PASIG MONTHLY CITATION BLAST: No.25 **October 2007**

Dear PASIG members:

As I write this many of our members are 'down under', attending the 17th annual International Association of Dance Medicine and Science (IADMS) conference in Canberra, Australia. I hope some of you will consider updating us on any new findings in dance medicine research in an upcoming OPTP.

Dates for PASIG members to note:

- Orthopaedic Section elections open on November 1st. Please participate in voting for the PASIG officers.

- Combined Sections Meeting in Nashville, February 7 – 9th, 2008.

- PASIG and Orthopaedic Section CSM activities include:

  Friday, February 8

  7 – 8 am PASIG Business Meeting

  8 – 11 am PASIG PROGRAMMING
  "*Evaluation and Treatment of Cervicothoracic Pain and Dysfunction - Freeing the Performing Artist to Reach New Heights*".
  8:00 – 8:45 Evidence based evaluation and treatment of neck pain in the performing artist. Josh Cleland PhD, PT, FAAOMPT
  8:45 – 9:00 Case Example.
  9:00 – 9:45 Evidence based evaluation of cervical radiculopathy. Sara Piva PhD, PT
  9:45 – 10:00 Case Example: A Dancer with Serratus Anterior Insufficiency.

Kendra Hollman PT
10:00 – 10:15 T3/T4 syndrome in performing artists. Sue Stralka MS PT
10:15 – 10:35 Medical interventions for cervical/thoracic pain(meds, imaging, interventional pain mgmt,etc). Bhaskar Aditya Mukherji M.D.
10:35–11:00 Panel Discussion. All Speakers

5 – 7 pm Orthopaedic Section Business Meeting/Reception

Saturday, February 9th
1 – 3 pm Orthopedic Section Platform Presentations

3 – 5 pm Orthopedic Section Platform Presentations

And, don't forget, students can still apply for the PASIG annual student research scholarship. The deadline for application is November 15, 2006. For more information on the research award please check our webpage (www.orthopt.org/sig_pa.php).

This month's Citation BLAST continues our special topic series: "*Metatarsal stress fractures in dancers"*, contributed by PASIG member, Alison T. DeLeo, MS, DPT (NRH Regional Rehab at Friendship Heights, Chevy Chase, MD and George Washington University Physical Therapy Department, Washington, DC). The format is an annotated bibliography of articles on the selected topic, with focus on recent literature (1997 – 2007). As always, each month's citations will be added to EndNote libraries available on the PASIG webpage for our members to access and download. (Information about EndNote referencing software can be found at http://www.endnote.com, including a 30-day free trial). If you'd like to suggest a topic or create one, please let me know.

Please write to me with your comments and suggestions. If you're seeking a research mentor, looking for a sounding board about a research idea, want some editorial suggestions on a manuscript, let me know and I'll try to connect you with the right researcher. Entry contributions to these Citation Blasts or other PA research ideas are always welcome.

Regards,
Shaw

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METATARSAL STRESS FRACTURES IN DANCERS

Injuries at the metatarsals and associated forefoot joints are among the most common injuries in the elite athlete population. The unique demands of technique and training on ballet dancers and gymnasts predispose these performing artists to higher incidence of injuries in these areas. The common sites of pathology demonstrated in the literature include stress fractures at the base (proximal aspect) of the second metatarsal,

sesamoid stress fractures of the hallux, inflammation of the Lisfranc joint, and spiral fractures at the distal aspect of the fifth metatarsal. The etiology of metatarsal and forefoot stress fractures is largely considered to be the result of overuse, a combination of repetitive loading activities and heavy training schedules. Other mechanisms implicated include pathomechanics, structural abnormalities (including second toe length), poor nutrition and amenorrhea.

Efficient diagnosis begins with a thorough patient history, evaluation of relative risk factors, careful palpation and technique specific symptomology. Imaging studies, such as magnetic resonance imaging, plain radiographic studies and bone scans are integral for successful diagnosis of metatarsal injuries. Prompt diagnosis and appropriate intervention results in decreased absence from training and/or work. Metatarsal stress fractures in performing artists can be managed non-operatively by incorporating medical management, decreased or non-weight bearing casting and modified training. When conservative treatment is not indicated or fails, metatarsal injuries in performing artists can be managed operatively with successful outcomes.

The following annotated bibliography includes research studies, case reports, and review articles pertaining to the diagnosis, incidence, treatment, and outcome of metatarsal injuries with emphasis placed on performing artists.

Alison T. DeLeo, MS, DPT

RESEARCH ARTICLES and CASE REPORTS

Biedert R, Hintermann B (2003). Stress fractures of the medial great toe sesamoids in athletes. *Foot Ankle Int* 24(2):137-142.

