

Tuning fork test utilization in detection of fractures: a review of the literature

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A review of the literature was conducted to find relevant publications on the validity, reliability and utilization of the tuning fork test in detection of stress and simple fractures. Medline 1966–1998, Cumulative Index to Nursing and Allied Health Literature (CINAHL) 1982–1997, Science Citation Index 1961–1997, Index to chiropractic literature 1980–1998 and Chiropractic Research Archives Collection 1984–1990 data bases were searched. Key words such as tuning fork, vibration, diapason, fracture, stress fracture were used. The literature regarding the utilization of the tuning fork test in detection of fractures is very scarce. There was no study found in the above data bases on the validity and or reliability of the tuning fork test in detection of simple acute fractures. This review of the literature indicates the necessity of such a study since the tuning fork test has been used on the field for diagnosis of simple acute fractures.

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KEY WORDS: diagnostic device, fracture, literature review, simple fracture, tuning fork, tuning fork test.

La documentation scientifique a fait l'objet d'une recherche dans le but de trouver des publications pertinentes sur la validité, la fiabilité et l'utilisation de l'épreuve au diapason pour déceler des fractures de stress simples. Cette recherche a été effectuée dans plusieurs bases de données : Medline 1966–1998, Cumulative Index to Nursing and Allied Health Literature (CINAHL) 1982–1997, Science Citation Index 1961–1997, Index to chiropractic literature 1980–1998 et Chiropractic Research Archives Collection 1984–1990. Différents mots clés ont servi à la recherche : diapason, vibration, fracture, fracture de stress. Les fruits de cette recherche ont été bien maigres : la documentation sur l'utilisation du diapason pour déceler des fractures s'est révélée très rare et aucune étude n'a été menée sur la validité et la fiabilité de la méthode pour déceler des fractures simples. Il faut donc en conclure qu'une étude sur l'épreuve au diapason s'impose puisqu'elle a déjà servi au diagnostic de fractures simples.

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MOTS CLÉS : outil diagnostique, fracture, diapason.

Introduction

Many clinical tests are used in the diagnosis of simple fractures: percussion, compression, localized tenderness, the grinding test and the tuning-fork test (TF test). These tests are especially important to health care professionals in assessing acute sports related injuries on the field where

diagnostic radiographic tests are not available. Often immediate decisions are required regarding the safety of allowing an athlete to return to the game.

Vibratory devices are used to detect and monitor the healing process of fractures.^{1,2,3} Finkenberg et al.⁴ used an electrical vibration apparatus on patients with a clinical

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diagnosis of occult fracture of the scaphoid. Yrjama and Vanharanta⁵ evaluated patients with low-back pain immediately prior to a discography examination by means of an electrical tool which produced bony vibration to the lumbar spinal processes. Therapeutic ultrasound (U/S) has been used to detect stress fractures.⁶⁻¹¹ The tuning fork has been used to detect hearing loss and vibratory sensation defects.¹²⁻¹⁵ This test has been used for detection and monitoring of diabetic,^{15,16,17} uraemic, alcoholic,¹⁸ and chemical peripheral neuropathies.^{19,20} Bache and Cross²¹ used the Barford test that combined tuning fork (128 Hz) and auscultation, to detect a fractured femoral neck. Misurya et al.²² used a child stethoscope and a 128 Hz tuning fork to detect fractures of the neck of the femur, the shaft of the femur, and the tibia. Finally, some authors suggest the use of the tuning fork test for the diagnosis of a potential stress fracture.^{23,24,25,26}

Among these various vibratory tests and devices, the tuning fork test in detection of acute simple fractures has not been researched, but yet commonly used by sports health professionals.

Discussion

Vibratory devices are used to detect and monitor the healing process of fractures.^{1,2,3} Nokes et al.¹ applied a mechanical oscillator to the tibial tuberosities of eleven patients with midshaft tibial fractures, and recorded the waves by an accelerometer at 60 mm distal to the tibial tuberosity and another accelerometer at 60 mm proximal to the medial malleolus. They found that early in the course of healing (in the first month) the proximal and distal fragments manifest different natural frequencies, and the proximal fragment was always the higher of the two. With the passage of time, and as fracture healing progressed, the natural frequencies of the two fragments were found to converge towards a common value.

