

The natural history and treatment of delayed union stress fractures of the anterior cortex of the tibia

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ABSTRACT

This study presents eight patients with stress fracture of the anterolateral cortex of the midshaft of the tibia. All of the patients, ranging in age from 14 to 23 years, were competitive basketball players who experienced pain while running or jumping for an average of 4.4 months before the diagnosis was made.

Eight patients were treated with rest and/or pulsing electromagnetic field therapy. Although one of the patients required bone grafting procedure, all eight of these patients showed complete healing and were able to return to full activity after an average of 8.7 months of treatment. They have remained asymptomatic for an average of 14.7 months. The overall time from initial symptoms to return to competition averaged 12.5 months in this group of athletes.

The results presented in this paper suggest that rest and pulsing electromagnetic field therapy may result in healing in some patients with delayed union stress fractures of the anterolateral cortex of the midshaft of the tibia. Although this injury is associated with a prolonged healing period, seven of eight patients with adequate followup in our study were able to return to competition without complications following treatment. One patient was asymptomatic for 33 months before experiencing a reinjury.

In conclusion, we feel that diagnosis of stress fracture should be a primary consideration in basketball players presenting with a prolonged history of pain on the anterolateral aspect of the midthird of the tibia. Once the diagnosis is made we recommend initial treatment consist of rest and external electrical stimulation for a

minimum time of 3 to 6 months prior to considering surgical intervention.

There have been numerous references in the literature concerning stress fractures of the tibia in athletes.^{4,8-14,16-19} Most of these have involved the posteromedial cortex of the tibia—the so-called posteromedial tibial stress syndrome. This study involves the much less frequently diagnosed fracture of the anterolateral cortex of the midshaft of the tibia. It has been shown by Brahm et al.⁵ that a nonunion of this area of the tibia can have severe consequences for a highly competitive athlete. Progression to a complete fracture is a most serious complication. In a recent study by Green et al.¹⁵ involving six patients with a delayed union of the anterolateral tibial cortex, five patients were observed to have progressed to complete fracture.

These studies point to an increasing awareness that a stress fracture of the anterior tibial cortex is a relatively difficult injury to treat. Even with immobilization and/or rest, it appears that fractures in this region may require a prolonged healing time.

Currently the use of electrical stimulation is being advocated by many as a means of treating delayed union fractures and has been used in over 60,000 patients. The use of a noninvasive system in which pulsed electromagnetic field (PEMF) is created across the fracture site has been shown to be effective in promoting healing of delayed union and nonunion tibial fractures.

This study was undertaken in order to provide more information regarding the natural history of the stress fracture of the anterior cortex of the tibia and its response to treatment using restriction of activities and in most cases pulsing electromagnetic field therapy.

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MATERIALS AND METHODS

Eight athletes are included in this study. In the period from January 1983 until June 1985, we observed five patients with delayed union stress fracture of the anterior cortex of the tibia at the Thomas A. Brady Sports Medicine Center in Indianapolis. The three other patients in this study were those of colleagues from various locations within the middle west. All eight patients (seven males, one female) are competitive basketball players.

It was recommended that all patients in this study undergo treatment with a noninvasive pulsing electromagnetic field system. Treatment with the PEMF system involved fitting the patient with electromagnetic coils either incorporated within a cast or placed directly on the skin at the level of the fracture. Each was instructed to use the unit 10 to 12 hours per day. Seven of the eight athletes complied with this treatment program.

The five patients initially seen at the Sports Medicine Center were instructed to limit their activity. This involved refraining from competition as well as abstaining from any activities which resulted in pain in the region of the fracture. All of these patients were seen and followed up at our clinic at various intervals.

Of the three patients not seen in our clinic, two were initially treated with limited activity and electrical stimulation. The third patient not seen in our clinic was placed on a regimen of vitamin supplements after an initial diagnosis of rickets. This treatment was continued for 8 months before the diagnosis of stress fracture was made following which he was treated with immobilization and electrical stimulation.

All of the patients in this study were radiographed at the time of initial presentation. In seven of the eight patients the diagnosis of stress fractures was based on radiologic evidence as well as clinical signs. A characteristic radiograph was noted in all cases best seen on a lateral view of the tibia. Characteristic appearance is that of a V or wedge-shaped defect in the mid-third of the anterior cortex of the tibia with or without hypertrophy of this cortex with the open end of the V being directed anteriorly. This radiographic finding is most characteristic of this condition. In a single patient whose condition was originally diagnosed as having rickets, a radionuclide bone scan was necessary before the diagnosis of stress fracture was established. Evidence for occurrence of healing was radiologic in all cases.

