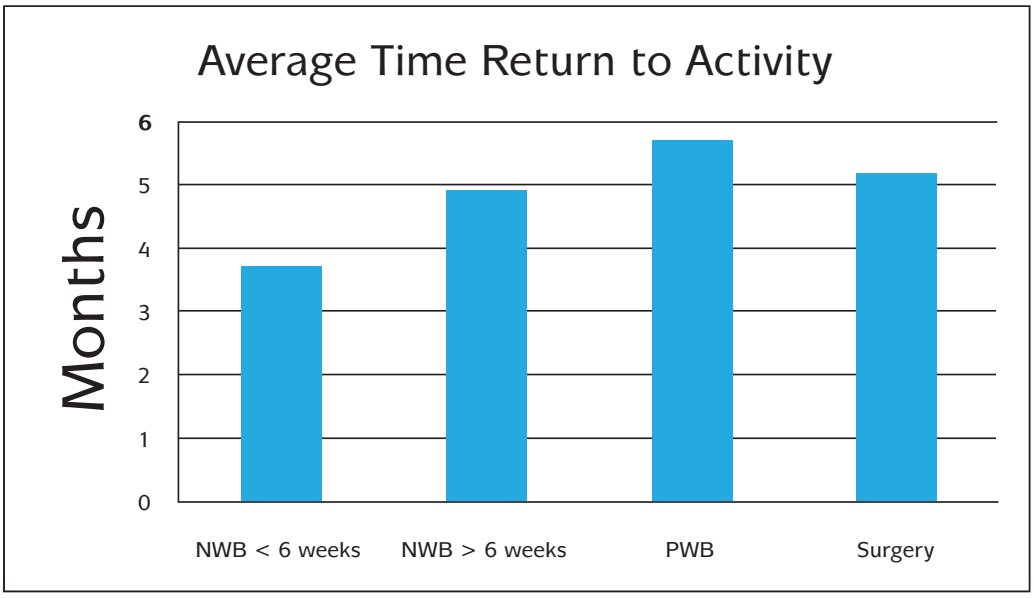

Figure 1: Average time return to activity (months).

management (96% successful outcomes) over surgery (82% successful outcomes). Patients treated with weight bearing protocols had a statistically significant difference in outcomes when compared with NWB conservative (p=0.0001) and surgical treatment (p = 0.0003).

The majority of the poor results from surgical intervention were described in two of the initial series documenting the treatment of tarsal navicular stress fractures (table 1)[11,12,16]. More recent studies have documented high success rates with both surgery and non-weight bearing conservative management[5,13,26,27]. Improved surgical technique and implants may have contributed to the increased success of operative treatment. Regardless, the increased risk of operative complications (infection, risks related to anesthesia, etc), even if minimal, cannot be justified given the high rate of healing in fractures treated non-operatively.

Conclusion

There is strong evidence supporting the effectiveness of proper conservative management for both partial and non-displaced, complete stress fractures of the tarsal navicular. The recent literature suggests that patients are undergoing surgery or are receiving weight bearing conservative management as a first line treatment option with the expectation that they will return to their activity more quickly. Although surgical treatment seems increasingly common, it remains largely underreported in the literature. Patients treated with non-weight bearing cast immobilization for six weeks should expect a successful outcome in over 90% of cases and a return to activity in approximately five months[7]. First line surgical treatment resulted in successful outcomes in only 82% of cases. A recent meta-analysis demonstrated a statistical trend favoring non-weight bearing management over surgical intervention. Interestingly, the fracture type has not been shown to affect outcomes, regardless of the type of treatment. Weight bearing conservative treatment is not recommended and often leads to an unsuccessful outcome, including delayed union or nonunion, re-fracture, fracture progression, or recurrence of symptoms. Conservative non- weight bearing management is the standard of care for initial treatment of both partial and complete stress fractures of the tarsal navicular[7].

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