Bilateral Stress Fractures of the Anterior Part of the Tibial Cortex

A CASE REPORT*

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Most stress fractures of the tibia, when treated appropriately, heal without sequelae. A stress fracture of the anterior part of the cortex of the tibia, an uncommon variant, is associated with atypical clinical and radiographic findings, has a propensity for nonunion, and can result in a complete fracture. We report the case of a patient who had chronic, bilateral stress fractures of the anterior part of the tibial cortex.

Case Report

A twenty-one-year-old male college football player who was in his junior year was first seen by us because of a five-year history of recurrent pain in both shins. The pain had worsened in September 1996, during the early part of the football season, when practices were held twice a day. Typically, the pain was most severe when the patient began running but would subside within a few minutes and then return on cessation of weight-bearing activity. The patient had not missed any games or practice sessions.

Clinical examination revealed moderate tenderness along the medial border of the distal and middle thirds of the right tibia, extending for a distance of twelve centimeters, and mild tenderness in the corresponding area of the left tibia. The patient had marked bilateral pes planus and rigidity of the midfoot and forefoot. The subtalar and ankle joints had a normal range of motion.

Radiographs had been made at regular intervals during the five years before the patient was evaluated in our office, and all had revealed normal findings. A triple-phase isotope bone scan was performed to confirm the provisional diagnosis of a stress fracture. The blood-pool images demonstrated mildly increased radionuclide uptake in the right as compared with the left tibia. The delayed-phase images showed four small, discrete areas of moderately increased uptake along the anterior border of the middle third of the right tibia and one similar area in the left tibia (Fig. 1).

The diagnosis of stress reaction of the tibia was made, and the patient was managed with modification of his training regimen, physical therapy modalities, strengthening exercises for the muscles of the leg, and foot orthoses. He practiced regularly and played for the entire 1996 to 1997 college football season with only slight discomfort. After a two-week period of rest, he resumed running on a hard surface in preparation for a January 1997 bowl game. Shortly after the resumption of running, the patient reported recurrent and increased pain, especially on the right side. He played in the game, but the pain persisted and was noticeable even during regular daily activities. He was unable to begin spring training in April 1997 because of pain along the anterior part of the tibial cortex.

Physical examination revealed moderate tenderness along the middle third of the anteromedial border of the right tibia. Plain radiographs showed four distinct radiolucent areas in the anterior part of the tibial cortex (Fig. 2). This finding was interpreted as being consistent with nonunion of multiple stress fractures. Sagittal magnetic resonance imaging scans showed transverse fracture lines in the anterior part of the cortex without any evidence of bone-marrow edema (Fig. 3-A). Axial scans through one of the fracture lines showed increased signal intensity in the anterior part of the cortex with evidence of a periosteal reaction along the medial and lateral tibial borders (Fig. 3-B).

The persistence of symptoms, the failure of nonoperative measures (including prolonged periods of rest) during the five years before the patient was seen by us, and the lack of osseous healing on bone scans and magnetic resonance images led to the decision to proceed with operative treatment in April 1997. An intramedullary rod, locked proximally but not distally in order to allow for compression while the patient was walking, was inserted into the right tibia to facilitate healing of the stress fractures. The postoperative course was uneventful, and the patient resumed football training in August 1997. A plain radiograph made five months postoperatively showed complete healing of two of the four radiolucent areas and a decrease in the size of the other two areas (Fig. 4).

In September 1997, the patient reported mild-to-moderate pain in the left tibia. A plain radiograph showed a single radiolucent defect in the anterior part of the cortex of the middle third of the left tibia (Fig. 5). A radionuclide bone scan showed mild, diffuse uptake