RESULTS

The eight patients in this series were all basketball players ranging in age from 14 to 23 years (Table 1). These patients experienced symptoms of pain with running and jumping activities for an average of 4.4 months (range, 4 weeks to 12 months) before seeking medical attention. Clinically, all had point tenderness over the anterolateral aspect of the midshaft of the tibia with a discrete fibrous mass noted in most cases.

One player was seen in our clinic with a history of pain

and tenderness over the anterior tibial cortex for 2 months during which time he continued to play basketball. Six weeks prior to presenting to us he felt a pop in his leg while playing in a tournament and sustained a complete fracture of the midshaft of the tibia. He was treated with a long leg cast. Radiographs 6 weeks after complete fracture showed early healing and he was placed in a tibial fracture brace and external stimulation was recommended. He did not comply with the use of the stimulator and has been lost to followup, although radiographs obtained from another hospital 7 months later revealed healing of the complete fracture but delayed union of the stress fracture (Fig. 1).

Of the seven athletes remaining all healed the fracture an average of 8.7 months after onset of treatment. The average time from onset of symptoms to complete return of symptom-free sports activities was 12.5 months, with a range of 10 to 19 months. The average follow-up time was 14.7 months, with a range of 4 to 30 months.

One NCAA Division I basketball player underwent a course of electrical stimulation and rest for 11 months followed by an attempted return to play. He noted recurrence of his symptoms and radiographs revealed persistence of the original fracture or a refracture in the same area. He was then treated with an excision and bone grafting procedure and continued electrical stimulation. He went on to solid union following this procedure and was out of competition for a total of 19 months, missing two full college basketball seasons. He returned to play in the National Basketball Association and was symptom-free for 30 months until he sustained a similar fracture at a different location in the anterior cortex of the ipsilateral tibia.

The remaining six basketball players were all treated with rest and/or immobilization plus PEMF therapy for an average duration of 7.5 months. These six athletes healed their fractures at an average time of 14 months after onset of symptoms and have remained asymptomatic for 14.5 months with competing at high school, collegiate, and professional levels.

CASE REPORTS

Case 1

In February 1984, a 19-year-old male college basketball player presented to the Sports Medicine Center complaining of increasing pain in his right tibial midshaft which occurred during basketball. He asserted that the pain has been present to some extent since April 1983, when he was struck with a helmet during spring football.

Upon physical examination he was observed to have a palpable enlargement with mild tenderness over the anterolateral region of the midshaft of the tibia. Radiologic examination revealed a stress fracture of the "saw tooth" type involving the anterior cortex of the tibia (Fig. 2A). The patient was placed on rest and fitted with a PEMF unit.

After 2 months of treatment, radiographs revealed increased but incomplete healing (Fig. 2B). The patient was instructed to avoid running and jumping activities but was

TABLE 1
Clinical data

Age	Sex	Symptoms to Diagnosis (months)	Treatment			Symptoms to activity (months)	Time symptom-free (months)
			Type	Duration (months)	Outcome		
19	M	10	PEMF	5	Healed	15	21
19	M	1	Rest	9	Healed	10	29
			PEMF				
			Rest				
14	M	12	Short leg cast	6	Healed	18	9
			PEMF				
19	M	1	Rest	11	Healed	12	17
			PEMF				
			Rest				
20	M	3	Short leg cast	16	Healed	19	30
			PEMF				
			Rest				
20	F	1	Short leg cast	8	Healed	15	4
			Bone grafting				
			PEMF				
18	M	2	Rest	Lost to followup			
			Long leg cast				
23	M	7	Fracture brace	6	Healed	13	7
			PEMF				
Average		4.4	Rest	8.7		12.7	14.7



A
Figure 1. Delayed union of stress fracture 7 months after healing of complete fracture.

allowed to return to weight lifting, bicycling, and swimming. The patient was seen again in July 1984, 14 months after onset of symptoms. At this time he was minimally symptomatic and was allowed to begin a jogging program with gradual return to full sports. Radiographs showed continued healing at this time (Fig. 2C). Final follow-up radiographs in March 1985, revealed solid union of the fracture and the patient has remained asymptomatic to this time.