The purpose of this study was to determine whether specific symptoms and findings are present in patients with symptomatic stress fractures of the sesamoids of the great toe and, if so, whether partial sesamoidectomy is sufficient for successful treatment. Five consecutive athletes (five females; mean age 16.8 years [range, 13 to 22 years]) with six feet that were treated for symptomatic stress fractures of the sesamoids of the great toe were included in this study. Four athletes (five feet) performed rhythmic sports gymnastics; the fifth athlete was a long jumper. Some swelling to the forefoot and activity-related pain that increased in forced dorsiflexion, but disappeared at rest was found in all patients. While plain X-rays evidenced fragmentation of the medial sesamoid, MRI (n=2) and frontal plane CT scan (n=3) did not always confirm the diagnosis, but bone scan (n=3) and axial as well as sagittal CT scan were useful to detect the pathology. After failure of conservative treatment measures, surgical excision of the proximal fragment was successful in all patients, and there were no complications. All patients were pain free and regained full sports activity within six months (range, 2.5 to six months). At final follow-up, which averaged 50.6 months (range, 20 to 110 months), the overall clinical results were graded as good/excellent in all patients, and there was only one patient with of restriction sports activities. The obtained AOFAS-Hallux-Score was 95.3 (75 to 100) points. Apparently, stress fractures occur more often at the medial sesamoid, and females are mainly involved. When a stress fracture is suspected, bone scan and CT scan are suggested as more reliable in confirming the diagnosis than other imaging methods. When conservative treatment has failed, surgical excision of the proximal fragment is recommended.

Chuckpaiwong B, Cook C, Pietrobon R, Nunley JA (2007). Second metatarsal stress fracture in sport: comparative risk factors between proximal and non-proximal locations. *Br J Sports Med.* 41(8): 510-514.

BACKGROUND: Stress fractures of the second metatarsal are common injuries in athletes and military recruits. There are two distinct areas in the second metatarsal where stress fractures develop: one proximal (at the base) and the other non-proximal (distal). Diagnosis can be difficult, and there is a difference in prognosis and treatment of the two types of stress fracture. Therefore differentiation of fracture location is warranted. Differences in risk factors and clinical outcomes between proximal and non-proximal stress fractures have not been studied. OBJECTIVE: To determine whether different risk factors and/or clinical outcomes associated with proximal and non-proximal stress fractures of the second metatarsal exist. METHODS: Patients diagnosed with proximal stress fractures of the second metatarsal were included in the study. Retrospectively, an age-matched control group with a non-proximal stress fracture was selected for comparison. Statistical analysis involved bivariate comparisons of demographic variables and clinical measurement between the two groups. RESULTS: Patients with proximal stress fractures were more likely to be chronically affected, usually exhibited an Achilles contracture, showed differences in length of first compared with second metatarsal, were more likely to experience multiple stress fractures, and exhibited low bone mass. In addition, a high degree of training slightly increased the risk of a non-proximal fracture, whereas low training volume was associated with a proximal stress fracture. CONCLUSION: The signs, symptoms and clinical findings associated with proximal metatarsal stress fractures are different from those of non-proximal stress fractures.

Davidson G, Pizzari T, Mayes S (2007). The influence of second toe and metatarsal length on stress fractures at the base of the second metatarsal in classical dancers. *Foot Ankle Int* 28(10):1082-1086.

BACKGROUND: Stress fractures at the base of the second metatarsal frequently occur in female classical dancers. There is a strong belief that a foot shape in which the first metatarsal or toe is shorter than the second metatarsal or toe increases the risk of this injury in dancers. However, there is a lack of empirical evidence to support this theory. The objective of this study was to examine the influence of the relative length difference between the first and second metatarsals and first and second toes on the frequency of stress fractures at the base of the second metatarsal in elite, female classical dancers. METHODS: Both feet of 50 elite female classical dancers were measured for length differences between the first and second toes and first and second metatarsals. Retrospective analysis of dancers' medical histories revealed 17 feet with stress injury and 83 without. The mean of the difference between the metatarsal and toe length for the stress-injury group was compared to that of the control group. RESULTS: No difference between the groups was identified for first and second toe length difference ($p = 0.865$) and the relative difference between the ends of the first two metatarsals ($p = 0.815$). CONCLUSIONS: Dancers who had a stress injury at the base of the second metatarsal displayed similar variances in the two independent variables as dancers who had not had such an injury.

Herrera-Soto JA, Scherb M, Duffy MF, Albright JC (2007). Fractures of the fifth metatarsal in children and adolescents. *J PediatricOrthop* 27(4): 427-431.

