Surgical Treatment of Refractory Tibial Stress Fractures in Elite Dancers : A Case Series

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Surgical Treatment of Refractory Tibial Stress Fractures in Elite Dancers

A Case Series

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Background: Treatment of tibial stress fractures in elite dancers is centered on rest and activity modification. Surgical intervention in refractory cases has important implications affecting the dancers' careers.

Hypothesis: Refractory tibial stress fractures in dancers can be treated successfully with drilling and bone grafting or intramedullary nailing.

Study Design: Case series; Level of evidence, 4.

Methods: Between 1992 and 2006, 1757 dancers were evaluated at a dance medicine clinic; 24 dancers (1.4%) had 31 tibial stress fractures. Of that subset, 7 (29.2%) elite dancers with 8 tibial stress fractures were treated operatively with either intramedullary nailing or drilling and bone grafting. Six of the patients were followed up closely until they were able to return to dance. One patient was available only for follow-up phone interview. Data concerning their preoperative treatment regimens, operative procedures, clinical union, radiographic union, and time until return to dance were recorded and analyzed.

Results: The mean age of the surgical patients at the time of stress fracture was 22.6 years. The mean duration of preoperative symptoms before surgical intervention was 25.8 months. Four of the dancers were male and 3 were female. All had failed nonoperative treatment regimens. Five patients (5 tibias) underwent drilling and bone grafting of the lesion, and 2 patients (3 tibias) with completed fractures or multiple refractory stress fractures underwent intramedullary nailing. Clinical union was achieved at a mean of 6 weeks and radiographic union at 5.1 months. Return to full dance activity was at an average of 6.5 months postoperatively.

Conclusion: Surgical intervention for tibial stress fractures in dancers who have not responded to nonoperative management allowed for resolution of symptoms and return to dancing with minimal morbidity.

Keywords: dance injury; tibial stress fracture; intramedullary nailing; bone grafting

Dancers are a subset of high-performance athletes who sustain a unique set of injuries. Along with the necessity for tremendous body control and flexibility and the requirement to hold extreme positions for long periods of time, the rigorous performance schedule predisposes dancers to overuse injuries, particularly of the lower extremities. Among the most problematic of these is the anterior tibial stress fracture, the *sine qua non* of which is the "dreaded black line" (Figure 1A). This is a result of repetitive loading of the tension side of the tibial shaft.

Treatment of this injury becomes especially difficult in professional dancers, whose career training and livelihood often depend on their ability to perform. Time away from dance secondary to injury must be minimized, and the option of ceasing dancing altogether is only a last resort.

Although most anterior tibial stress fractures can be successfully managed nonoperatively with rest from axial loading, activity modification, and adjuncts such as electrical bone stimulators, daily pulsed low-intensity ultrasound, and pneumatic lower leg braces, a certain subset progress to nonunion of the stress fracture.[1,3,6,8,14] Previous operative management of anterior tibial stress fractures has included reamed intramedullary nailing,

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Figure 1. A, radiograph of tibia of a 21-year-old dancer demonstrating the "dreaded black line" involving the anterior cortex consistent with stress fracture. B, 9 months postoperatively after drilling and bone grafting, the tibial stress fracture shows complete healing. The patient was able to return to full dance activity.

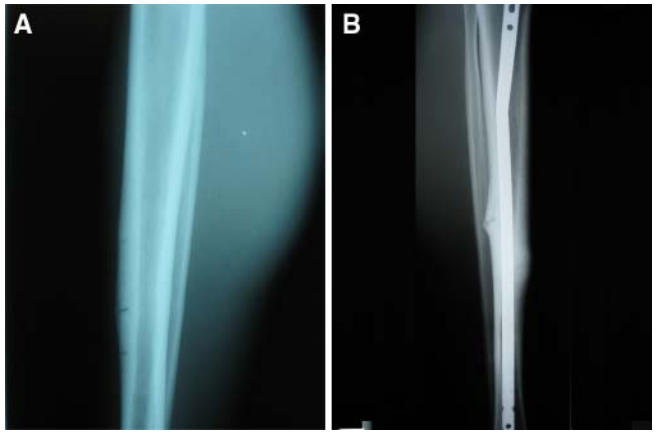

Figure 2. A, radiograph of the tibia of a 26-year-old dancer demonstrating stress fracture of the anterior cortex. The fracture later completed and displaced. B, radiograph of tibia 6 months after intramedullary nailing. Abundant callus formation is noted. The patient was able to return to full dance activity.

percutaneous drilling with grafting, and anterior tension band plating.[2,4,10,12,16] A small number of tibial stress fractures that have progressed to complete tibial fractures have been reported.[8,11,13]

The purpose of this study was to report on a series of 7 elite dancers with 8 tibial stress fractures treated operatively after unsuccessful nonoperative management.