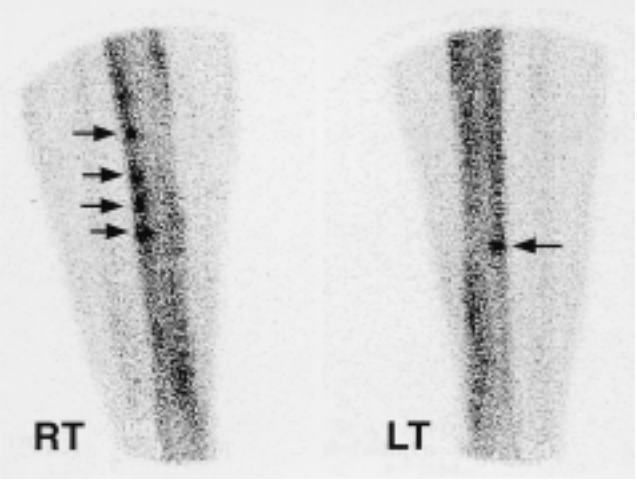

FIG. 1

Delayed-phase images of a radionuclide bone scan showing four discrete areas of moderately increased uptake of technetium (arrows) along the anterior border of the middle third of the right tibia (RT) and one similar area in the left tibia (LT).

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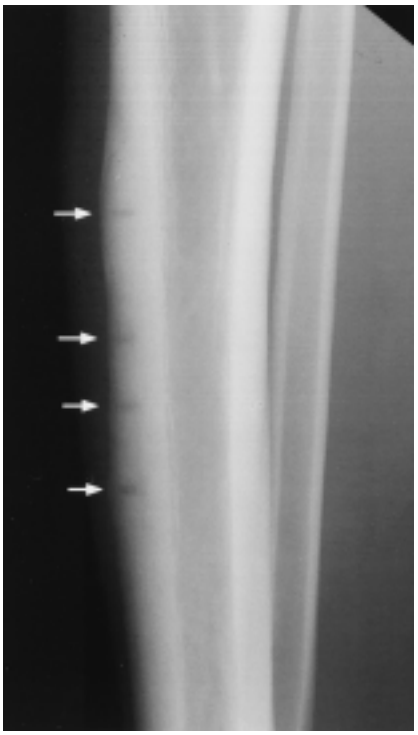

FIG. 2

Plain radiograph showing four radiolucent areas (arrows) in the anterior part of the cortex of the middle third of the right tibia.

along the medial border of the left tibia but no focal areas of increased uptake (Fig. 6). Magnetic resonance imaging scans showed no evidence of a transverse line through the tibia and no evidence of bone-marrow edema; the only abnormality was a slight increase in signal intensity in the posterior aspect of the periosteum. Clinical muscle-testing revealed that the patient was able to perform only five single-leg calf raises before he was unable to continue because of fatigue. Measurements of total bone-mineral content and regional bone density were within normal limits. The serum levels of calcium, phosphate, and alkaline phosphatase revealed no abnormalities of bone metabolism.

Custom-molded foot orthoses with a viscoelastic insole were used in an attempt to decrease some of the impact forces. A pneumatic leg brace (Aircast; Aircast, Summit, New Jersey) was used to provide relief from pain; the patient wore the brace during training sessions but not during games. An Orthopak bone-growth stimulator (Biolectron, Hackensack, New Jersey) was attached to the brace for ten hours a day. Our decision to allow the patient to play football was based on the fact that he was asymptomatic at the start of the season and had already played for five years with tibial pain. We believed that the risk of a complete fracture would be low with close monitoring.

The patient completed the football season but reported persistent mild-to-moderate pain in the left tibia. Radiographs made during and at the end of the season showed persistence of the anterior cortical defect. At the time of the most recent follow-up, the patient had pain in the left tibia, for which he was still being managed nonoperatively. After the patient graduated, he was employed and no longer played football. He had no residual pain in the right tibia but reported some pain in the left tibia during sports activities. He did not have pain on a daily basis.

Discussion

Stress fractures of the anterior part of the cortex of the middle third of the tibia apparently were first described in 1956 by Burrows[15], who reported on five ballet dancers who had such a lesion. Multiple stress fractures of the anterior part of the tibial cortex and simultaneous bilateral fractures have not been frequently reported. Previous reports have indicated that these fractures do not heal with nonoperative treatment[8,9,20,21,29], but those reports included very small numbers of patients. Blank[8], in a study of five patients who had had symptoms for one to nine years, reported that none of the fractures healed despite prolonged rest, immobilization in a cast, and cessation of all physical activity. Similarly, Green et al.[21], in a study of six patients, reported that none of the fractures healed despite immobilization in a cast for three to fifteen months. One patient went on to have a complete fracture, one was managed with electromagnetic stimulation but continued to have symptoms two years after the time of presentation, and three were managed with excision of the lesion followed by bone-grafting. There was no information on the sixth patient.

