ORIGINAL ARTICLE

VALIDATION OF TUNING FORK TEST IN STRESS FRACTURES AND ITS COMPARISON WITH RADIONUCLIDE BONE SCAN

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Background: Stress fractures are quite common both in athletes and military recruits. The purpose of the study was to evaluate the efficacy of tuning fork in stress fractures by comparing it with three phase bone scan. **Methods:** The current study examined 55 subjects whose age ranged 18–28 years. X-rays of all the subjects were unremarkable. After history and clinical examination tuning fork test (TFT) was performed on each case by placing 128 Hertz vibrating tuning fork on the site of pain (underlying bony surface) of tibia or fibula. Each case was scanned using triple phase bone scintigraphy. **Results:** Fifty-five patients had a total of 67 stress fractures, out of which 53 were picked up by TFT. Sensitivity of TFT was found to be 79% and specificity of 63%. Positive and negative predictive values were 88% and 46% respectively. **Conclusion:** Tuning fork test is a simple and easy approach of diagnosing stress fractures which can be performed even by athletics and military trainers. Management should be initiated in patients who have history of stress related below-knee pain and positive tuning fork test without waiting for bone scintigraphy. For complicated cases the bone scan is the gold standard for diagnosis.

Keywords: stress fracture, bone scan, tuning fork test

INTRODUCTION

Stress fractures are overuse injuries of bone. Bone is an adaptable tissue capable of repair, regeneration, and remodelling in response to environmental signals. Bones are exposed to both load and deformation with weight bearing exercise.[1] Wolff law states that bone develops the structure most suited to resist the forces acting upon it. A physiological threshold appears to exist, below which micro damage is not detectable. Increased osteoclastic activity at sites of bone stress or strain may cause transient weakening of the bone locally, predisposing the area to micro-damage. Otter *et al* proposed that the perfusion and reperfusion of bone after a repetitive load causes a temporary oxygen debt to the area of bone being stressed.[2] This ischemia, in turn, facilitates bone remodelling and subsequent bone weakness and stress fracture. The temporary lack of oxygen is not the only cause of ischemia. Repeated pressure to the capillaries is also believed to cause micro-damage to the vessels. As neutrophils respond to plug the damaged capillaries, the blood flow through the vessels is further restricted.[3] Small leaks in the vessels allow fluid flow into the surrounding tissue, thereby further restricting the perfusion of oxygen into the cells. This leaking increases with subsequent bouts of loading, worsening ischemia and triggering a further increase in remodelling. The repetition of this cycle causes an increase in remodelling; a breakdown in the cortex, a weakening of the bone, and potentially a stress fracture. The most salient historical feature in the diagnosis of stress fracture is the insidious onset of activity-related pain. Early on, the pain typically is mild and occurs toward the end of the inciting activity. Subsequently, the pain may worsen and may occur earlier, limiting participation in activities. Upon physical examination, inspection of the site may reveal localised swelling and, possibly, erythema over the area of tenderness. A palpable bump may indicate periosteal reaction. Patients will often have an antalgic gait. Individuals with stress fractures typically report pain upon palpation or percussion of the affected area. Many clinical tests are used in the diagnosis of stress fractures like Percussion, Compression, Grinding test, Hop test, Fulcrum test and Tuning-fork test. Imaging modalities include plain radiography, CT scan, MRI and bone scintigraphy. Radiographic changes might not be evident for at least 2–3 weeks after the onset of the patient's symptoms. Proper management of stress fractures is critical for trainers. The foundation of treatment for symptomatic stress injury is activity modification.

The objective of the study was to evaluate the efficacy of tuning fork in stress fractures by comparing it with three phase bone scan.