OBJECTIVE: Fractures of the fifth metatarsal are the most common metatarsal fractures in children. Their treatment is based on the adult literature. The purpose of our study was to identify the different types of fifth metatarsal fractures, to determine the mean time to healing, and to examine whether current adult recommendations can be extrapolated to children and adolescents. METHODS: A total of 103 patients met the inclusion criteria. The fractures were classified according to location. Type I represented an apophyseal injury. Type II represented tubercle fractures with intra-articular extension. Type III injuries represented Jones fracture. Metatarsal neck and shaft fractures were included separately. RESULTS: Apophyseal fractures did well with a short-leg walking cast for 3 to 6 weeks. Displaced intraarticular

fractures had a significant delay in healing versus nondisplaced ones. Jones fractures had delays in healing if not treated surgically. Neck and shaft fractures did well with casting. CONCLUSIONS: Most fractures of the fifth metatarsal in the pediatric population do well clinically after a course of walking cast, unless the fracture is an intra-articular displaced fracture type or the fracture occurs in the proximal diaphyseal area. Fixation of Jones fractures in active adolescents should be considered to allow faster return to regular activities and prevent refracture. We recommend non-weight bearing casts for all angulated or displaced intra-articular injuries to avoid delays in healing and angulation. From our series, it is evident that most pediatric fifth metatarsal fractures behave as those found in adults and can be treated similarly.

Kadel N, Boenisch M, Teitz C, Trepman E (2005) Stability of Lisfranc joints in ballet pointe position. *Foot Ankle Int* 26(5) 394-400.

BACKGROUND: Ballerinas develop stress fractures at the second metatarsal base associated with dancing en pointe. The purpose of this study was to evaluate the relative importance of the pointe shoe and the tarsometatarsal ligaments in Lisfranc joint stability en pointe. METHODS: Eleven cadaver feet were dressed with pointe shoes, loaded in foot flat with ligaments intact, and loaded en pointe before and after sequential sectioning of the dorsal, interosseous, and plantar ligaments between the first and second metatarsals and cuneiforms. Relative motion between the first and second metatarsals and cuneiforms was determined radiographically. RESULTS: No significant displacement of the Lisfranc joints occurred when the shod foot with intact ligaments was loaded in the foot flat or en pointe positions. Serial sectioning of the ligaments from dorsal to plantar in the shod foot en pointe demonstrated no change in alignment after the dorsal and interosseous ligaments were cut, but a significant change in alignment between the second metatarsal and second cuneiform was noted after the plantar ligament was cut ($p < 0.0001$). Removal of the pointe shoe after cutting the ligaments and applying a minimal (1 to 2 kg) load resulted in complete subluxation and diastasis through the first-second intermetatarsal and intercuneiform region. Replacing the shoe improved alignment en pointe with similar loading. CONCLUSIONS: Both the pointe shoe and Lisfranc ligaments are important for Lisfranc region stability in feet en pointe. The plantar ligaments are major stabilizers of the Lisfranc region in the loaded, shod foot en pointe. Selection of a pointe shoe with adequate support may limit susceptibility to stress fracture of the second metatarsal base in ballerinas.

Muscolo L, Migues A, Slullitel G, Costa-Paz M (2004) Stress fracture nonunion at the base of the second metatarsal in a ballet dancer: a case report. *Am J Sport Med* 32(6):1535-1537.

Stress fractures are defined as spontaneous fractures of normal bone that are the result of repetitive stresses that are themselves harmless. Although the metatarsal shaft is the most common location of a stress fracture in the general population, the base of the second metatarsal is by far the most common site in ballet dancers. Few series published in the orthopaedic literature report a quick recovery of this fracture after conservative treatment, and cases of non-union have not been previously reported. We report a nonunion at the base of the second metatarsal, secondary to stress fracture, in a 24-year-old professional ballet dancer with successful outcome after surgical repair.

Niemeyer P, Weinberg A, Schmitt H, Kreuz PC, Ewerbeck V, Kasten P (2006). Stress fractures in adolescent competitive athletes with open physis. *Knee Surg Sports Traumatol Arthrosc* 14(8):771-777.