The most remarkable feature in the case of our patient was the progression to radiographic nonunion in the absence of the typical symptoms of an acute stress fracture. In the case of a typical stress fracture, pain initially develops during the latter part of the exercise period and then gradually develops earlier during the exercise period. Eventually, the pain develops at the onset of exercise and persists after exercise. The pain that is caused by a typical stress fracture can become sufficiently severe to limit participation in sports activities.

FIG. 3-A

Figs. 3-A and 3-B: T2-weighted magnetic resonance imaging scans of the right tibia.

Fig. 3-A: Sagittal scan showing three transverse lines (arrows) in the anterior part of the cortex. There is no evidence of bone-marrow edema.

In contrast, our patient was able to participate in competitive sports activities for five years without extensive limitations. This course of events was very different from that associated with a typical stress fracture[14]. While we recognize that generalizations should not be made on the basis of a single case, we believe that this difference should be noted and should encourage the physician to exercise vigilance when determining the definitive diagnosis and treatment. In the case of our patient, the diagnosis of nonunion was based on the long duration of symptoms and the appearance of the lesions on radiographs.

We were able to find only one report that described the results of bone-scanning in patients who had tibial stress fractures. Blank[8], in a report in which three such fractures were evaluated with bone scans, noted minimum uptake at the fracture site and suggested that this finding was consistent with nonunion. In that study, the blood-flow and blood-pool image revealed normal findings and the delayed image demonstrated only slight uptake. In the case of our patient, we believed that the findings on bone scans and the presence of radiolucent areas in the anterior part of the tibial cortex as seen on radiographs were consistent with nonunion. It is not known whether stress fractures of the anterior part of the tibial cortex follow the same clinical course as typical stress fractures or whether they are associated with a different underlying mechanism.

The radiographic appearance of a stress fracture of the anterior aspect of the midpart of the tibial shaft is characterized by a discontinuity of the anterior part of the cortex (a so-called black line) that is thought to be suggestive of bone resorption and the possibility of a nonunion. Histopathological studies of biopsy specimens have demonstrated the presence of dense cortical bone and empty lacunae with sparse granulation tissue at the site of the nonunion[23,26]. Rolf et al.[26], in a histopathological study of the biopsy specimens from two patients who had a stress fracture of the anterior part of the tibia, reported no evidence of bone-remodeling, the absence of inflammatory cells, extensive fibrotic infiltration, and local avascular bone necrosis. Those authors described the histopathological appearance of the lesions as being typical of a pseudarthrosis. Rettig et al.[25], in a study of eight patients, stated that the anterior cortex of the tibia is a relatively hypovascular area because of its subcutaneous location, but they did not provide any data to substantiate this statement.

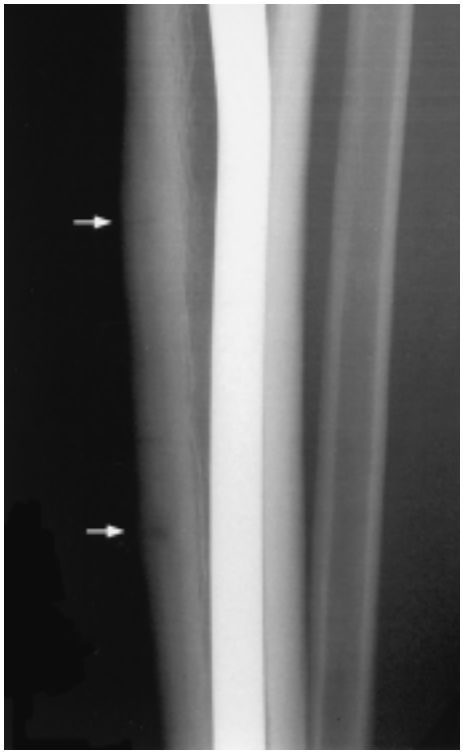

FIG. 4

Plain radiograph of the right tibia, made five months after internal fixation, showing that two of the four fractures had healed and that the remaining two had decreased in size (arrows).

