Management of Tarsal Navicular Stress Fractures: Conservative Versus Surgical Treatment: A Meta-Analysis

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CME

Conservative Versus Surgical Treatment: A Meta-Analysis

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Purpose: This study was conducted to provide a statistical analysis of previously reported tarsal navicular stress fracture studies regarding the outcomes and effectiveness of conservative and surgical management.

Study Design: Systematic review.

Methods: 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 (ie, complete or incomplete), type of treatment, result of that treatment, and the 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 3 different types of treatment: conservative, weightbearing permitted (WBR); conservative, non-weightbearing (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.

Results: There was no statistically significant difference between NWB conservative treatment and surgical treatment regarding outcome ($P = .6441$). However, there is a statistical trend favoring NWB management (96% successful outcomes) over surgery (82% successful outcomes). Weightbearing as a conservative treatment was shown to be significantly less effective than either NWB ($P = .0001$) or surgical treatment ($P < .0003$).

Conclusion: Non-weightbearing conservative management should be considered the standard of care for tarsal navicular stress fractures. The authors could find no advantage for surgical treatment compared with NWB immobilization. However, there is a statistical trend favoring NWB over surgery. Rest or immobilization with weightbearing was inferior to both other treatments analyzed. The authors concluded that conservative NWB management is the standard of care for initial treatment of both partial and complete stress fractures of the tarsal navicular.

Keywords: tarsal navicular stress fractures; outcomes; management guidelines; treatment

The purpose of this article is to provide a systemic review and meta-analysis of previously reported tarsal navicular stress fracture (TNSF) studies regarding the outcome effectiveness of conservative and surgical management by evaluating 3 parameters: (1) the success rate and time of return to activity of incomplete compared with complete TNSFs that were managed with non-weightbearing (NWB) cast immobilization or surgery; (2) the success rates for management of TNSFs utilizing NWB cast immobilization for 6 weeks, NWB cast immobilization for less than 6 weeks, weightbearing cast and/or rest, and surgical management consisting of open reduction and internal fixation (ORIF) and/or bone grafting; and (3) differences regarding return to activity between conservative management consisting of NWB cast immobilization for 6 weeks or less, weightbearing cast and/or rest, and surgical management.

The stress fracture of the tarsal navicular was first described in humans in a 1970 case study by Towne et al.[31] Early studies showed that it was a rare injury, accounting for only 0.7% to 2.4% of all stress fractures. As awareness of the injury has increased, so have the reported number of cases, with tarsal navicular stress fractures currently representing up to 14% of stress fractures in some series.[3,5,17,19]

In 1982, a retrospective study of 21 cases demonstrated that both uncomplicated, partial stress fractures and

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nondisplaced, complete stress fractures of the tarsal navicular heal with conservative treatment.[30] Conservative treatment consisted of NWB cast immobilization for 6 to 8 weeks, followed by gradual weightbearing in a boot for 2 to 6 weeks until pain-free. The effectiveness of this treatment has been reaffirmed by several subsequently published studies.[15,18] It appears, however, that current management of this injury more frequently utilizes surgical intervention both as a first-line treatment or following failed treatment with weightbearing conservative management because of pressure on both the athlete and the physician to have the athlete more quickly return to competition.[6,7,11] In 2000, Saxena et al[28] suggested that surgical intervention will decrease the amount of time for an athlete to return to preinjury activity level. The most recently reported data by Saxena and Fullem[27] in 2006 contradict this, demonstrating that there is no significant difference between surgical and conservative management. In 1992, Khan et al[18] reported that NWB cast treatment compares favorably with surgical treatment after failed weightbearing treatment. A meta-analysis of previously reported outcomes of conservative and surgical management of TNSF studies may clarify the issue.

MATERIALS AND METHODS

A systematic review of the published literature on TNSF was conducted. We searched MEDLINE through Ovid, PubMed, ScienceDirect, and the EBSCOhost Reseach Database. The following search terms were entered and modified according to the requirement of each database: "tarsal navicular" and "stress fracture" or injury; and "treatment" or "surgery" or "management." There were no restrictions on date of publication, publication status, or language. The search generated 31 articles, with 23 reports, of which 12 were case reports, 4 were case series, and 7 were comparative cohort studies (see online Appendix for this article at http://ajs.sagepub.com/supplemental/). Ten of the articles were limited to descriptive reviews of the fracture.