There have been no studies devoted exclusively to stress fractures in competitive athletes with immature skeletal systems so far. The object of this case series was to describe special features of stress fractures in athletes with immature skeletal systems, with special reference to sport-specific strain, diagnosis and treatment results. The study population was made up of 19 children and adolescents with a total of 21 stress fractures. The average observation period was 4.83 years [standard deviation (SD) 2.69] and the average age at diagnosis, 14.04

years (SD 4.7). The lower extremity was affected in most of our cases. In adolescent athletes, endurance sports appear to lead preferentially to stress fractures in the region of the metatarsal bones, while sports requiring sudden stops at high speed appear to increase the risk of fractures in the region of the tibial diaphysis (P=0.0322). Most (20 of 21) of the fractures in this study were treated conservatively with refraining from athletic activity and reduction of stress/weight-bearing for an average of 6.73 weeks (SD 2.91). In five cases the extremity was in addition immobilized in a plaster cast for 5.32 weeks (SD 2.21). Complete healing was achieved in 14 cases. In seven cases, however, the treatment did not lead to a satisfactory outcome. Most of the patients whose symptoms persisted over a long period had fractures in the tibia and were engaged in sports requiring frequent sudden stops. Our data suggest that stress fractures in athletes, whose skeletal systems are still immature, lead to a clinical picture that does not always culminate in a good outcome of treatment. We therefore recommend a thorough and early diagnostic investigation (including MRI) and consistent treatment whenever a patient's history and clinical picture give any indication that a stress fracture might be present.

O'Malley MJ, Hamilton WG, Munyak J (1996). Fractures of the distal shaft of the fifth metatarsal. "Dancer's Fracture". *Am J Sports Med* 24(2) 240-243.

We retrospectively reviewed the office records of the senior author--which include two national ballet companies--and identified 35 dancers who sustained distal shaft fractures of the fifth metatarsal. The usual fracture pattern is a spiral, oblique fracture starting distal-lateral and running proximal-medial. Treatment consisted of open reduction and internal fixation for 2 patients, closed reduction and percutaneus fixation for 2 patients, short leg weightbearing cast for 7 patients, and an elastic wrap and treatment of symptoms for 24 patients. Patients with marked displacement of the fracture underwent internal fixation early in the study period; but more recent treatment emphasized nonoperative means, even for displaced fractures. The average time to pain free walking was 6.1 weeks (range, 0 to 16); return to barre exercises, 11.6 weeks (range, 4 to 48); and return to performance, 19 weeks (range, 6 to 52). There was one delayed union (7 months) and one refracture (2 months) that subsequently healed. All patients returned to professional performance without limitation and no patient reported pain with performance at followup. Spiral fractures of the distal shaft of the fifth metatarsal are common injuries and can usually be treated nonoperatively for these high performance athletes without long-term functional sequelae.

O'Malley MJ, Hamilton WG, Munyak J, DeFranco MJ (1996) Stress fractures at the base of the second metatarsal in ballet dancers. *Foot Ankle Int* 17(2):89-94.

Stress fractures are a frequent injury in ballet companies and the most common location is at the base of the second metatarsal. While previous reports have focused on risk factors for this injury (overtraining, delayed menarche, poor nutrition), there is no published series describing the natural history and outcome following this fracture. We reviewed the office records of the senior author and identified 51 professional dancers (64 fractures) who sustained a stress fracture at the base of the second metatarsal. History of a previous stress fracture in the lower extremity was seen in 19 patients and delayed menarche in the women was common. The clinical presentation was insidious onset of midfoot pain an average of 2.5 weeks prior to seeking medical care. The initial radiographs of the foot were positive in 19 patients, questionable in 3 patients, and negative in 42 patients. The usual location of the fracture was at the proximal metaphyseal-diaphyseal junction (three fractures extended into the tarsometatarsal joint). Treatment consisted of a short leg walking cast for 6 patients, and a wooden shoe and symptomatic treatment for the remainder. At follow-up, 14% of patients still had occasional pain or stiffness in the midfoot with dancing. The patients returned to performance at an average of 6.2 weeks following diagnosis. No patients required bone grafting for persistent symptoms. There were eight refractures (at the same site) occurring an average of 4.3 years, all of which healed with conservative care. Stress fractures at the base of the second metatarsal are common in ballet dancers and can usually be treated with

symptomatically. The results of this study are discussed in terms of risk factors, the use of a posterior-anterior view of the foot to eliminate overlap at Lisfranc's joint, and our present treatment regimen.

Oztekin HH, Boya H, Nalcakan M, Ozcan O (2007). Second toe length and forefoot disorders in ballet and folk dancers. *J Am Podiatr Med Assoc* 97(5): 385-388.
Background: Although there is no ideal foot type for classical dancers, second-toe length seems to be a factor in the etiology of foot disorders in ballet dancers. Methods: We investigated the relationship between second-toe length and foot disorders in 30 ballet dance students and 25 folk dance students. Second-toe length in relation to the hallux (longer or equal/shorter), hallux deformities, first metatarsophalangeal joint inflammation, number of callosities, and daily pain scores were recorded in both groups and compared. Results: There was no statistically significant difference in toe length between the two groups (P > .05). Ballet dancers with equal-length or shorter second toes had lower pain scores, less first metatarsophalangeal joint inflammation, and fewer callosities in their feet compared with dancers with longer second toes. Conclusions: Second-toe length seems to be a factor in the development of forefoot disorders in classical ballet dancers but not folk dancers. Dancers who have equal-length or shorter second toes in relation to the hallux may have fewer forefoot disorders as dance professionals.