Case 2

A 19-year-old male Division I basketball player presented with pain in his right tibia which persisted for approximately 1 month. He stated that the pain was most severe during jumping activities. Radiologic examination revealed a stress fracture of the anterior cortex of the tibia in the mid-third (Fig. 3A). Subsequently he was placed in a cast for 6 weeks and was instructed to withdraw from basketball for the remainder of the season.

After 6 months of treatment he improved significantly. He was nontender and radiographs showed early healing of the fracture (Fig. 3B). At this point the patient was allowed to return to scrimmage activity. During this period of return to activity the patient stated he felt close to 100% but still had some pain while warming up and performing lay-ups. One month later he was kicked in the right leg and experienced increasingly severe pain. Physical examination revealed increased tenderness over the anterior tibial cortex in the midshaft at the point of the previous injury. Radiographs revealed persistence of a stress fracture in this area (Fig. 3C).

At this point the patient was instructed to rest and was fitted with an electrical stimulation unit. After 3 months of treatment physical examination revealed minimal tender-

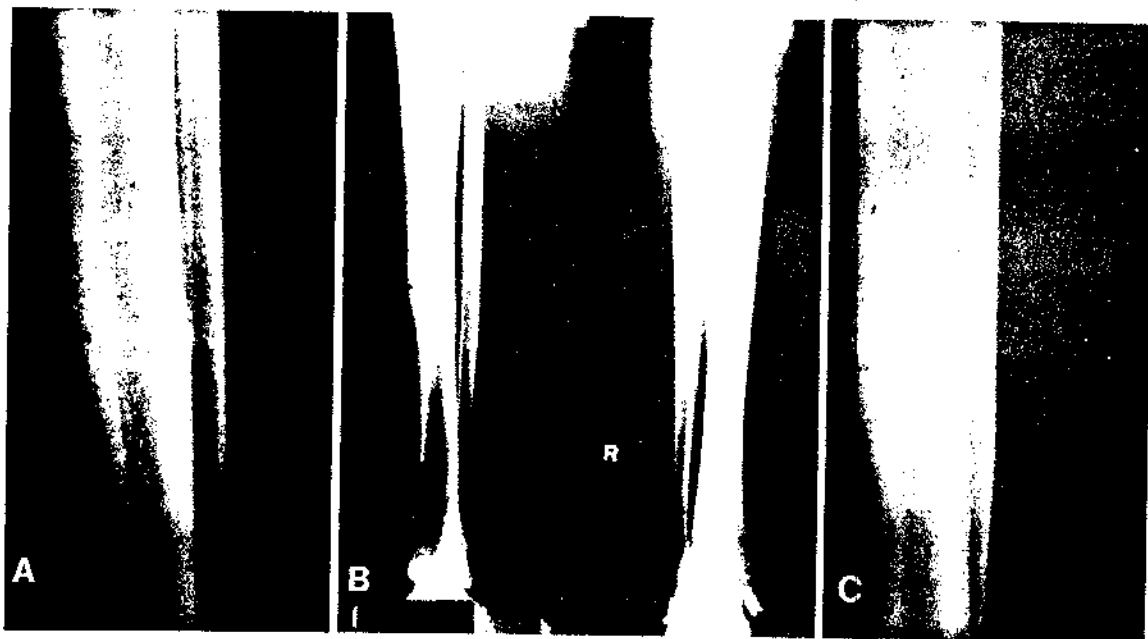


Figure 2. A, "saw tooth" stress fracture revealed at presentation. B, incomplete healing is observed after 2 months of PEMF treatment. C, continued healing is observed 12 months later.