MATERIAL AND METHODS

This study was carried out at Nuclear Medical Centre (NMC) Armed Force institute of Pathology AFIP, Rawalpindi and Institute of Nuclear Medicine, Oncology and Radiotherapy (INOR), Abbottabad. The study population comprised of a total of 55 subjects ranging in age from 18–28 years complaining of gradual onset of below-knee activity related pain and/or swelling and limping. Stress fracture was suspected after excluding bone trauma. X-rays of all these patients were unremarkable. Out of 55 subjects, 30 had history of bilateral leg pain (they provided a total of 61 sites of pain for evaluation of stress fractures by tuning fork test and bone scan), and 25 subjects had history of unilateral leg pain (they provided 25 sites for evaluation of stress fractures). Thus these 55 subjects had a total of 86 sites with history of activity related pain, so these 55 subjects were considered as 86 cases in this study.

The cases were divided according to relationship of pain with activity into three groups, Group A: Pain occurring at rest, Group B: Pain occurring at initial phase of running (can travel a distance of 1 mile), and Group C: Pain occurring at the end of running (can travel a distance of 5 miles). Tuning fork test was performed on each case by placing 128 Hertz vibrating tuning fork on the site of pain (underlying bony surface) of Tibia/Fibula. Subjective feeling of pain or exacerbation of pain was taken as positive for stress fracture. After tuning fork test, Triple phase planar imaging was performed on each case. The scans were reported as positive or negative on the basis of radiotracer concentration at suspected stress fracture site. The lesions were further categorised into four grades of stress fracture according to dimension, bone extension, and tracer concentration in the lesions.

RESULTS

Out of 86 cases, 28 had pain even on rest, 34 had pain at initial phase of activity and 24 cases had pain at the end of activity. On triple phase bone scan 21 cases in group A, 30 cases in group B and 16 cases in group C had stress fractures on bone scan. Whereas, 20 cases in group A, 22 cases in Group B and finally 11 cases in group C had positive tuning fork test. This revealed that frequency of lesion detection by tuning fork test is directly related to the severity of pain (Table-1).

Tibial shaft was divided into three parts, i.e., upper, middle and lower thirds. The bone scan showed that out of total of 61 tibial stress fractures, 39% were located in upper third, 54% in middle third and 7% were located in lower thirds. The comparison of tuning fork test and bone scan with respect to site of lesions showed that 16 out of 24 stress fractures diagnosed on bone scan had positive tuning fork test in upper third. Twenty-nine out of 33 stress fractures had positive tuning fork test in middle third. Finally 2 out of 4 stress fractures located in lower thirds had positive tuning fork test. The stress fractures in fibular shaft, lateral and medial malleolus were all diagnosed on tuning fork test (Table-2).

Out of 67 cases with lesions, 62 had positive bone scan for tibia and/or fibular shaft stress fractures. Out of these 62 cases, 12 cases had grade I stress fracture, out of which 6 (50%) had positive tuning fork test. Twenty-nine cases had grade II stress fracture, out of which 22 (76%) had positive tuning fork test. Eighteen cases had grade III stress fracture, out of which 17 (94%) had positive tuning fork test. Similarly 3 cases had grade IV stress fracture, all of which had positive tuning fork test. The higher the grade of stress fracture (tibia/fibula), more was the sensitivity of tuning fork test (Table-3).

Table-1: Relationship between severity of pain, bone scan, and tuning fork test

	Group A	Group B	Group C
Total cases	28	34	24
Bone scan	21	30	16
Tuning fork test	20	22	11

Table-2: Relationship between tuning fork test and bone scan findings with respect to site

	Bone scan	Tuning fork test
Upper ⅓	24	16
Middle ⅓	33	29
Lower ⅓	4	2
Fibula	1	1
Lateral Malleolus	2	2
Middle Malleolus	3	3

Table-3: Sensitivity of tuning fork test with respect to grade of stress fractures

	Grade I	Grade II	Grade III	Grade IV
Bone scan (n)	12	29	18	3
Tuning fork test (n)	6	22	17	3
Sensitivity (%)	50	75.86	94.44	100

For validation of tuning fork test, it was compared with 3 phase bone scan since it is highly sensitive imaging modality for diagnosing stress fractures. The sensitivity of tuning fork test was 79%, specificity was 63%, Positive Predictive Value (PPV) was 88%, and Negative Predictive Value (NPV) was (46%.