Kuo RS, Tejwani NC, Digiovanni CW, Holt SK, Benirschke SK, Hansen ST Jr., Sangeorzan BJ (2000). Outcome after open reduction and internal fixation of Lisfranc joint injuries. *J Bone Joint Surg Am* 82-A(11):1609-18.
BACKGROUND: Open reduction and internal fixation has been recommended as the treatment for most unstable injuries of the Lisfranc (tarsometatarsal) joint. It has been thought that purely ligamentous injuries have a poor outcome despite such surgical management. METHODS: We performed a retrospective study of patients who underwent open reduction and screw fixation of a Lisfranc injury in a seven-year period. Among ninety-two adults treated for that injury, forty-eight patients with forty-eight injuries were followed for an average of fifty-two months (range, thirteen to 114 months). Fifteen injuries were purely ligamentous, and thirty-three were combined ligamentous and osseous. Patient outcome was assessed with use of the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot score and the long-form Musculoskeletal Function Assessment (MFA) score. RESULTS: The average AOFAS midfoot score was 77 points (on a scale of 0 to 100 points, with 100 points indicating an excellent outcome), with patients losing points for mild pain, decreased recreational function, and orthotic requirements. The average MFA score was 19 points (on a scale of 0 to 100 points, with 0 points indicating an excellent outcome), with patients losing points because of problems with "leisure activities" and difficulties with "life changes and feelings due to the injury." Twelve patients (25 percent) had posttraumatic osteoarthritis of the tarsometatarsal joints, and six of them required arthrodesis. The major determinant of a good result was anatomical reduction (p = 0.05). The subgroup of patients with purely ligamentous injury showed a trend toward poorer outcomes despite anatomical reduction and screw fixation. CONCLUSIONS: Our results support the concept that stable anatomical reduction of fracture-dislocations of the Lisfranc joint leads to the best long-term outcomes as patients so treated have less arthritis as well as better AOFAS midfoot scores.

Sarimo J, Orava S, Alanen J (2007). Operative treatment of stress fractures of the proximal second metatarsal. *Scand J Med Sci Sports* 17(4): 383-386.
Proximal stress fractures of the second metatarsal are rare. They have been reported mainly in classical ballet dancers. Non-operative treatment has usually led to good results and rapid return to full activities. We present a series of nine cases with stress fractures of the proximal second metatarsal. The patients were all actively involved in sports. None of them were dancers. In all of these patients non-operative treatment lasting for an average of 13 months had failed. All of the patients were operated on using the same method. In the operation

drilling was performed around and through the fracture line. The patients were followed for an average of 38 months. All except one of the patients were able to return to their prior level of activity within 4-6 months. In conclusion if non-operative treatment fails surgery seems to give good results in most patients with a stress fracture of the proximal second metatarsal.

Saxena A, Krisdakumtorn T, Erikson S (2001). Proximal fourth metatarsal injuries in athletes: similarity to proximal fifth metatarsal injury. *Foot Ankle Int* 22(7): 603-608.

Proximal fourth metatarsal injuries are rarely reported. We present five case histories in which athletic patients sustained injuries at the shaft-base junction of the fourth metatarsal. Similar to proximal fifth metatarsal injuries, adduction of the forefoot appears to be associated. Our patients returned to their activities in two to eight months. These patients injuries tended to take longer to heal than other lesser metatarsal fractures and stress fractures (which are typically more distal). Some patients were continually symptomatic, even after three months of rest and immobilization. This coincides with proximal fifth metatarsal injuries and stress fractures. For treatment of proximal fourth metatarsal injuries to be successful, ideal treatment appears to involve nonweightbearing below-knee cast/boot immobilization for three weeks. This is followed by an additional three or more weeks of weightbearing immobilization. Healing may still be prolonged.

REVIEW ARTICLES

Boden BP, Osbahr DC (2000). High-risk stress fractures: evaluation and treatment. *J Am Acad Orthop Surg* 8(6):344-353.