MATERIALS AND METHODS

A retrospective review of medical records and imaging studies was performed to identify elite dancers who were treated operatively for tibial stress fractures at our institution between June 1992 and September 2006. During this time period, 1757 dancers were evaluated and treated by an orthopaedic dance medicine specialist (DJR); 24 dancers had a diagnosis of and were treated for 31 tibial stress fractures. Seventeen dancers with 23 tibial stress fractures had resolution of their symptoms with modification of activities and protected weightbearing at a mean 3 months after treatment. Ultimately, 7 of these patients with 8 tibial stress fractures were treated surgically with either intramedullary nailing or drilling and bone grafting. The age and sex of each patient was recorded as well as the type of dance, duration of preoperative symptoms, and preoperative treatment regimens. Details of the operative procedure, postoperative treatment regimens, and time until return to dancing were also recorded.

Of the 7 dancers treated operatively, 6 were professional dancers (paid to dance as an occupation) whereas 1 was performing for a dance troupe as a nonsalaried position. Because 1 of the dancers was not a paid professional but did perform at an advanced level for a traveling dance troupe in a nonsalaried position, we used the term *elite* to describe our cohort of dancers. None of the dancers in our series had preexisting medical comorbidities, metabolic bone diseases, previous symptomatic stress fractures, or eating disorders.

All patients had sustained activity-related pain during dancing. Lateral tibial radiographs showed a classic radiolucent defect in the anterior tibial cortex in all 7 patients, consistent with the diagnosis of stress fracture. All dancers underwent a period of nonoperative treatment including rest, activity modification, restraint from painful activities, and marking of jumps for a minimum of 8 to 12 weeks. If symptoms and radiographic studies had not improved, dancers were then considered for surgical intervention.

Two of the patients (patients 1 and 4) used an electrical bone stimulator (Biomet, Parsippany, New Jersey) preoperatively for a period of 6 weeks without resolution of symptoms. One patient (patient 5) had undergone a prior resection and curettage of her stress fracture at a different institution for a preoperative diagnosis of osteoid osteoma but had noted continued pain with dance activity postoperatively. Finally, 2 patients (patients 1 and 2) completed their fractures on attempted return to dance after a period of nonoperative treatment (Figure 2). In 1 of these dancers, multiple refractory stress fractures were noted in the contralateral tibia, and he subsequently underwent prophylactic intramedullary nailing (Figure 3).

Intramedullary nailing was performed by one attending surgeon (KAE), and drilling and grafting procedures were performed by a second attending surgeon (DJR). In cases with a single nondisplaced stress fracture, drilling and grafting of the lesion were performed. First, the location of the lesion was identified under fluoroscopic guidance. A 2- to 3-cm longitudinal incision was made overlying the lesion, followed by curettage and drilling of the lesion with multiple passes in a radial fashion through the cortex into the medullary cavity using a 2.0-mm drill. Care was taken to ensure that bleeding was evident from bone surrounding the fracture site. This was followed by packing of the lesion with bone graft, iliac crest aspirate, demineralized bone matrix putty (Grafton DBM, Osteotech, Eatontown, New Jersey), and/or BMP-7 (OP-1, Stryker, Mahwah, New Jersey). As potent bone stimulation products evolved over

Figure 3. Radiograph demonstrating multiple refractory stress fractures of anterior tibial cortex.

the course of the 14-year period, these were used at the surgeon's discretion as opposed to autogenous iliac crest graft with its potentially increased morbidity to the dancers.

In cases of multiple refractory stress fractures or when completion of the tibial stress fracture occurred, intramedullary nailing was used. A midline incision was made followed by retraction of the patellar tendon laterally. The intramedullary canal was over reamed by 1.0 cm, and a 10-mm diameter nail (Synthes, Paoli, Pennsylvania) was inserted followed by locking both proximally and distally.

Postoperatively, all patients who had undergone intramedullary nailing were made weightbearing as tolerated with crutches, whereas those undergoing drilling and grafting were toe-touch weightbearing for the first 4 to 6 weeks. All dancers were evaluated postoperatively within 2 weeks and then followed at 4- to 6-week intervals for a period of no less than 4 months. Crutches were discontinued when the dancer could ambulate without noticeable pain or limp and showed evidence of clinical union. Clinical union was defined as the resolution of preoperative pain and functional use of the extremity in daily activities. Radiographic union was considered resolution of the "black line" in the case of nondisplaced fractures, whereas in the case of displaced fractures callus formation on 3 of 4 cortices was considered union.