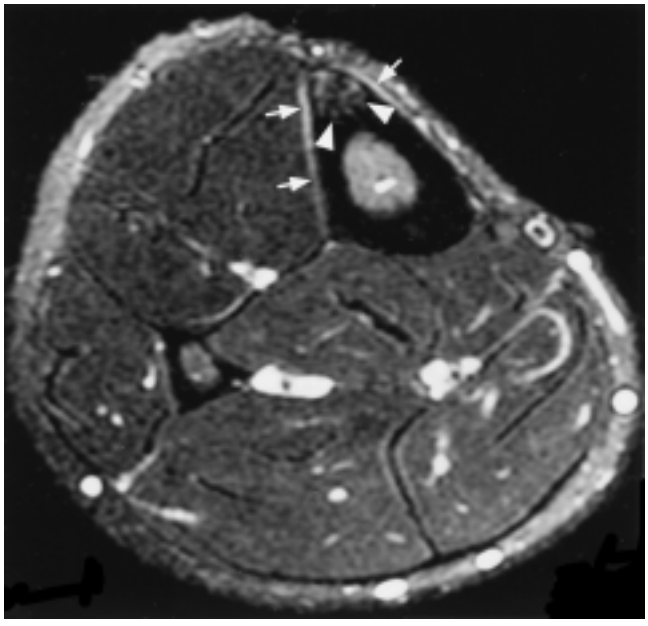

FIG. 3-B

Axial image with fat saturation, showing an abnormal area of increased signal intensity (arrowheads) in the anterior part of the cortex and evidence of a slight periosteal reaction (arrows) along the medial and lateral tibial borders.

Another possible complication of this type of stress fracture is the development of an acute fracture. Brahms et al.[9] described the case of a professional football player who was asymptomatic despite the appearance of nonunion on radiographs. The patient played for three and a half seasons before sustaining an acute tibial fracture through the site of the stress fracture. Our patient, a college football player, was able to play for a full season with only slight discomfort, even though the stress fractures progressed to nonunion.

Bennell et al.[7] performed a prospective study of fifty-three women and fifty-eight men to determine the risk factors for stress fractures in track-and-field ath-

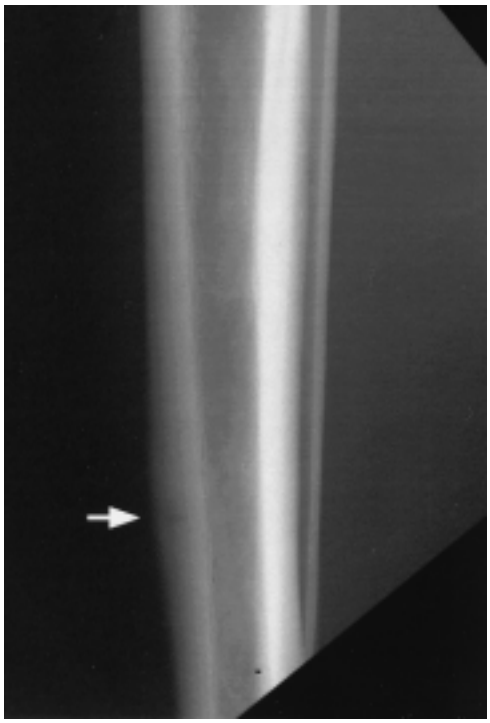

FIG. 5

Plain radiograph made after the start of the football season, showing a single radiolucent defect (arrow) in the anterior part of the cortex of the middle third of the left tibia.

letes. Those authors noted a substantial reduction in the girth of the calves of female athletes who had stress fractures compared with those who did not. They found no such difference among male athletes. In the case of our patient, it is possible that weakness of the calf muscles may have contributed to an increased load on the bone because of the lack of attenuation of impact forces. Our patient had severe pes planus that was worse on the right side as well as marked rigidity of the midfoot and the forefoot. The role of such biomechanical abnormalities in the development of stress fractures is unknown. Bennell et al. found that leg-length discrepancy was a risk factor for the development of stress fractures in women. Other potential risk factors included low bone density and a pathological osseous lesion.