Stress fractures are common overuse injuries seen in athletes and military recruits. The pathogenesis is multifactorial and usually involves repetitive submaximal stresses. Intrinsic factors, such as hormonal imbalances, may also contribute to the onset of stress fractures, especially in women. The classic presentation is a patient who experiences the insidious onset of pain after an abrupt increase in the duration or intensity of exercise. The diagnosis is primarily clinical, but imaging modalities such as plain radiography, scintigraphy, computed tomography, and magnetic resonance imaging may provide confirmation. Most stress fractures are uncomplicated and can be managed by rest and restriction from the precipitating activity. A subset of stress fractures can present a high risk for progression to complete fracture, delayed union, or nonunion. Specific sites for this type of stress fracture are the femoral neck (tension side), the patella, the anterior cortex of the tibia, the medial malleolus, the talus, the tarsal navicular, the fifth metatarsal, and the great toe sesamoids. Tensile forces and the relative avascularity at the site of a stress-induced fracture often lead to poor healing. Therefore, high-risk stress fractures require aggressive treatment.

Bruker P, Bennell K (1997). Stress fractures in female athletes: diagnosis, management and rehabilitation. *Sports Med* 24(6): 419-429.

Stress fractures are a common overuse injury among athletes. The incidence of stress fractures among females is higher in the military, but this difference is not as evident in the athletic population. The history of the patient with stress fracture is typically one of insidious onset of activity-related pain. If the patient continues to exercise, the pain may well become more severe or occur at an earlier stage of exercise. As well as obtaining a history of the patient's pain and its relation to exercise, it is important to determine the presence of predisposing factors. On physical examination, the most obvious feature is localised bony tenderness. Occasionally, redness, swelling or periosteal thickening may be present at the site of the stress fracture. The diagnosis of stress fracture is primarily a clinical one; however, if the diagnosis is uncertain, various imaging techniques can be used to confirm the diagnosis. In the majority of stress fractures, there is no obvious abnormality on plain radiograph. Although the triple phase bone radiograph is extremely sensitive, the fracture itself is not visualised and it may be difficult to precisely locate the site, especially in the foot. The radionuclide scan will detect evolving stress fractures at the stage of accelerated remodelling,

so the findings must be closely correlated with the clinical picture. The characteristic bone scan appearance of a stress fracture is of a sharply marginated area of increased uptake, usually involving one cortex of the bone. Computerised tomography scanning is a helpful addition if the fracture needs to be visualised, or to distinguish between a stress reaction and stress fracture. Magnetic resonance imaging (MRI) is being used increasingly as the investigation of choice for stress fractures. The typical findings on MRI are of periosteal and marrow oedema, as well as fracture line. The basis of treatment of a stress fracture involves rest from the aggravating activity. Most stress fractures will heal in a straightforward manner, and return to sport occurs within 6 to 8 weeks. The rate of resumption of activity should be influenced by symptoms and physical findings. When free of pain, the aggravating activity can be resumed and slowly increased. It is important that the athlete with a stress fracture maintain fitness during this period of rehabilitation. The most commonly used methods are cycling, swimming, upper body weights and water running. There are a number of specific stress fractures that require additional treatment because of a tendency to develop delayed union or nonunion. These include stress fractures of the neck of the femur, anterior cortex of the tibia, navicular and second and fifth metatarsals. An essential component of the management of stress fractures, as with any overuse injury, involves identification of the factors that have contributed to the injury and, where possible, correction or modification of some of these factors to reduce the risk of the injury recurring. Stress fractures are more common in female athletes with menstrual disturbances. This may be due to the effect on bone density. The role of hormonal replacement in the management of these athletes is unclear at this stage.

Chilvers M, Donahue M, Nasser L, Manoli A 2nd (2007). Foot and ankle injuries in elite female gymnasts. *Foot Ankle Int* 28(2): 124-218.

BACKGROUND: Gymnastics is a competitive and popular sport that is started at an early age, and elite female gymnasts reach their prime in mid-teenage years. The level of intensity of practice and competition, the number of events, and the degree of difficulty of the maneuvers make gymnastics one of the most injury-producing sports. METHODS: Over a 3-year period, 14 elite, female gymnasts were seen in one foot and ankle center. The mean age was 17 (range 14 to 21) years. All gymnasts sustained acute or sub-acute injuries to the foot or ankle requiring surgery. The mechanism of injury, the type of injury, operative repair, and followup were recorded. RESULTS: There were five Lisfranc fracture-dislocations, and five talocalcaneal, two multiple metatarsal, one medial malleolar, one phalangeal, and one sesamoid fracture. All injuries had operative repair. One gymnast with a Lisfranc injury was able to return to full competition; all others with a Lisfranc injury retired from gymnastics, were lost to followup, or graduated from college. One gymnast with a talar osteochondral injury was not able to return to competition but all other injured gymnasts were able to return to gymnastics at the same level or higher. CONCLUSION: Elite female gymnasts can sustain significant injury to the foot and ankle region. In our study, Lisfranc injuries were most likely career-ending.

