ROLE OF ULTRASOUND THERAPY IN THE TREATMENT OF STRESS FRACTURES

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ABSTRACT

Repetitive stress of exercise when exceeds bone's ability to remodel itself, leads to stress fractures. Stress fractures are the leading cause of morbidity amongst recruits during training and account for the maximum number of lost manpower days during training. Basic treatment for stress fractures is rest from aggravating activities for 4 to 8 weeks. Ultrasound has been reported to speed up healing of stress fractures, though it has not yet definitively been proven effective in the treatment of stress fractures. A study has been carried out to find out the efficacy of Ultrasound therapy (UST) in the treatment of stress fractures. A total of 75 cases of stress fractures, positive on radiograph, were studied. Of these 32 cases comprised the control group and underwent conventional therapy while 45 cases were treated with UST as out-door patients. Mean duration of treatment in conventional therapy including sick leave was 75.3 days and mean hospitalization period was 37.28 days. Mean duration of treatment with UST was 15.05 days. Results of the study prove that UST speeds up healing of stress fractures and drastically reduces the time required to return to training, thus saving the lost number of manpower days.

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KEY WORDS: Stress fractures; Ultrasound therapy.

Introduction

Stress fractures or fatigue fractures are a form of overuse injury. They result from sustained microtrauma to the bone that exceeds its ability to remodel. During running the load that lower extremity encounters has been reported to range from three times body weight to eight times body weight with each stride and it takes more than 1500 strides just to cover a mile. The surface may absorb some load and the sole of the shoe absorbs some of the reactive force. However, lower extremity must absorb most of the ground reactive force. A significant load is probably absorbed by the bones and joint surfaces of the ankle, knee and hip. The muscles of the lower extremity however are most important in the dissipation of the resultant ground reactive force. When muscles fatigue and become unable to absorb added shock, stress overload is transferred to bones, resulting in microfractures.

Stress fractures are common injuries among athletes especially when participants increase their training frequency, duration or intensity or abruptly change their activity. Another important group in which stress fractures are seen is military recruits. In fact stress fractures were first described in the medical literature as march fractures by Briethaupt in 1855 who found them in the metatarsals of Prussian Army recruits [1].

Stress fractures seem to be a very innocuous condition, as most stress fractures are relatively straightforward

management problems, surrendering quietly with rest and correction of training errors. However, stress fractures are the leading cause for morbidity amongst recruits during training and during 1996-98 were found to be the leading cause for hospital admission and over the same period were also the single most important cause for the lost number of manpower days during training amongst recruits at Artillery Centre, Hyderabad. A direct and most important fallout of this is the increased cost of training. Cases of stress fractures per thousand during the corresponding period is shown in Fig-1.

Basic treatment for patients who have uncomplicated stress fractures is rest from aggravating activity for 4 to 8 weeks. Recent evidence has provided support for the use of ultrasound therapy in the treatment of stress fractures [2,3]. This modality however, has not yet been definitively proven effective in athletes who have stress fractures. Aim of this study was to evaluate the efficacy of UST in the treatment of stress fractures and the results have been very encouraging.

Material and Methods

The range of high frequency sound beyond the normal human audible range of 20,000 hertz is known as ultrasound. Therapeutic ultrasound uses these high frequency sound waves to produce mechanical and thermal effect in tissues. Clinical ultrasound has a frequency of 1 to 3 megahertz.

In the present study 75 cases of stress fractures from amongst the recruits undergoing training at Artillery Centre Hyderabad were studied during Nov 98 to May 99. control group comprised

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STRESS FRACTURES PER THOUSAND 1996-98

Fig. 1: A bar diagram showing the cases of stress fractures per thousand recruits during 1996-98. The absolute number of cases in the three years varied, as did the recruit intake.

of 32 cases who were admitted at random to the hospital and underwent conventional therapy mainly comprising rest in the hospital and NSAID's to control pain and further rest from aggravating activities by sending the patients on sick leave and review thereafter in the hospital after expiry of sick leave. The experimental group comprised of 43 patients. They were treated as outpatients in the Sports Medicine Centre at Artillery Centre, Hyderabad. Pulsed ultrasound of 1 watt/sq.cm was given daily for 5 minutes till they fulfilled the criteria given below. Pain control was achieved through Paracetamol and icing. NSAID were avoided as they may slow healing response [3]. Aggravating activities like running, jumping, drill etc. were stopped during the course of the treatment, while they were allowed to attend their other classes.