Patients were allowed to return to dance when clinical and radiographic union was achieved and appropriate range of motion and muscular strength were attained as deemed by the surgeons. Return to dance was defined as return to unrestricted performance level dance activity including jumping. Once return to dance had been successfully achieved, dancers were followed up as necessary by our office.

RESULTS

Seven elite dancers with 8 anterior tibial stress fractures were treated surgically at our institution's dance medicine clinic between June 1992 and September 2006. Five dancers with 5 nondisplaced fractures were treated with drilling of the tibial cortex, curettage of the lesion, and supplementation with bone graft or bone graft substitute (Figure 1), and 2 of the dancers with 2 displaced tibia fractures and 1 case of multiple refractory stress fractures were treated with reamed intramedullary nailing (Figure 2). A summary of the patient characteristics is available in Table 1.

Of the 7 patients, 4 had left-sided tibial stress fractures, 2 had right-sided tibial stress fractures, and 1 had bilateral tibial stress fractures. Two of the subjects had complete fracture of the tibia at the site of the preexisting tibial stress fracture (patient 1 and patient 2 left side), necessitating reamed intramedullary nailing.

The mean age of the patients was 22.6 years (range, 18-26 years). Four of the patients were male dancers with a mean age of 23.3 years (range, 20-26 years). Three of the patients were female dancers with a mean age of 21.7 years (range, 18-26 years). Patients had experienced symptoms for a mean of 25.8 months (range, 4-48 months) before surgical intervention. Five of the patients were ballet dancers and 2 were modern dancers.

One patient with bilateral stress fractures moved to another state after treatment for family help with convalescence and was available only for follow-up phone interview. His short-term data (clinical/radiographic union) were unavailable. Six patients with 6 tibial stress fractures were available for long-term follow-up at our institution. Clinical union was achieved in all at a mean of 6 weeks (range, 4-10 weeks). Radiographic union was attained at a mean of 5.1 months (range, 3.5-9 months). Patients returned to full dance activity at a mean of 6.5 months (range, 4-12 months). One patient (patient 3) developed posterior tibial tendinitis on the same side as his tibial stress fracture postoperatively. He was managed with anti-inflammatory medication, physiotherapy, and medial wedge orthosis before resolution of his symptoms and progressing to full dance activity.

At last follow-up (range, 4.5-47 months), all 7 patients were satisfied with their procedures and were back to elite dancing full-time.

DISCUSSION

The treatment of stress fractures can be problematic in any patient population, but the treatment of these injuries

TABLE 1
Patient Characteristics and Treatments for Tibial Stress Fractures[a]

Patient	Age, y	Sex	Side	Type of Dance	Onset of Symptoms to Surgery, mo	Preoperative Treatment	Operative Procedure	Graft Type	Clinical Union, wk	Radiographic Union, mo	Return to Dance, mo
1	26	M	L	Ballet	4	Rest, activity modification, bone stimulator	Intramedullary nailing	—	10	4	6
2[b]	23	M	L R	Ballet	48	Rest, activity modification	Intramedullary nailing	—	—	—	12
					48	Rest, activity modification	Intramedullary nailing	—	—	—	12
3	24	M	L	Ballet	12	Rest, activity modification	Drilling + graft	ICBG	6	4	4
4	20	M	L	Ballet	6	Rest, activity modification, bone stimulator	Drilling + graft	OP-1	5	4	4
5	18	F	L	Ballet	10	Rest, activity modification, resection	Drilling + graft	Grafton + cancellous allograft	5	6	6
6	21	F	R	Modern	48	Rest, activity modification	Drilling + graft	OP-1	6	9	9
7	26	F	R	Modern	30	Rest, activity modification	Drilling + graft	Grafton + cancellous allograft	4	3.5	4.5

[a]ICBG, iliac crest bone graft; OP-1, product containing bone morphogenic protein-7; Grafton, product containing demineralized bone matrix putty.
[b]Patient lost to short-term follow. Available only by telephone interview.

in dancers, particularly elite dancers, can be particularly challenging. We found a 1.3% incidence of tibial stress fractures in elite dancers seen at our specialty clinic over a 14-year period. Although these injuries represent a rare cause of disability in this patient population, the sequelae of this injury can be quite serious.

Although stress fractures in dancers have been reported in nearly every bone in the lower extremity and the acetabulum, they are most frequently diagnosed in the metatarsals and the tibia.[7,15] This finding is believed to be the result of a number of factors including anatomical, hormonal, nutritional, and physiological.[9] The emphasis on physical appearance and presentation inherent in dance predisposes female dancers to the female athlete triad (menstrual irregularity, disordered eating, and osteopenia) and, as a result, makes them more prone to stress fractures.[5] The treatment of these injuries is a delicate balance of treating the injury to completion while minimizing time away from dance.