Colier and Donarski² used an accelerometer placed on the medial face about 1/3 of the length of the tibia below the knee and a vibrator was placed at various positions below this point. Measurements had been carried out within 0–500 Hz. They reported that fractures only transmitted low frequencies, below 200 Hz. The tibia resonant frequency was found to be a measure of the strength of a bone; for a fracture it was often as low as half that of the strength of bone. As the fracture healed, change in resonant frequency indicated increase in the strength of the

bone.² Fellingner et al.³ suggested a non-invasive method for monitoring the healing process of tibial fractures based on evaluation of changes in mechanical vibration reactions of the bone. Their measuring system was composed of two sound transducers, an amplifier module and an AD converter attached to a PC. The assessment of 150 healthy individuals as well as an initial measuring series after treatment of tibial fractures in 38 patients with an external fixator system revealed highly significant differences between intact and fractured tibias.³

Finkenberg et al.⁴ used an electrical vibration apparatus (emitting as 100 mW audible vibration that is a mixture of frequencies between 200 and 8500 Hz) on 86 patients with a clinical diagnosis of occult fracture of the scaphoid. The vibrating apparatus was placed on the snuff-box region, the radial styloid, and the proximal and distal scaphoid poles of the injured and uninjured wrist, while the clinical examination and standard four-view x-ray examination findings were unknown to the persons who performed the vibratory testing. The test was considered positive if the patient withdrew his or her hand due to induced discomfort. Thirty-six patients had radiographically confirmed scaphoid fractures and, after their vibratory tests, were eliminated from the study. The remaining fifty patients, 39 men and 11 women, did not reveal a scaphoid fracture radiographically. Distinction between fracture and no-fracture patients was made with a limited two-phase technetium bone scan and delayed x-ray examination. All 36 patients with known scaphoid fractures radiographically had positive findings on vibratory test. Vibratory testing identified all six of the patients with occult scaphoid fractures shown by bone scan and delayed radiographs (sensitivity 100%). There were two false-positive and no false-negative. One of the patients with false-positive results had a fracture of the trapezium, and the other had reflex sympathetic dystrophy.

Yrjama and Vanharanta⁵ evaluated 57 patients with low-back pain immediately prior to a discography examination by means of an electrical tool which produced bony vibration to the lumbar spinal processes. The vibrator was composed of standard electric toothbrush shaft (Braun) with a blunt head instead of the brush. The lumbar spinal processes were compressed one by one for a few seconds with this vibrator. The patient's pain provoked by vibration was compared with that from injections during discography. They reported 96% sensitivity and 72%

specificity after excluding the patients with previously operated backs and painful, prolapsed discs.

Therapeutic ultrasound (U/S) has been used to detect stress fractures.⁶⁻¹¹ Moss and Mowat⁸ suggested that the application of continuous U/S, with a 3 cm head at 0.75 mHz sonated directly over tibia, fibula and femur, was helpful in early diagnosis of stress fractures (90.9% sensitivity using scintigraphy as gold standard). If the intensity was gradually increased, to a maximum of 2.0 watts per square centimetre, a positive response was defined as a very unpleasant sensation of intense pressure or pain. They suggested that "damaged periosteum may absorb continuous U/S energy with its conversion to heat and the development of pain, but that intact periosteum involved in significant callus formation does not absorb this energy."⁸ Pain on application of U/S may be due to the mechanical vibratory effect selectively irritating the nerve endings in the area,¹¹ but Delacerda⁶ found that no pain was exhibited when the U/S was pulsed or below 0.65 W/cm.² Bedford, Glasgow and Wilson⁷ reported discomfort and pain with 1 mHz U/S at 0.5 to 1.5 W applied over recent fractures.

The tuning fork has been used to detect hearing loss and vibratory sensation defects.¹²⁻¹⁵ To distinguish between conductive and sensorineural hearing loss, Bates¹² suggests using 512 Hz or 1024 Hz tuning fork since these frequencies fall within the range of human speech (300 Hz to 3000 Hz). Tuning forks are also used in the test of lateralization (Weber test) and to compare air conduction and bone conduction (Rinne test).^{12,13,14} These tests are based on the transmission of the vibration via skull bones to the middle ear ossicles versus the transmission of vibratory sound via air.