Denton J (1997). Overuse foot and ankle injuries in ballet. *Clin Podiatr Med Surg* 14: 525-532.

Incorrect techniques repeated daily by a dancer can lead to overuse injuries. This article discusses the causes and treatment of foot and ankle injuries in the ballet dancer. The author also addresses skin lesions that are common in dancers who wear pointe shoes.

Fetzer GB, Wright RW (2006). Metatarsal shaft fractures and fractures of the proximal fifth metatarsal. *Clin Sports Med* 25(1):139-150.

Metatarsal fractures represent a relatively common injury, especially in athletes. The pertinent anatomy, evaluation, diagnosis, classification, and treatment of acute and chronic (stress) metatarsal shaft fractures are discussed. Fractures of the proximal fifth metatarsal, which are unique and important injuries, are also discussed. Treatment remains relatively straightforward for the traumatic metatarsal injury, whereas traditional stress fractures typically heal with

decreased activity. The problematic proximal fifth metatarsal fracture (Jones fracture) frequently requires surgical intervention in patients who want to avoid non-weight-bearing cast immobilization. The authors' current treatment for this fracture includes the option of intramedullary fixation versus cast immobilization.

Fredericson M, Jennings F, Beaulieu C, Matheson GO (2006). Stress fractures in athletes. *Top Magn Reson Imaging* 17(5):309-325.

A stress fracture is a partial or complete bone fracture that results from repeated application of stress lower than the stress required to fracture the bone in a single loading. Otherwise healthy athletes, especially runners, sustain stress injuries or fractures. Prevention or early intervention is the preferable treatment. However, it is difficult to predict injury because runners vary with regard to biomechanical predisposition, training methods, and other factors such as diet, muscle strength, and flexibility. Stress fractures account for 0.7% to 20% of all sports medicine clinic injuries. Track-and-field athletes have the highest incidence of stress fractures compared with other athletes. Stress fractures of the tibia, metatarsals, and fibula are the most frequently reported sites. The sites of stress fractures vary from sport to sport (eg, among track athletes, stress fractures of the navicular, tibia, and metatarsal are common; in distance runners, it is the tibia and fibula; in dancers, the metatarsals). In the military, the calcaneus and metatarsals were the most commonly cited injuries, especially in new recruits, owing to the sudden increase in running and marching without adequate preparation. However, newer studies from the military show the incidence and distribution of stress fractures to be similar to those found in sports clinics. Fractures of the upper extremities are relatively rare, although most studies have focused only on lower-extremity injuries. The ulna is the upper-extremity bone injured most frequently. Imaging plays a key role in the diagnosis and management of stress injuries. Plain radiography is useful when positive, but generally has low sensitivity. Radionuclide bone scanning is highly sensitive, but lacks specificity and the ability to directly visualize fracture lines. In this article, we focus on magnetic resonance imaging, which provides highly sensitive and specific evaluation for bone marrow edema, periosteal reaction as well as detection of subtle fracture lines.

Hillier JC, Peace K, Hulme A, Healy JC (2004). Pictorial review: MRI features of foot and ankle injuries in ballet dancers. *Br J Radiol* 77(918): 532-537.

Foot and ankle pain is common in ballet dancers. Although clinical examination often points to the underlying cause, imaging is often necessary to confirm the diagnosis and thus ensure appropriate future management. Factors predisposing to the increased incidence of injuries in this population include the classical position in which ballet dancers stand, which is on the tips of the toes in the en pointe position or on the balls of the feet in the demi-pointe position. Furthermore, the repetitious nature of ballet and the long hours spent rehearsing cause over-use injuries. The causes of foot and ankle pain can be thought of in four different groups: the impingement syndromes; tendon abnormalities; osseous pathology; and ligament abnormalities. These will be discussed and illustrated.

Kadel NJ (2006). Foot and ankle injuries in dance. *Phys Med Rehabil Clin N Am* 17(4): 813-826.

Although dancers develop overuse injuries common in other athletes, they are also susceptible to unique injuries. This article reviews common foot and ankle problems seen in dancers and provides some basic diagnosis and treatment strategies.

Murray SR, Reeder MT, Udermann BE, Pettit RW (2006). High-risk stress fractures: pathogenesis, evaluation, and treatment. *Compr. Ther* 32(1):20-25.