The data are presented as 3 subsets depending on parameter documentation. Subset I included studies that reported fracture types as partial or complete, treatment variables, successful/unsuccessful outcomes, and time to return to activity. Subset II included all reports that documented the fracture without defining if it was partial or complete but defined treatment variables, successful/unsuccessful outcomes, and time to return to activity. Subset III included reports limited to documentation of the fracture and successful/unsuccessful outcomes without including time to return to activity.

The reports that provided the type of stress fracture, type of treatment, result of that treatment, and the amount of time required to return to full activity were selected for analysis. The type of stress fractures reported were classified as either "incomplete" or "complete" based on the radiographic and/or imaging information provided. The outcome of the treatment was considered "unsuccessful" if the patient continued to have pain following the end of treatment, was unable to return to his or her previous activity level, or experienced a recurrence of the fracture. A "successful" outcome was one in which the patient was pain-free, able to return to previous activity level, and did not have recurrence of the fracture.

TABLE 1
Meta-Regression Results of Fracture Type, Onset of Treatment, Type of Treatment, Age, and Sex on Outcome (Successful/Unsuccessful)

Effect	*F* Value	*P*
Fracture type		.9943
Onset of treatment		.7008
Type of treatment		.0002
Age		.3323
Sex		.1255

The cases were separated into 4 groups based on the type of treatment: (1) conservative, weightbearing permitted; (2) conservative, NWB for 6 weeks; (3) conservative, NWB for less than 6 weeks; and (4) surgical treatment. The cases were classified based on whether the treatment modality was the initial treatment, or secondary treatment after a failed initial therapy. The majority of cases with failed initial therapy involved weightbearing; therefore, our analysis primarily compares NWB conservative treatment with surgical intervention. The outcome was recorded as either successful or unsuccessful based on the stated criteria. Sources of variation within and among the groups examined included type of fracture, time elapsed until onset of treatment; type of treatment, age, and gender. Statistical analysis was performed using a mixed generalized linear model with study analyzed as a random effect (assumes heterogeneity among studies) and treatment, fracture type, age, and sex as fixed effects. The SAS v9.1 statistical software (SAS Institute, Cary, North Carolina) was used for all analyses. Analysis of variance and the Fisher exact test were calculated for comparisons using a 2-tailed significance level of $P \leq .05$.

RESULTS

Three hundred thirteen TNSFs were identified in 23 reports in the peer review literature and are included in this analysis.

Subset I

In subset I, 17 reports with fractures that met the inclusion criteria were analyzed. As described, the cases were separated into 3 groups, and the mixed generalized linear model was used to examine random effect. It was determined that of the variations examined, only the type of treatment was statistically significant regarding a successful outcome ($P = .0002$). The data indicate the propensity of TNSFs to respond to treatment was independent of fracture type (ie, partial vs complete). Fifty incomplete fractures and 12 complete fractures were treated conservatively, compared with 13 incomplete fractures and 12 complete fractures treated surgically. The fracture type,

TABLE 2
Summary of Subset I and Subset II Reports and Success of Various Initial Treatment Modalities[a]

	Authors/Year/No. of TNSFs								Totals
Treatment	Torg et al[30]/ 1982/21	Fitch et al[11]/ 1989/34	Khan et al[18]/ 1992/86	Bojanic and Pecina[4]/ 1997/18	Saxena et al[28]/ 2000/22	Saxena and Fullem[27]/ 2006/19	Burne et al[6]/ 2005/20	Others[b]/ 31	251
NWB/cast, 6 wk	10/10		19/22	18/18		6/6	2/2	15/15	70/73 (96%)
NWB/cast, <6 wk			9/13				4/5	4/4	17/22 (77%)
WBR	2/9	13/18	9/34		8/13		8/13	3/5	43/92 (47%)
Surgery[c]	2/2	12/16	12/20		9/9	13/13		6/6	54/66 (82%)

[a]TNSF, tarsal navicular stress fracture; NWB, non-weightbearing; WBR, conservative, weightbearing permitted.
[b]Others include Ostlie and Simons[23] (2001), Alfred et al[1] (1992), Murray et al[22] (2005), Goergen et al[12] (1981), Ariyoshi et al[2] (1998), Miller and Poulos[21] (1985), Gordon and Solar[13] (1985), Ting et al[29] (1988), Towne et al[31] (1970), Dennis and Lombardi[10] (1988), Roper et al[26] (1986), and Hunter[16] (1981).
[c]Surgery includes open reduction and internal fixation, bone grafting, and ossicle excision.

