Role of Ultrasound Therapy in the Healing of Tibial Stress Fractures

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Abstract

Background: Stress fracture is the single most common cause for the lost number of manpower days during training. The conventional treatment options begin with rest and cessation of precipitating activity. However the demands of military training provide little tolerance for prolonged periods of rest. In the recent past ultrasound therapy (UST) has been reported to speed up healing of stress fractures.

Methods: In the present study, a total of 67 cases of stress fracture were studied for the effect of ultrasound therapy on healing time. Study protocol used was double blind placebo controlled.

Result: Study results showed that the mean number of days of incapacitation was 25.46 days in the ultrasound treatment group as compared to 39.92 in the placebo group, a difference of 14 days, which was statistically highly significant.

Conclusion: The results of the study convincingly prove that ultrasound treatment is effective in cases of stress fracture.

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Key Words: Stress fracture; Ultrasound therapy

Introduction

Stress fractures or fatigue fractures are a form of overuse injury of the bone. They result from repetitive sub-threshold loading that exceeds the bone's intrinsic ability to repair itself. Stress fracture is commonly seen in athletes especially when participants increase their training frequency, duration, 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 the Prussian Army recruits [1].

Stress fractures are one of the commonest cause for the lost number of manpower days during recruit training [2]. Specific sites of stress fractures are the neck of the femur, anterior cortex of the middle third of the tibia, medial malleolus, talus, tarsal navicular and fifth metatarsal. Tibial stress fracture which occurs in the anterior cortex of the midshaft is prone to non-union and progression to complete fracture. They are not identified until late in the course of the injury when a defect (commonly known as the "dreaded black line") can be seen on plain radiographs.

Ultrasound therapy (UST) has been used to relieve pain and inflammation, promote tissue healing, reduce muscle spasm and increase range of motion. Of late,

results of various studies have suggested that UST promotes healing in stress fractures too. Although the mechanism by which ultrasound accelerates bone healing is uncertain, experts believe that ultrasound waves stimulate bone tissue to regenerate by causing small, controlled stresses in the bone cells, which increases blood flow in the area and mobilizes calcium. The present study, using double blind placebo controlled protocol, has studied the effectiveness of UST in promoting healing in stress fractures in military recruits.

Material and Methods

For the present study, conventional ultrasound therapy machine using a frequency of 3 megahertz, power of 1 W/cm². pulsed mode with a duty cycle of 50% for 10 minutes was used. A total of 67 patients admitted to MH Kirkee with stress fractures of tibia were studied.

Protocol used was double blind, placebo controlled. The subjects were randomly assigned to the ultrasound or placebo treatment groups by chit method. They all received daily ultrasound stimulation treatment for ten minutes applied to the affected bone with a functioning or non-functioning unit identical in appearance. The patients who were administered the ultrasound, as well as the study's researchers were blinded as to which patients were being treated with the active or non-active unit. Patients in both groups were matched in terms of age, height, demographics, and delay from symptom onset to diagnosis. There was no significant difference in ultrasound compliance between the active treatment and

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placebo groups. Pain control was achieved through paracetamol and icing. Other NSAIDs were avoided as they may slow healing response [3]. Cases were selected primarily based on clinical diagnosis. History, including training history was taken. In addition to local examination for tenderness, swelling and erythema, clinical tests like fulcrum test, one leg hop test and percussion sign were carried out. Radiographs were taken to classify cases into various grades. Classification of stress fractures is given in Table 1 [4].

Assessment of healing is a clinical judgment. The radiographs and bone scans are poor at predicting the degree of healing or the timing of healing. Bone scans can remain positive for up to one year or more and consequently should not be used to monitor healing [5, 6]. Consolidation of the fracture site radiologically continues even after the clinical healing is over. Patients were declared fit for discharge on fulfilling the following criteria; pain free during activities of daily living; no local tenderness on palpation or percussion; no warmth in the localised region; a negative fulcrum test and a one leg hop test performed without pain and adequate balance. On return to training, patients were followed up to one month for any evidence of recurrence of pain at the stress fracture site.

Table 1**Classification of stress fractures [4]**

Grade	Criteria
0	Normal bone with equal osteoblastic and osteoclastic activity. Both plain films and bone scans are negative
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

Table 2**Distribution of grades of stress fractures in relation to treatment arms**

Management	Grade of stress fracture		Total
	2	3	
Ultrasound treatment	25	14	39
Row %	64.1	35.9	100.0
Placebo	17	11	28
Row %	60.7	39.3	100.0
Total	42	25	67
Row %	62.7	37.3	100.0

Statistical tests	Chi-square 2 tailed p
Chi square – uncorrected	0.0800 0.7773035808
Chi square – Mantel-Haenszel	0.0788 0.7789282185
Chi square – corrected (Yates)	0.0007 0.9786554393

Table 3**Mean number of days of incapacitation in the two groups along with range, percentiles and modes**