Ideally control group should have been administered similar schedule of sham insonation treatment and kept in Artillery Centre under conditions similar to those of the experimental group. However, stress fractures with continued activity, in the absence of any treatment can progress to complete fractures. Because of this risk to the patients, subjects out of the same population group undergoing conventional therapy in service hospital during the same period were treated as controls. Duration of treatment in conventional therapy is similar to the current recommendation of rest from aggravating activities for 4-8 weeks.

Cases were selected based on clinical history, physical examination and positive radiographic findings. Clinical tests used were - (1) *Fulcrum test* for femur it is performed by having the athlete sit on a table with the lower leg hanging off the edge of the table. Examiner's forearm is placed under the affected thigh and free hand is placed on the athlete's knee and downward pressure is applied. For tibia-examiner uses his own knee as a fulcrum to spring the tibia. A positive test produces pain, usually sharp and possibly apprehension. (2) *Percussion sign*-On percussion of the bone at a distance, there will be transmission of pain to the fracture area. (3) *Tuning fork test*-sliding a vibrating tuning fork along the skin should severely exacerbate the pain at the site of stress fracture.

Plain radiographs are highly specific for diagnosis of stress fractures, but have poor sensitivity. Most of the patients who have stress fractures will not have findings on radiographs for the first 2-3 weeks and at times radiographs may be negative till as late as 3 months after the onset of symptoms. Occasionally radiographic

changes may not appear at all. When applicable, antero-posterior (AP), lateral and oblique views must be taken to achieve tangential visualisation because often only single cortex is involved. Also the present emphasis on radiographic findings needs to be reduced as far as diagnosis and initiation of treatment of stress fractures is concerned. Diagnosis of stress fractures should be primarily clinical as stress fractures in the absence of any treatment can progress to complete fractures. However, for the purpose of the study, only cases with positive radiographic findings, i.e. grade III stress fractures, were taken. Classification of stress fractures is given in Table 1. This was done so as to include only confirmed cases of stress fractures in the study and to exclude other causes of leg pain like medial tibial stress syndrome (MTSS) or shin splints, stress reactions, tendinitis and rarely infection and neoplasms. Other imaging techniques like bone scans, which are the 'Gold Standard' diagnostic test for stress fractures with sensitivity approaching 100%, though specificity is poor, and CT scans and MRI were not available for use. Also they are not cost effective in the routine management of stress fractures due to their prohibitive cost.

TABLE 1

Classification of Stress fractures

Grade	Criteria
0	Normal bone with equal osteoblastic and osteoclastic activity
I	Asymptomatic stress reaction. Not visualised on plain films but bone scans are positive
II	Associated with pain. Plain films still negative
III	Associated with significant pain and are positive on both plain films and bone scans

The assessment of healing is a clinical judgement. Both radiographs and bone scans are poor at predicting the degree of healing or the timing of healing. Bone scans can stay positive for up to one year or more and consequently should not be used to monitor healing [4,5]. Consolidation of the fracture site radiologically carries on till much after the clinical healing is over. Patients in the experimental group were allowed to resume training on fulfilling the following criteria's, which have been adapted according to our requirement and facilities available [2].

- pain free during activities of daily living
- no local tenderness on palpation or percussion
- no warmth in the localised region
- a negative fulcrum test
- one leg hop performed without pain and with adequate balance.

On return to training, patients were followed for upto one month for any evidence of recurrence of pain at the stress fracture site, because repaired tissue is most vulnerable to re-injury in the first four weeks after re-introducing activity.

Observation and Results

All the 75 patients were recruits in the age group of 17 to 21 years undergoing training at Artillery Centre, Hyderabad. All the stress fractures encountered were in the lower extremity. Site wise distribution is given in Table 2. One patient's radiograph in the experimental group showed the 'dreaded black line' at the anterior cortex of the Tibia in the middle one-third which demonstrates non-union and suggests bony resorption. These stress fractures are at high risk for progression to complete fractures, delayed or non-union. Because of this risk, aggressive management is advocated in these cases. Current recommendation being non-weight bearing

cast for 3-6 months or early surgery in the form of intramedullary rod insertion which enables return to training in 6-8 weeks [2,5,6].