In the case of our patient, treatment with an intramedullary rod led to satisfactory clinical and radiographic healing of the four fractures in the right tibia. Chang and Harris[16] reviewed the cases of five patients who had a recalcitrant nonunion despite prolonged immobilization of the limb in a cast and cessation of sports activity. All five patients were managed with intramedullary tibial nailing; two had an excellent result and three, a good result. Rettig et al.[25] reported osseous union in seven of eight patients who had been managed with pulsed electromagnetic stimulation together with immobilization of the limb in a cast and rest. In the eighth patient, bone-grafting was necessary in order to achieve union. Green et al.[21] reported union in three patients who had been managed with excision of the area of nonunion followed by bone-grafting. Orava et al.[23] reported osseous union in eight of seventeen patients who had been managed nonoperatively. The remaining nine patients were managed with transverse drilling of the area of nonunion. Rolf et al.[26] reported on two athletes in whom a stress fracture of the anterior part of the tibia persisted despite six months and one year of nonoperative treatment. Both patients had complete healing of the fracture within eight months after operative stabilization.

Several investigators have studied the utilization of a pneumatic leg brace for the treatment of the more common stress fracture involving the distal third of the tibia without any involvement of the anterior part of the cortex[18,30,31]. All of those investigators noted a reduction in the time needed to return to activity. Dickson and Kichline[18] reported on thirteen patients who were managed with a pneumatic leg brace, all of whom were able to return to compete at the same level as they had before the onset of symptoms. Swenson et al.[30] managed eighteen patients with a pneumatic leg brace and rest. Light activity was begun after seven days and unrestricted activity, after twenty-one days. Whitelaw et al.[31] managed seventeen patients with a pneumatic leg brace and reported that the patients were able to begin light training at one week, intensive training at 3.7 weeks, and competition at 5.3 weeks. We are not aware of any reports on the use of the pneumatic leg brace for the treatment of fractures of the anterior part of the tibial cortex. In the case of our patient, the stress fracture of the left tibia was treated with a viscoelastic foot ortho-

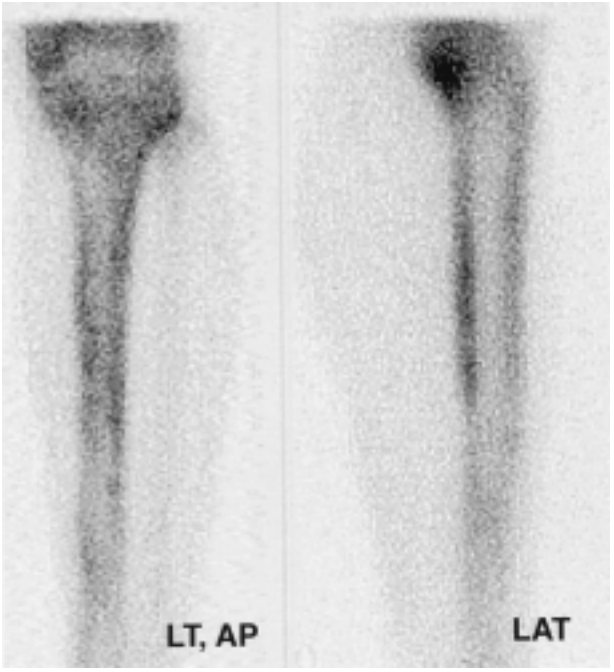

FIG. 6

Anteroposterior (AP) and lateral (LAT) technetium bone scans showing patchy, mildly increased uptake along the medial border of the left tibia (LT) but no focal areas of increased uptake.

sis to reduce the effect of impact loading, the application of a pneumatic leg brace (Aircast) for the relief of symptoms, and electrical stimulation. Although the patient was able to continue to play football, there was no evidence of healing of the nonunion at the time of the latest follow-up evaluation.

Pulsed electromagnetic fields[1-5,17,22,28], direct electrical current[10,12,19,24], as well as capacitively coupled electric fields[10-13,27] all have been shown to have a positive effect on the healing of nonunion of traumatic fractures, but we are not aware of any studies on the use of such measures for the treatment of anterior tibial stress fractures. Benazzo et al.[6] reported on twenty-five stress fractures in athletes that were treated with the application of an alternating current in the form of a sinusoidal wave. Twenty-two of the fractures healed, two showed signs of healing, and one did not heal. Most of these fractures involved the tarsal navicular and the fifth metatarsal, which are associated with an increased prevalence of delayed union or nonunion.