Management	Mean	Standard deviation	Minimum	25 %	Median	75 %	Maximum	Mode
Ultrasound treatment	25.4615	3.8447	19.0000	23.0000	25.0000	29.00000	34.0000	21.0000
Placebo	39.9286	5.3605	33.0000	36.0000	39.0000	43.0000	55.0000	39.0000

T Statistics (two sample) = 12.8752; p value < 0.001

Results

Out of the 39 subjects in the ultrasound treatment arm 25 (64.1%) had grade 2 stress fracture and 14 (35.9%) had grade 3 stress fracture; the corresponding figures for the 28 subjects in the placebo group were 17 (60.7%) and 11 (39.3%) (Table 2). The difference in the grades of stress fracture in the two arms was not significant ($p > 0.05$). Table 3 shows that the mean number of days of incapacitation was 25.46 days in the ultrasound treatment group as compared to 39.92 in the placebo group, which was statistically significant.

Discussion

Conventional management for treating uncomplicated stress fractures is divided into four phases. Phase I is based on 'RICE' principal i.e. rest, ice, compression and elevation. As a general guideline, running is ceased for three to six weeks in fibular stress fractures and for four to ten weeks in tibial stress fracture. To avoid deconditioning, 'active rest' is given, where patient continues to do activities that do not cause pain. Fitness is maintained by participation in non or reduced weight bearing activities such as stationary cycling, swimming and deep water running in a pool. Phase II starts when there is no pain at rest. Focus is on stretching all muscle groups surrounding the injury. Phase III focuses on strengthening exercises for all lower leg muscle groups and Phase IV stresses on functional training where job/sports specific training programs are carried out.

Other measures include ultrasound therapy, nutritional augmentation with calcium, correction of biomechanical abnormalities using orthotics and correction of training errors. Evidence over the past few years has provided support for the use of ultrasound therapy in the treatment of stress fractures [3,4]. Because of the mechanical pressure that ultrasound waves deliver to the stress fracture site, some authors have even studied its role in the diagnosis of stress fractures. Romani et al [7], carried out a study to determine whether 1 MHz of continuous ultrasound can identify tibial stress fractures in subjects. They concluded that using visual analog scores is not sensitive for identifying subjects with tibial stress fractures.

Brand et al [8], evaluated the efficacy of daily pulsed low intensity ultrasound (LIUS) with early return to activities for the treatment of lower extremity stress fractures. They concluded that daily pulsed LIUS was effective in pain relief and early return to vigorous

activity. Jensen et al [9], used specifically programmed LIUS device to study its effectiveness in shortening the time of healing in stress fractures in a well known gymnast with an Olympic deadline. At three weeks, the stress fracture responded well and the patient was allowed use of tumble track, trampoline and to do some weight bearing activities, such as jumping in the pool and loading type activities. At four to five weeks, the patient progressed to full workout activities and participated in a trial meet for the Olympics. At six weeks, the patient participated in the women's gymnastic team event and was a factor in the United States receiving a gold medal.

In addition to stress fractures, a large number of studies have also been done to study the effectiveness of ultrasound therapy on time to fracture healing. Recent work has shown that the effect of therapeutic ultrasound therapy on healing bone is dictated by the intensity used. A high-intensity continuous-wave ultrasound signal appears to be harmful, while low-intensity pulsed ultrasound signal promotes healing [10]. Jason W Busse et al [10] in a meta analysis of 138 studies showed that time to fracture healing was significantly shorter in the groups receiving low-intensity ultrasound therapy than in the control groups. The weighted average effect size was 6.41 (95% CI 1.01 – 11.81), which converts to a mean difference in healing time of 64 days between the treatment and control groups.

Rue et al [11], in their study of 26 midshipmen with tibial stress fractures, using 20 minute daily pulsed ultrasound or placebo treatment, did not find any significant reduction in healing time with pulsed ultrasound. The main reason for this difference in the outcome of the various studies seems to be the difference in the various treatment parameters chosen. In the pulsed mode there can be a variation in the duty cycle. Two other important factors that need to be considered are the 'effective radiating area' (ERA) and the 'beam nonuniformity ratio' (BNR). These address the output characteristics of the crystal and can affect treatment parameters. The ERA describes the surface area of the crystal that is emitting significant mechanical energy and is always smaller than the actual size of the crystal. Transducers whose ERAs are close to the actual size of the transducer are generally better quality crystals and provide a more consistent treatment.

The BNR is another measure of the consistency and quality of the crystal. Ultrasound energy is not consistent as it is emitted from the sound head. The meter displays the average intensity delivered (watts/cm²), but there

may be regions that are delivering much higher intensities in the beam. The BNR is the ratio of the highest intensity found in the ultrasound beam compared to the average intensity indicated on the power meter. The lower the BNR, the better, although a BNR of 6:1 is generally considered to be acceptable.

All cases in the present study were of tibial stress fractures. Further studies are required for UST of stress fractures of other sites which are embedded deep within the muscles such as fibula, neck femur, and shaft femur.

Conflicts of Interest

None identified

Intellectual Contribution of Authors

Study Concept : Lt Col YK Yadav

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