TABLE 2

Site wise distribution of stress fractures

Site	No. of cases	
	Controgroup	Experimentagroup
Tibia	23 (71.9%)	39 (90.7%)
Fibula	6 (18.7%)	1 (2.3%)
Femur	1 (3.1%)	3 (7.0%)
Tibia and fibula both	2 (6.3%)	Nil

In the experimental group, four patients (9.3%) failed to show significant improvement after UST ranging over 9 to 15 days and hence were admitted to the hospital to ensure complete rest. Of these one patient, unlike in stress fractures, had oedema over the entire affected leg. Case was discussed with the medical and surgical specialist and superadded pathology could not be ruled out. The number of failure cases in control group was 3 (9.4%). These patients continued to be symptomatic even at the end of sick leave. Two of them were downgraded to cat CEE (T) for 3 months while the third patient was excused physical training for further one month.

In the experimental group, four cases (9.3%) had recurrence of symptoms after resumption of training. Of these two were again treated with UST after which they were able to return to training successfully while the other two were admitted to the hospital as one of them was unwilling to undergo further treatment as outpatient and one had developed symptoms severe enough to make even walking difficult. Recurrence in control group was in 1 case (3.1%). Success rate in control group was 87.5% (28 cases) while in the experimental group it was 81.4% (35 cases).

The mean duration of treatment including the sick leave period in successfully treated cases in the control group was 75.3 days. Mean duration of hospitalization in control group was 37.28 days. Mean duration of treatment with UST in successfully treated cases in experimental group including the one which demonstrated 'dreaded black line', was 15.05 days. The range of duration was 9 to 25 days. The patient requiring 25 days of UST had extensive callus formation spread over 7 cm on initial presentation. The duration of UST in different successfully treated cases is shown in Table 3.

TABLE 3

Frequency table for no. of days of treatment with UST in different cases

No. of days of UST applied	No. of cases
9-11	8
12 - 14	12
15 - 17	6
18 - 20	4
21 - 23	4
24 - 26	1
Total	35

The 't' test was applied to test the difference between the means of duration of UST and the total treatment period in conventional therapy as well as between the means of UST and hospi-

talization period in conventional therapy. The two group variances are unequal so modified 't' test was applied for testing the two means. For means between the duration of UST and total treatment period in conventional therapy 't' value was 29.457, $p < 0.001$ i.e. significant at 0.1% level. Even in comparison of the mean of UST therapy and hospitalization period, 't' value was 9.457, $p < 0.001$ i.e. significant at 0.1% level. So UST is responsible for speeding up healing of stress fractures and cutting down the time required to return back to training.

Discussion

Ultrasound has been used for more than 50 years to relieve pain and inflammation, promote tissue healing, reduce muscle spasms and increase range of motion. It is frequently used to treat tendinitis, bursitis, joint sprains and muscle strains.

Though of late, additional evidence has provided support for the use of ultrasound in the treatment of stress fractures, no studies could be come across on use of UST in the treatment of stress fractures to compare the results of the present study. However, a study by Dr RB Heppenstall, Professor of Orthopaedics at the University of Pennsylvania USA has reported util-

Fig. 2 : A radiograph of a patient showing a 'dreaded black line' at anterior cortex of the middle third of tibia. This demonstrates non-union and suggests bony resorption. These patients are at high risk for progression to complete fractures, delayed or non-union.

Fig. 3 : Radiograph of the same patient as shown in Fig. 2 after 8 days of ultrasound therapy, shows obliteration of the 'dreaded black line'. This also corresponded with the clinical healing of the stress fracture.

ity of ultrasound in speeding up healing of bone fractures [7]. In his study more than 80% of patients with fractured bones that had failed to fuse benefited from the therapy. Ultrasound helps bones heal by stimulating conversion of cartilage to bone. Apparently it stimulates osteoblastic activity. Repeat radiograph of

the patient showing the 'dreaded black line', after 8 days of UST showed disappearance of this line (Fig-2 and 3). Similarly, another patient's radiograph showing a fracture line on the initial radiograph, in the repeat radiograph after 13 days of UST showed disappearance of the fracture line. These radiographic findings also correlated with clinical healing of stress fractures. Histological studies at various stages of UST may be helpful in revealing the changes at cellular level and improve our understanding of how ultrasound helps in healing of stress fractures.

To conclude, ultrasound is an extremely safe, non-invasive modality that can greatly benefit patients with stress fractures and cut down cost of training by cutting down the lost number of manpower days by facilitating early return to training.

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