Stress fractures of the anterior part of the tibial cortex have unique features in terms of both clinical presentation and outcome. The subacute nature of the symptoms often permits the patient's continued participation in sports activities and belies the propensity for progression to nonunion. In order to provide appropriate treatment, the physician should be aware of this lesion and its surprisingly small impact on the ability of the patient to participate in sports. Because the plain radiographs of patients who have pain in the shin usually reveal normal findings, there is an inclination to perform bone-scanning or magnetic resonance imaging as the initial investigation of choice. We found follow-up plain radiographs to be extremely helpful, and we believe that they should always be made when a patient reports pain over the middle third of the tibia.

References

1. **Barker, A. T.; Dixon, R. A.; Sharrard, W. J.;** and **Sutcliffe, M. L.:** Pulsed magnetic field therapy for tibial non-union. Interim results of a double-blind trial. *Lancet,* 1: 994-996, 1984.
2. **Bassett, C. A.; Pawluk, R. J.;** and **Pilla, A. A.:** Augmentation of bone repair by inductively coupled electromagnetic fields. *Science,* 184: 575-577, 1974.
3. **Bassett, C. A. L.; Mitchell, S. N.; Pilla, A. A.;** and **Pawluk, R. J.:** A non-operative salvage of surgically-resistant pseudarthroses and nonunions by pulsating electromagnetic fields. A preliminary report. *Clin. Orthop.,* 124: 128-143, 1977.
4. **Bassett, C. A.; Mitchell, S. N.; Norton, L.;** and **Pilla, A.:** Repair of non-unions by pulsing electromagnetic fields. *Acta Orthop. Belgica,* 44: 706-724, 1978.
5. **Bassett, C. A. L.; Mitchell, S. N.;** and **Gaston, S. R.:** Treatment of ununited tibial diaphyseal fractures with pulsing electromagnetic fields. *J. Bone and Joint Surg.,* 63-A: 511-523, April 1981.
6. **Benazzo, F.; Mosconi, M.; Beccarisi, G.;** and **Galli, U.:** Use of capacitive coupled electric fields in stress fractures in athletes. *Clin. Orthop.,* 310: 145-149, 1995.
7. **Bennell, K. L.; Malcolm, S. A.; Thomas, S. A.; Reid, S. J.; Brukner, P. D.; Ebeling, P. R.;** and **Wark, J. D.:** Risk factors for stress fractures in track and field athletes. A twelve-month prospective study. *Am. J. Sports Med.,* 24: 810-818, 1996.
8. **Blank, S.:** Transverse tibial stress fractures. A special problem. *Am. J. Sports Med.,* 15: 597-602, 1987.
9. **Brahms, M. A.; Fumich, R. M.;** and **Ippolito, V. D.:** Atypical stress fracture of tibia in a professional athlete. *Am. J. Sports Med.,* 8: 131-132, 1980.
10. **Brighton, C. T.; Black, J.; Friedenberg, Z. B.; Esterhai, J. L.; Day, L. J.;** and **Connolly, J. F.:** A multicenter study of the treatment of nonunion with constant direct current. *J. Bone and Joint Surg.,* 63-A: 2-13, Jan. 1981.
11. **Brighton, C. T.,** and **Pollock, S. R.:** Treatment of nonunion of the tibia with a capacitively coupled electrical field. *J. Trauma,* 24: 153-155, 1984.
12. **Brighton, C. T.,** and **Pollock, S. R.:** Treatment of recalcitrant non-union with a capacitively coupled electrical field. A preliminary report. *J. Bone and Joint Surg.,* 67-A: 577-585, April 1985.
13. **Brighton, C. T.; Shaman, P.; Heppenstall, R. B.; Esterhai, J. L., Jr.; Pollack, S. R.;** and **Friedenberg, Z. B.:** Tibial nonunion treated with direct current, capacitive coupling, or bone graft. *Clin. Orthop.,* 321: 223-234, 1995.
14. **Brukner, P.; Bennell, K.;** and **Matheson, G.:** *Stress Fractures.* Victoria, Australia, Blackwell Science Asia, 1999.
15. **Burrows, H. J.:** Fatigue infraction of the middle of the tibia in ballet dancers. *J. Bone and Joint Surg.,* 38-B(1): 83-94, 1956.
16. **Chang, P. S.,** and **Harris, R. M.:** Intramedullary nailing for chronic tibial stress fractures. A review of five cases. *Am. J. Sports Med.,* 24: 688-692, 1996.
17. **De Haas, W. G.; Beaupré, A.; Cameron, H.;** and **English, E.:** The Canadian experience with pulsed magnetic fields in the treatment of ununited tibial fractures. *Clin. Orthop.,* 208: 55-58, 1986.
18. **Dickson, T. B., Jr.,** and **Kichline, P. D.:** Functional management of stress fractures in female athletes using a pneumatic leg brace. *Am. J. Sports Med.,* 15: 86-89, 1987.
19. **Esterhai, J. L., Jr.; Brighton, C. T.; Heppenstall, R. B.; Alavi, A.;** and **Desai, A. G.:** Detection of synovial pseudarthrosis by ^{99m}Tc scintigraphy: application to treatment of traumatic nonunion with constant direct current. *Clin. Orthop.,* 161: 15-23, 1981.
20. **Friedenberg, Z. B.:** Fatigue fractures of the tibia. *Clin. Orthop.,* 76: 111-115, 1971.
21. **Green, N. E.; Rogers, R. A.;** and **Lipscomb, B.:** Nonunions of stress fractures of the tibia. *Am. J. Sports Med.,* 13: 171-176, 1985.
22. **O'Connor, B. T.:** Pulsed magnetic field therapy for tibial non-union [letter]. *Lancet,* 2: 171-172, 1984.
23. **Orava, S.; Karpakka, J.; Hulkko, A.; Vaananen, K.; Takala, T.; Kallinen, M.;** and **Alen, M.:** Diagnosis and treatment of stress fractures located at the mid-tibial shaft in athletes. *Internat. J. Sports Med.,* 12: 419-422, 1991.
24. **Parnell, E. J.,** and **Simonis, R. B.:** The effect of electrical stimulation in the treatment of non-union of the tibia. *J. Bone and Joint Surg.,* 73-B (Supplement 2): S178, 1991.
25. **Rettig, A. C.; Shelbourne, K. D.; McCarroll, J. R.; Bisesi, M.;** and **Watts, J.:** The natural history and treatment of delayed union stress fractures of the anterior cortex of the tibia. *Am. J. Sports Med.,* 16: 250-255, 1988.