TABLE 3
Summary of Subset I and Subset II Reports on Average Time to Return to Activity in Months[a]

	Authors/Year/No. of TNSFs								Totals
Treatment	Torg et al[30]/ 1982/21	Fitch et al[11]/ 1989/34	Khan et al[18]/ 1992/86	Bojanic and Pecina[4]/ 1997/18	Saxena et al[28]/ 2000/22	Saxena and Fullem[27]/ 2006/19	Burne et al[6]/ 2005/20	Others[b]/ 31	251
NWB/cast, 6 wk	3.9		5.6	6		4		5.7	4.9
NWB/cast, <6 wk			3.7					4.2	3.7
WBR	5.5	10	5.8		4.3			3	5.7
Surgery[c]	6	8	5.4		3.1	3.7		4.9	5.2

[a]TNSF, tarsal navicular stress fracture; NWB, non-weightbearing; WBR, conservative, weightbearing permitted.
[b]Others include Ostlie and Simons[23] (2001), Alfred et al[1] (1992), Murray et al[22] (2005), Goergen et al[12] (1981), Ariyoshi et al[2] (1998), Miller and Poulos[21] (1985), Gordon and Solar[13] (1985), Ting et al[29] (1988), Towne et al[31] (1970), Dennis and Lombardi[10] (1988), Roper et al[26] (1986), and Hunter[16] (1981).
[c]Surgery includes open reduction and internal fixation, bone grafting, and ossicle excision.

partial or complete, was not statistically significant when comparing NWB conservative and surgical treatment with regard to a successful outcome ($P = .994$) (Table 1).

Analysis of subset I data further determined the outcomes (fracture healing) were not statistically different comparing fracture type ($P = .9943$), time of onset of treatment ($P = .7008$), age of patient ($P = .3323$), or sex of patient ($P = .1255$) (Table 1).

Subset II

As described, subset II included those reports that documented fracture treatment variables, successful/unsuccessful outcomes, and time to return to activity without defining if the fracture was partial or complete.

Analysis of Combined Subsets I and II Reports on Treatment Modalities and Time to Return to Activity

Having demonstrated that the type of fracture was not a statistically significant variable regarding success of outcome, a more comprehensive data analysis was performed incorporating other published studies that provided statistical summaries of fracture healing and time to return to activity outcomes. Data analysis included outcome success and return to activity for 251 TNSFs reported in the literature between 1970 and 2005. 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. Seventeen (77%) of the 22 fractures treated with NWB cast immobilization for less than 6 weeks had a successful outcome with return to activity in an average of 3.7 months. Only 43 (47%) of the 92 patients initially treated with weightbearing rest and/or cast immobilization experienced a successful outcome, with return to activity on average 5.7 months. Fifty-four (82%) of 66 fractures initially treated surgically had a successful outcome with return to activity in an average of 5.2 months (Tables 2 and 3).

Comparing the modes of treatment, there is no statistically significant difference between NWB conservative treatment and surgery ($P = .6441$). However, there is a statistical trend favoring NWB management (96% successful outcomes) over

TABLE 4
Differences of Treatment (Least Square Means)[a]

Treatment 1	Treatment 2	P
NWB	SURG	.6441
NWB	WBR	<.0001
SURG	WBR	.0003

[a]NWB, non-weightbearing; WBR, conservative, weightbearing permitted; SURG, surgery.

surgery (82% successful outcomes). There is a statistically significant difference between conservative treatment with weightbearing permitted and NWB conservative ($P = .0001$) and surgical treatment ($P = .0003$) (Table 4).

Analysis of Secondary Treatment

We further analyzed and compared the effectiveness of NWB treatment with surgical intervention as secondary treatment modalities following failed weightbearing management. The same sources of variation were examined as for the cases of initial treatment. Although of limited value because of the small numbers, there was no statistically significant difference between the treatment methods ($P = .5783$) (Table 5).