High-risk stress fractures require precise assessment and treatment because of their propensity for delayed union, nonunion, or complete fracture and their resulting disabling complications. Proper diagnosis necessitates a thorough clinical evaluation, centering on the patient's diet and history, particularly the training regimen. For a definitive diagnosis, plain radiography, ultrasound, bone scintigraphy, magnetic resonance imagery (MRI), and

computed tomography (CT) are helpful, and each plays a specific role. High-risk stress fractures typically require aggressive treatment such as nonweight-bearing immobilization coupled with therapy and often surgery.

Rammelt S, Heineck J, Zwipp H (2004). Metatarsal fractures. *Injury* 2:77-86.
Metatarsal fractures are relatively common and if malunited, a frequent source of pain and disability. Nondisplaced fractures and fractures of the second to fourth metatarsal with displacement in the horizontal plane can be treated conservatively with protected weight bearing in a cast shoe for 4-6 weeks. In most displaced fractures, closed reduction can be achieved but maintenance of the reduction needs internal fixation. Percutaneous pinning is suitable for most fractures of the lesser metatarsals. Fractures with joint involvement and multiple fragments frequently require open reduction and plate fixation. Transverse fractures at the metaphyseal-diaphyseal junction of the fifth metatarsal ("Jones fractures") require an individualized approach tailored to the level of activity and time to union. Avulsion fractures of the fifth metatarsal bone are treated by open reduction and tension-band wiring or screw fixation if displaced more than 2 mm or with more that 30% of the joint involved. The metatarsals are the most common site of stress fractures, most of which are treated nonoperatively. Symptomatic posttraumatic deformities need adequate correction, in most cases by osteotomy across the former fracture site.

Rosenberg GA, Sferra JJ (2000). Treatment strategies for acute fractures and non-unions of the proximal fifth metatarsal. *J Am Acad Orthop Surg* 8(5):332-338.
There are at least three distinct fracture patterns that occur in the proximal fifth metatarsal: tuberosity avulsion fractures, acute Jones fractures, and diaphyseal stress fractures. Each of these fracture patterns has its own mechanism of injury, location, treatment options, and prognosis regarding delayed union and nonunion. Tuberosity avulsion fractures are the most common in this region of the foot. The majority heal with symptomatic care in a hard-soled shoe. The true Jones fracture is an acute injury involving the fourth-fifth intermetatarsal facet. These injuries are best treated with non-weight-bearing cast immobilization for 6 to 8 weeks. The rate of successful union with this treatment has been reported to be between 72% and 93%. For the high-performance athlete with an acute Jones fracture, early intramedullary-screw fixation is an accepted treatment option. Nonacute diaphyseal stress fractures of the proximal fifth metatarsal and Jones fractures that develop into delayed unions and nonunions can both be managed with operative fixation with either closed axial intramedullary-screw fixation or autogenous corticocancellous grafting. Early results with the use of electrical stimulation are promising; however, prospective studies are needed to better define the role of this modality in managing these injuries.

Strayer SM, Reece SG, Petrizzi MJ (1999). Fractures of the proximal fifth metatarsal. *Am Fam Physician* 59(9):2516-22.
Fractures of the proximal portion of the fifth metatarsal may be classified as avulsions of the tuberosity or fractures of the shaft within 1.5 cm of the tuberosity. Tuberosity avulsion fractures cause pain and tenderness at the base of the fifth metatarsal and follow forced inversion during plantar flexion of the foot and ankle. Local bruising, swelling and other injuries may be present. Nondisplaced tuberosity fractures are usually treated conservatively, but orthopedic referral is indicated for fractures that are comminuted or displaced, fractures that involve more than 30 percent of the cubo-metatarsal articulation surface and fractures with delayed union. Management and prognosis of both acute (Jones fracture) and stress fracture of the fifth metatarsal within 1.5 cm of the tuberosity depend on the type of fracture, based on Torg's classification. Type I fractures are generally treated conservatively with a nonweight-bearing short leg cast for six to eight weeks. Type II fractures may also be treated conservatively or may be managed surgically, depending on patient preference and other factors. All displaced fractures and type III fractures should be managed surgically. Although most fractures of the

proximal portion of the fifth metatarsal respond well to appropriate management, delayed union, muscle atrophy and chronic pain may be long-term complications.

Stretanski MF, Weber GJ (2002). Medical and rehabilitation issues in classical ballet: Literature review. *Am J Phys Med Rehabil* 81: 383-391.

Classical ballet is a demanding professional occupation, with participants who are often underserved in terms of accurate diagnosis and appropriate comprehensive medical care. The view that follows is designed to be as global and insightful as published to date. Specific rehabilitation considerations, dance mechanics, idiosyncratic differential diagnosis, and personality and equipment issues are discussed, and a rational view of dogma presented.