The tuning fork with lower frequencies i.e. 128 Hz or 256 Hz having slower reduction of vibration, has been used to assess vibration sense.^{12,13} Vibration sense is often the first sensation to be lost in a peripheral neuropathy.¹² This test has been used for detection and monitoring of diabetic,^{15,16,17} uraemic, alcoholic,¹⁸ and chemical peripheral neuropathies.^{19,20}

Bache and Cross²¹ used the Barford test that combined tuning fork (128 Hz) and auscultation, to detect a fractured femoral neck in 100 consecutive patients (18 male and 82 female; average age 78.6 years). An initial diagnosis was made on routine clinical examination (the method was not disclosed in the paper), the Barford test was performed, and the diagnosis was then made radiographically. The

Barford test is described as, "Placing the uninjured lower limb in a similar position to that of the injured leg, followed by placing the conical bell of a stethoscope over the symphysis pubis. A vibrating 128 Hz tuning fork is placed over each medial femoral condyle in turn (or each patella if more convenient) so that sound conduction on the two sides can be compared. Reduced conduction on the injured side suggests a femoral neck fracture. Conversely, a negative result (equal conduction bilaterally) suggests that there is no fracture."²¹ Fifty-six of the 100 patients had a fractured neck of femur: 48 (85.7% sensitivity) of the fractures were diagnosed correctly using the conventional clinical methods while the Barford test was positive in 51 cases (91.1% sensitivity). There were 44 patients without femoral neck fractures, the Barford test being correct in 36 cases (81.8% specificity) against 34 cases (77.4% specificity) on clinical examination.

Misurya et al.²² used a child stethoscope and a 128 Hz tuning fork to detect fractures of the neck of the femur, the shaft of the femur, and the tibia in 50 patients. For fractures in the thigh, the stethoscope was placed over the anterior superior iliac spine and the tuning fork, after striking, was placed over the patella. To differentiate fractures of the neck from those of the femoral shaft, the bell of the stethoscope was placed over the greater trochanter and the tuning fork over the patella as before. For fractures of tibia, the stethoscope was placed over the tibial tubercle and the tuning fork over the medial malleolus. The sound conducted was compared with that in the uninjured limb. Reduction or abolishment of the sound marked the fracture. They compared clinical diagnosis and the auscultatory tuning fork test against the gold standard of x-ray examination. All 50 patients had radiographic evidence of fracture in one of the tested areas. Forty seven patients were correctly detected by the Barford test (94% sensitivity) versus 44 patients (88% sensitivity) by clinical diagnosis for which the criteria were not disclosed.

Some authors suggest the use of the tuning fork test for the diagnosis of a potential stress fracture.^{23,24,25} However, none of them provide a reference for their statement. "With this test, a vibrating tuning fork with a flat base is placed onto the tender area. If discomfort or pain is felt (which is not present when the unaffected limb is tested), it is suggestive of a stress fracture. While this test is not always positive, it is seldom positive without a stress fracture being present."²³

Finally Lesho²⁶ compared the performance of the tuning fork test with nuclear scintigraphy for the identification of tibial stress fractures. He took fifty two patients with a history and physical examination suggestive of tibial stress fracture, examined them using the tuning fork test followed by a bone scan. He applied a 128-Hz tuning fork to the anterior surface of the tibia. He considered the tuning fork test to be positive if the patient reported a marked exacerbation or reproduction of shin pain in a localized area of the tibia. He found the sensitivity and specificity of the tuning fork test to be 75 and 67%, respectively. The positive and negative predictive values were 77 and 63%, respectively. Lesho concluded that the tuning fork test was not sensitive enough to rule out a stress fracture on the basis of a negative test. However, he recommended that in a setting in which there was a moderate to high risk of stress fractures, it might be reasonable to avoid bone scan by instituting treatment for tibial stress fractures when the tuning fork test was positive.

Conclusions

The validity or reliability of the tuning fork test in the detection of acute simple fractures has not been thoroughly researched. However this test is commonly used by sports health professionals. A validity study, using plain film radiography as the gold standard, is recommended in order to establish the sensitivity, specificity, positive and negative predictive values of the tuning fork test in the detection of the simple acute fractures. If the sensitivity and specificity of this test is found to be high, then the tuning fork test may be considered a valuable tool in diagnosis of the simple acute fractures on the field or in the office where plain film radiography may not be readily available.

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