After a thorough review of the literature, to our knowledge, this report is the largest series of the treatment of tibial stress fractures in elite dancers. Our treatment protocol called for a period of nonoperative treatment including rest, activity modification including a hiatus from all dance activities, and bone stimulators in selected cases for a period of at least 8 to 12 weeks. Close clinical and radiologic follow-up is necessary to determine whether symptoms improve. After this initial period of nonoperative treatment, the patient and physician must thoroughly discuss surgical options and expectations when no clinical or radiographic evidence of healing is noted. Although intramedullary nailing provides excellent union rates and allows for early weightbearing, it requires violation of the knee joint and may cause anterior knee pain with kneeling and with deep knee bending. In dancers, this is particularly pertinent in positions such as plié, grande plié, and possé. This should be reserved for cases in which there is fracture completion and complete displacement or when multiple refractory stress fractures are present in the tibia.

Meanwhile, open biopsy, drilling, and grafting of the fracture site preserve the integrity of the knee joint but may preclude early weightbearing. The choice of procedure should take into account the age of the dancer, the dancer's performance level, and expectations about outcome. Martinez and Murphy[11] reported on a professional ballet dancer who sustained a second stress fracture despite having his tibia treated with intramedullary nailing after his initial stress fracture.

Our results show that drilling/bone grafting of tibial stress fractures in elite dancers was a suitable and effective treatment. Both patients who underwent intramedullary nailing were also able to return to elite dance with no long-term sequelae. All of our patients were able to return to full dance activities at their prior elite level. The treatment algorithm used is outlined in Figure 4.

Limitations of this study include the retrospective nature of the analysis, which may have led us to miss some potential cases. Small numbers of this case series preclude any meaningful statistical analysis. Finally, as time evolved, some aspects of management changed as bone morphogenic proteins were introduced and used.

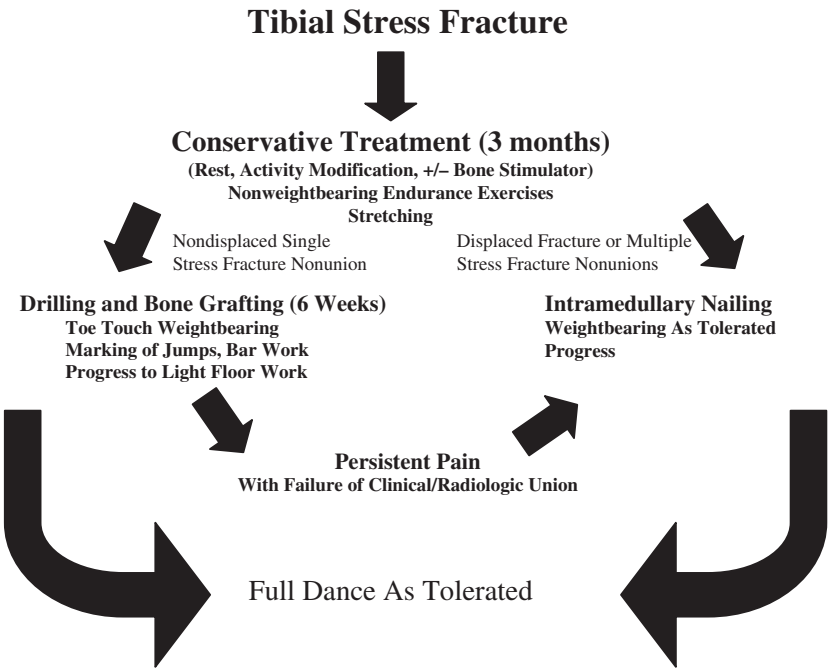

Figure 4. Treatment algorithm used for refractory tibial stress fractures.

A large part of our treatment that is often understated is that treating injuries in elite dancers involves not only treatment but also prevention of injury. The physician and patient must thoroughly discuss factors that predispose dancers to injury and address concepts such as overuse injury, appropriate training regimens, and nutrition. Vital to the success and longevity of a dancer's career is frequent communication between the artistic director, choreographer, and orthopaedic surgeon.

CONCLUSION

Physicians who treat elite dancers must be alert for the signs and symptoms of this rare but problematic injury. If a tibial stress fracture is suspected, rest and activity modification remain the first line of treatment with success achieved in most cases by 12 weeks. If this method of treatment fails, the physician should consider drilling a singular lesion with a bone graft procedure as a first-line surgical intervention. If that fails, if multiple refractory stress fracture sites exist, or if the patient sustains fracture completion and displacement, intramedullary nailing may be performed with good results expected. Physicians should feel comfortable that these dancers will be able to return to their previous level of activity.

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