DISCUSSION

Overuse musculoskeletal injuries are responsible for the greatest loss of training time in military trainees,[4] and are the common orthopaedic problem[5]. The incidence of stress fractures is high in military training programs, basic training posts, military training academies and specialty training units.[6–8] There are certain problems for diagnosing stress fractures in military recruits. One major problem is the lack of easy accessibility of these patients to nuclear medical centres since; these centres are located in major cities, whereas military training camps are situated in peripheral and unpopulated areas. Another major problem is the clinical history based diagnosis of stress fractures. In many times, these military recruits are considered as maligners and are not given proper rest which is the main stay of treatment. As a result stress related injuries are converted into overt fractures. Secondly, the normal X-rays are asked to rule out the stress fractures which are usually not evident on simple radiography. Here question arises, "Is there any other non-invasive, sensitive/specific available test/ investigation which could help physicians to effectively diagnose these cases and save the patient's time and expenses for a more complicated test like bone scan or MRI?" If that particular non-invasive test is available than the workload on nuclear medicine department could be decreased and progression of stress fractures into full fledge fractures could be prevented. Here comes the role of tuning fork test which is not well known among healthcare personnel in Pakistan. However universal literature has shown its effectiveness in evaluation of stress fractures.

All the cases included in the study were military recruits. The relationship between clinical features, tuning fork test and bone scintigraphy revealed that the worse were the signs and symptoms; the higher was the detection rate of tuning fork test.

Most of the stress fractures detected on bone scan as well as on tuning fork test were located in middle third of tibial shaft. Stress fractures in fibula, lateral malleolus and medial malleolus were all diagnosed on tuning fork test. Tibial and fibular shaft stress fractures were graded according to the international grading system. The grade of stress fractures was directly proportional to the severity of clinical presentation. However in this study, no clear relationship was found between the duration of pain and the grades of stress fractures. The attributing factors for this may be the relative period of rest before bone scan, severity of stress and local osteogenic response of the patient.

It was revealed that frequency of lesion detection by tuning fork test was directly related with the grade of stress fracture. Thus, all the stress fractures having grade IV were detected on tuning fork test.

Seven cases had history of activity related pain but they neither had positive tuning fork test nor was stress fracture detected on bone scan. Five cases had positive tuning fork test, whereas no stress fractures was detected on bone scan. However out of these five cases, 3 cases had shin splints on bone scan and one case had activity induced Enthesopathy. Finally one case had no lesion on bone scan.

Considering bone scan as gold standard, sensitivity of tuning fork test was calculated to be 79% and specificity of 63% for stress fractures. So tuning fork test was not specific enough to differentiate between different stress-related injuries. Although, the positive predictive value came out to be high, its negative predictive value was only 46%, thereby, disclosing the fact that stress fractures can not be ruled out on the basis of negative tuning fork test. The patients having negative tuning fork must be further evaluated by using radionuclide bone scan. For patients having positive tuning fork, management should be considered. The tuning fork test can save the patient's time and expenses for a more complicated test like bone scan.

Tuning fork test sensitivity is high in severe signs and symptoms, middle third of tibial shaft, grade III and IV stress fractures. In these cases medical personnel should go for management directly. Comparatively less sensitivity of tuning fork test was found in less severe signs and symptoms, upper and lower thirds and grade I and grade II cases. In such cases the diagnosis should be confirmed by using radionuclide bone scan.

CONCLUSION

The tuning fork test has shown promising results regarding detection of stress fractures. Stress fracture cannot be ruled out on the basis of a negative tuning fork test. In cases with high suspicion of stress fracture and positive tuning fork test direct management should be started without waiting for the bone scan results.

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