Subset III

Potter et al[24] reported 32 fractures in 26 subjects in a series in which time to return to activity was not included. Treatment outcomes were not statistically significant for pain ($P = .984$) or function ($P = .170$) between NWB cast immobilization and surgical fixation. Also, Hulkko et al[15] reported 9 fractures that did not meet subset I and II inclusion criteria.

DISCUSSION

There is strong evidence supporting the effectiveness of proper conservative management for both partial and nondisplaced, complete stress fractures of the tarsal navicular. Case series or reports from Ostlie and Simons,[23] Alfred et al,[1] Murray et al,[22] Towne et al,[31] Goergen et al,[12] Ariyoshi et al,[2] Miller and Poulos,[21] and Ting et al[29] all reported a 100% success rate when NWB management of at least 6 weeks was utilized. The data also strongly reaffirm that weightbearing rest or limited activity as a conservative treatment often leads to an unsuccessful outcome, including delayed union or nonunion, refracture, fracture progression, or recurrence of symptoms.[6,10,11,14,18,30,31]

In a multi-institutional study published in 1982, Torg et al[30] analyzed 21 stress fractures of the tarsal navicular bone in 19 patients with particular reference to the clinical and radiographic characteristics, the results of treatment, and the complications associated with the fracture. In addition, microangiographic studies were done on 5 fresh human cadaveric specimens to determine the vascular patterns peculiar to the tarsal navicular bone. The fractures occurred predominantly in young male athletes (mean age, 21.8 years). Because routine radiographs failed to show the fracture, or showed it but it was not recognized, the interval between the onset of symptoms and diagnosis ranged from less than 1 month to 38 months (mean interval, 7.2 months). For 14 of the 21 lesions, radionuclide bone scans were needed to locate the abnormality in the tarsal navicular and for 17, AP tomograms were made with the dorsum of the foot parallel to confirm the diagnosis of fracture or to evaluate further the stage of healing. The characteristic fracture was oriented in the sagittal plane and located in the central one-third of the bone, and was either partial or complete. Initially, 19 fractures were treated conservatively and 2 were treated surgically. Treatment included immobilization in an NWB cast for 6 to 8 weeks for 10 fractures, immobilization in a weightbearing cast for 4, limitation of activity with continued weightbearing for 5, open reduction and internal fixation for 1 acute displaced fracture, and an autogenous bone graft for 1 nonunion. All 10 fractures that were initially treated in NWB casts healed without complications. Seven of the 9 patients whose fractures were treated by limitation of activity but continued weightbearing or by immobilization in a weightbearing cast were unable to resume vigorous activity after that treatment because of pain associated with delayed union, nonunion, or recurrence of the fracture.

In 1989, Fitch et al[11] reported on the management of 37 stress fractures of the tarsal navicular. Thirteen of the 18 fractures treated with either plaster immobilization or rest with continued weightbearing received a satisfactory result with resumption of activities at an average of 10 months. They reported successful outcomes with 12 of the 16 fractures treated surgically with an average return to activities of 8 months. After reviewing the results of Torg et al, the authors stated that they now treat recent

TABLE 5
Results of Secondary Treatment Following Failure of Initial Weightbearing Permitted/Cast Management[a]

Treatment	Variable	N	Mean	Standard Deviation	Minimum	Maximum
NWB	Age, y	3	17.6	4.04	14	22
	Onset of treatment, mo	3	6	7.0	1	14
	Weeks in cast/boot	3	4.6	1.2	4	6
	Time to full activity return, mo	3	7.6	3.5	4	11
SURG	Age, y	18	23.5	8.0	15	45
	Onset of treatment, mo	18	4.27	6.1	0	24
	Weeks in cast/boot	17	16.8	13.4	2	44
	Time to full activity return, mo	17	6.82	1.8	3	8

[a]NWB, non-weightbearing; SURG, surgery.

fractures with 8 to 10 weeks of NWB in a cast. However, Fitch et al still considered autogenous bone graft as the treatment of choice for complete fracture and those who develop a medullary cyst.