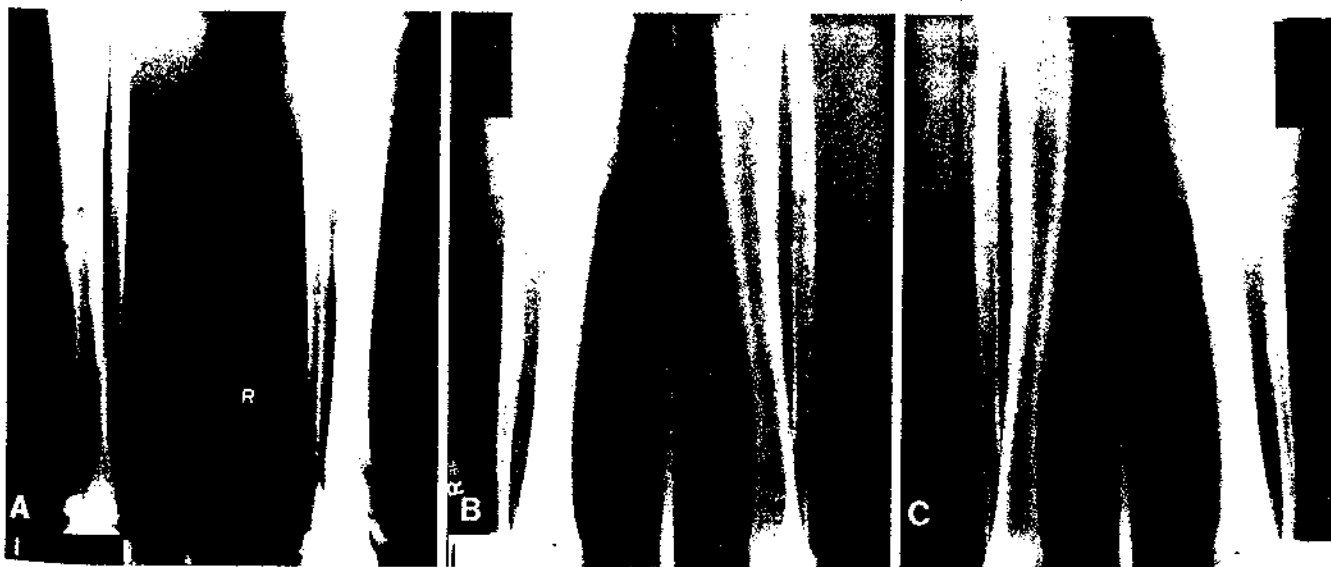


Figure 3. A, stress fracture upon presentation. B, early healing after 6 months of treatment. C, persistence of pain after reinjury revealed continued stress fracture.

ness at the fracture site and radiographs showed progressive healing. He was allowed to return to full activity at this point, which was 11 months following onset of his symptoms. He has remained symptom-free to the present time, encompassing a period of 29 months.

Case 3

The patient was a 14-year-old male basketball player who experienced pain over the anterior aspect of the right tibia

for approximately 12 months before presenting to our clinic. He presented because of pain during basketball and track. Additionally, he observed a palpable enlargement over the anterior aspect of the tibia.

Radiologic examination revealed a tension-type stress fracture of the anterior cortex of the tibial midshaft (Fig. 4A). The patient was treated with restriction of activities and started on electrical stimulation.

The patient was followed with radiographs over the next 6 months which gradually showed progressive healing (Fig.

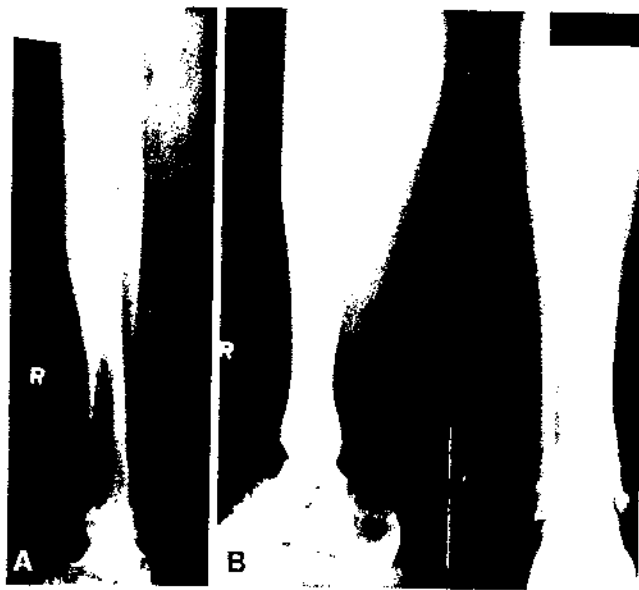


Figure 4. A, tension-type stress fracture in a 14-year-old male. B, 6 months after presentation progressive healing is observed.

4B). Six months following the initial visit the patient was nontender and asymptomatic and he was allowed to return to full activity. He returned to symptom-free activity 18 months following the onset of his symptoms. At the present time he has been symptom-free for 9 months.

DISCUSSION

Stress fractures of the tibia have appeared in the literature on numerous occasions; however, fractures of the anterior cortex of the tibia have only been discussed briefly in the literature.

Burrows³ originally described this fracture in ballet dancers in 1956. In his series, four of five dancers returned to activity at an average of 15 months following diagnosis. The fifth sustained a comminuted fracture of the midtibia 2 weeks after onset of symptoms. This fracture healed after 14 months with 8 months in a long leg cast. Three of these patients underwent biopsy of the lesion which showed dense cortical bone with some evidence of granulation tissue.