26. **Rolf, C.; Ekenman, I.; Tornqvist, H.;** and **Gad, A.:** The anterior stress fracture of the tibia: an atrophic pseudoarthrosis? *Scandinavian J. Med. and Sci. Sports,* 7: 249-252, 1997.
27. **Scott, G.,** and **King, J. B.:** A prospective, double-blind trial of electrical capacitive coupling in the treatment of non-union of long bones. *J. Bone and Joint Surg.,* 76-A: 820-826, June 1994.
28. **Sharrard, W. J. W.:** A double-blind trial of pulsed electromagnetic fields for delayed union of tibial fractures. *J. Bone and Joint Surg.,* 72-B(3): 347-355, 1990.
29. **Stanitski, C. L.; McMaster, J. H.;** and **Scranton, P. E.:** On the nature of stress fractures. *Am. J. Sports Med.,* 6: 391-396, 1978.
30. **Swenson, E. J., Jr.; DeHaven, K. E.; Sebastianelli, W. J.; Hanks, G.; Kalenak, A.;** and **Lynch, J. M.:** The effect of a pneumatic leg brace on return to play in athletes with tibial stress fractures. *Am. J. Sports Med.,* 25: 322-328, 1997.
31. **Whitelaw, G. P.; Wetzler, M. J.; Levy, A. S.; Segal, D.;** and **Bissonnette, K.:** A pneumatic leg brace for the treatment of tibial stress fractures. *Clin. Orthop.,* 270: 301-305, 1991.