In 1992, Khan et al[18] reported on the outcomes of conservative and surgical management of 86 navicular stress fractures of athletes. Nineteen (86%) of 22 patients who had initial NWB cast immobilization returned to sports activities at an average of 5.6 months as compared with only 12 (30%) of the 40 patients who initially had continued weightbearing with limited activity with an average return to activity time of 9.3 months. They also reported a successful outcome for 5 (83%) of the 6 patients who initially underwent surgical treatment, with average return to activities of 3.8 months. It should be noted that 2 of these patients simply had small ossicles removed, with no reported fracture. As a secondary treatment following failed weightbearing conservative management, 9 (90%) of the 10 patients treated with NWB cast immobilization healed in comparison to 13 (61%) of the 21 patients who underwent surgery. These results led the authors to conclude that NWB cast immobilization is the treatment of choice for TNSFs, and that this treatment also compares favorably with surgical treatment in patients who present after failed weightbearing treatment.

Bojanic and Pecina[4] reported on 18 TNSFs treated with an NWB short-leg cast for 6 to 8 weeks, all of whom returned to resumption of full athletic activities at an average of 6 months.

Saxena et al[27,28] reported 2 series, 1 consisting of 22 navicular stress fractures, 9 of which underwent ORIF with average return to activity of 3.1 months (range, 1.5-5 months). Thirteen patients were treated conservatively with a weightbearing regimen and 8 of the 13 fractures had favorable outcomes with a return to activity of 4.3 months (range, 2-13 months). Five of the 13 had an unsatisfactory outcome and surgery was recommended for both incomplete and complete fractures as well as those with cystic changes and sclerosis.

In 2006, Saxena and Fullem[27] presented a second series of 19 fractures in athletes. Six were treated successfully in an NWB plaster cast with an average return to activities at 4 months and 13 were treated by ORIF with an average return to activity in 4.1 months. Combining the findings of these 2 series, 23 had surgery and 18 were treated nonoperatively. The difference in return to activity between the treatment groups was not statistically significant, and the authors concluded that TNSFs take 4 months to heal with nonoperative or operative treatment.

In 2005, Burne et al[6] reported on 20 TNSFs and observed that "the published recommendation of [a] minimum of six weeks [of] non-weight-bearing cast treatment does not appear to be translated into clinical management; few patients seem to receive this treatment today." Burne et al found that the clinical outcome of alternative therapies were inferior to that which is reported for cast immobilization. They also stated that "there is limited evidence to support surgical intervention as a first line of management" and suggested that the large variance in different surgical approaches "may reflect a lack of consistently satisfactory outcomes." They also noted that TNSFs prevented almost half of the participants in their study from returning to sports at their previous level.

In 2004, Lee and Anderson[20] published a case report in which they observed that "because most injuries occur in the dedicated athlete, prolonged conservative treatment options may be unsatisfactory." They reported a case of a 28-year-old professional football player, who spent 2 weeks in an NWB cast, in whom surgical intervention was undertaken because of his high demand and his "desire to return to professional level as soon as possible." Also noted to justify the surgical intervention, they misrepresented the data of Khan et al, stating that the average return to activity was 3.8 months, when actually it was 5.4 months, the same as the 5.6-month return to activity for NWB cast immobilization for 6 weeks.

Worthy of note was Ronald Quirk's Presidential Guest Lecture to the American Orthopaedic Foot and Ankle Society in 1998,[25] when he stated that "all patients no matter how long their history are to be placed for six weeks on crutches and a below knee non-weight-bearing cast. This has been successful even in several patients who previously failed surgery." He also pointed out that postoperative complications include nonunion, recurrence of a fracture, and progression of partial fracture to complete fracture.

The recent literature suggests that patients are undergoing surgery or are receiving weightbearing conservative management as a first-line treatment option with the expectation that they will return to their activity more quickly.[6,27,28] Although surgical treatment seems increasingly common, it remains largely underreported in the literature. It is our contention that many patients are undergoing unnecessary surgical management for these injuries.

CONCLUSION

There is no statistically significant difference between NWB conservative management and surgical fixation regarding successful outcome ($P = .6441$) or time to return to activity. We could not show any advantage for surgical treatment over NWB immobilization. However, there is a statistical trend favoring NWB management over surgery. We conclude that conservative NWB management is the standard of care for initial treatment of both partial and complete stress fractures of the tarsal navicular.

RECOMMENDATIONS FOR THE FUTURE

It is interesting to note that there are case reports suggesting that NWB therapy without cast immobilization was equally effective as NWB therapy with cast immobilization.[10,31] A future study should involve a comparison of NWB therapy with and without cast immobilization. If equally effective, we believe that patient comfort would be improved if treatment did not require the patient to undergo cast immobilization during the course of NWB treatment.

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