Friedenberg,¹³ in 1971, reported two cases of anterior tibial cortex fracture, one of which healed after 5 years, the second of which remained symptomatic. Biopsies in both cases revealed granulation tissue and dense bone devoid of osteocytic nuclei and no evidence of healing.

Stanitski et al.,¹⁸ in 1978, reported a case of bilateral anterior tibial cortex stress fractures in a college basketball player. Biopsy revealed thick fibrous vascular periosteum with subperiosteal new bone formation. Despite rest periods and casting this athlete continued to be symptomatic at the time of publication.

Brahms et al.,⁵ in 1980, presented a case report of a stress fracture of the anterior tibial cortex in a professional run-

ning back which was diagnosed but was asymptomatic. He played three and one-half seasons of professional football before he spontaneously sustained a complete fracture through the stress fracture area with no history of contact. The fracture was treated with reduction and casting and the athlete never returned to his sport. The author pointed out that this type of fracture occurs on the tension side of the bone and that for this reason it is more likely to fracture completely.

Green et al.,¹⁵ in 1985, discussed six cases of nonunion stress fractures of the anterior tibial cortex in athletes. Five of these athletes went on to sustain complete fractures and bone grafting was performed in three patients at an average of 11 months following completion of the fracture. Five of the six athletes were treated with casting for an average of 6 months. The fractures treated with bone grafting united within 5 months following surgery. The author's recommendation for such fractures is an initial period of immobilization and if no evidence of union is present at 4 to 6 months, excision and bone grafting should be considered. In addition, they recommend that no athlete be allowed to return to competition until complete radiographic union of the fracture has been achieved and the athlete should be cautioned in all cases that a risk for complete fracture is still present.

In this study eight athletes, all basketball players, developed stress fracture of the anterior tibial cortex in the midshaft. Of the seven with adequate followup an average of 4.4 months elapsed between time of onset of symptoms to diagnosis and an average of 12.7 months existed between the onset of symptoms to return to full symptom free activity. The average treatment time was 8.7 months. Six of the athletes in this study have returned to basketball on a competitive level without problems following nonoperative treatment.

The appearance of the fracture on radiograph and the fact that it involves the anterior cortex points to the fact that this is most likely a failure of the bone in tension rather than compression. It may be that individuals are predisposed to this type of injury due to increased anterior bowing of the tibia.

The etiology of stress fractures is multifactorial. The fracture onset is a function of the amount and duration of stress occurring in a bone in concert with the degree of reparative ability of that bone. The fracture can be portrayed as a continuum of the interplay between force and repetition.

Traditionally, one concept of stress fracture was that fracture failure within a bone is preceded by fatigue within surrounding muscles thus allowing excessive forces to be transmitted to the underlying bone. The second theory advocated by Stanitski et al.¹⁸ is that concentrated muscle forces acting across a specific bone enhance the loading which occurs simply from direct weightbearing. The rhythmic repetitive muscle action that causes subthreshold mechanical insults summates beyond the stress bearing capacity of bone, and fracture ensues. The anterior cortex fractures of the tibia may result from forces caused by the

large posterior muscle groups causing increased tension across the anterior cortex of the tibia.

Once diagnosed there are two significant complications of stress fractures of the anterior tibial cortex: delayed union and complete fracture. Delayed union is a common complication as evidenced by the above literature review and the cases in this series. The relative hypovascularity of the anterior tibial cortex due to its subcutaneous location may be a factor mitigating toward this complication.

Stress fractures occurring on the tension side of a bone are more at risk to go on to complete fracture than those occurring on the compression side. According to Frankel¹⁸ the compression side stress fracture is a much slower process in which repair mechanisms are more easily mobilized, thus preventing complete fracture.

Electrical stimulation using the PEMF system has been shown to be of benefit in effecting healing in delayed or nonunion fractures of the tibia.^{1-3,5,7} In our series the combination of rest and restriction of activities with or without the use of external electrical stimulation has resulted in union in seven of eight cases without surgical intervention and the patients are performing at highly competitive levels.

In conclusion, we would like to emphasize that stress fractures of the anterior tibial cortex should be considered in any athlete who presents with pain and tenderness over the anterior aspect of the midshaft of the tibia. We certainly agree with other authors that these stress fractures require prolonged healing time. We recommend that initial treatment of this type of stress fracture consist of rest and electrical stimulation for a minimum of 3 to 6 months before considering surgical intervention.

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