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Detection of a radial head fracture by imaging methods versus clinical methods: a case report

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Many people present in a clinical setting with severe pain after experiencing profound physical trauma from falls and collisions. It is in this population of patients that the possibility of fracture may be real and present. A chiropractor can utilize several available diagnostic instruments that can confirm or rule out fracture. Among these available tools are tuning forks and therapeutic ultrasound over the area of complaint, and diagnostic imaging such as plain film radiography, computerized tomography and bone scintigraphy. Following is the case of a 23-year-old female patient presenting with localized right elbow pain attributed to a fall off her bike. Application of tuning forks and therapeutic ultrasound over the injured elbow joint failed to reproduce pain. Based upon the negative results of these two tests, it was erroneously concluded that a fracture was not present. Plain film radiography and computerized tomography eleven days post-trauma confirmed the presence of a non-displaced chisel fracture (Mason type I fracture) of the radial head. The application of tuning forks and therapeutic ultrasound to confirm the presence of fracture is presented and discussed.
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KEY WORDS: fracture, tuning fork, ultrasonic therapy.

Beaucoup de personnes se présentent en consultation pour douleur intense après avoir subi un traumatisme physique profond à la suite d'une chute ou d'une collision. La possibilité de fracture dans ce groupe de patients est bien réelle. Le chiropraticien dispose de plusieurs instruments diagnostiques pour confirmer ou exclure la présence d'une fracture. Parmi ceux-ci, notons le diapason et l'application d'ultrasons thérapeutiques sur la région douloureuse ainsi que les appareils d'imagerie diagnostique comme les radiographies simples, la tomographie par ordinateur et la scintigraphie osseuse. Voici le cas d'une jeune femme de 23 ans qui est venue consulter pour une douleur ressentie au coude droit après avoir fait une chute de sa bicyclette. L'application du diapason et d'ultrasons thérapeutiques sur l'articulation blessée n'a pas permis de reproduire la douleur. Devant les résultats négatifs de ces deux épreuves, on a conclu à tort qu'il n'y avait pas de fracture. Par contre, une radiographie simple du coude et une tomographie par ordinateur effectuées 11 jours après l'accident ont révélé la présence d'une fracture en oblique, sans déplacement, de la tête du radius (fracture de Mason, type I). Il sera donc question dans le présent article de l'utilisation du diapason et des ultrasons thérapeutiques pour confirmer la présence d'une fracture.
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MOTS CLÉS : fracture, diapason, ultrasonothérapie.

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Case report

A 23-year-old female presented to a chiropractic clinic with a chief complaint of right elbow pain after being thrown off her bike while rapidly descending a hill. The pain was localized within the right olecranon and surrounding soft tissues. She recalled hitting her head on the ground first, then tumbling forward, but was unsure how her upper limb struck the ground. She denied any loss of consciousness. Upon impact, she immediately experienced pain in the right brachium. Range of motion at the time of trauma was still full, but painful.

The pain in the area of complaint progressively worsened by the following day, with subjective reduction of all ranges of motion. The intensity of pain was rated 7/10; it was described as throbbing and constant. Any movement involving the right elbow induced intense pain. Advil and the application of ice about the elbow joint reduced the pain intensity. There was no past history of previous elbow injury. Secondary sites of injury included the left knee, left lumbosacral region and the right shoulder with visible ecchymosis and effusion.

On presentation, one day after the fall, active and passive ranges of motion of the right elbow were limited by pain to 95 degrees of flexion (140–150 degrees for normal) and 5 degrees of supination (90 degrees for normal). Active and passive ranges of motion for extension were inhibited by pain with the elbow at 25 degrees of flexion. Pronation was full with reproduction of pain in active and passive ranges of motion. All resisted ranges of motion were painful for the right elbow. All wrist ranges of motion were full and pain-free except resisted extension, which intensified pain within the area of complaint.

Distal pulses were present and not diminished. Neurological examination involving deep tendon reflexes, sensation and muscle strength was normal for both upper limbs.

On orthopedic examination, the medial olecranon and medial brachium were painful to digital palpation.

Figure 1 Lateral radiograph of the right elbow. (Arrow: cortical disruption of the superior aspect of the radial head)

Figure 2 Anteroposterior radiograph of right elbow with pronation. (Arrow: cortical disruption of superior aspect of the radial head)

Pain was provoked with light percussion over the bony prominences of the elbow. Elbow hyperextension/ hyperflexion could not be performed adequately due to pain. Valgus and varus strains provoked further pain.

A 128 Hz tuning fork was applied to all bony prominences of the right elbow without eliciting further pain. Therapeutic continuous ultrasound at 1.2 W/cm^2 was applied to all bony prominences of the right elbow without eliciting further pain. Plain film radiographs were not taken at that time.

The tentative diagnosis made was acute myofascial strain of the right elbow (medial and lateral myofascial structures) secondary to trauma. Therapeutic plan of management involved electrotherapy, cryotherapy with massage, and early active range of motion of the right elbow.

The patient elected for six treatments of conservative care over the next ten days. The tuning fork test was applied on two later occasions. However, the tuning fork tests did not provoke further pain. The pain experienced over the next ten days did not decrease in intensity. Consequently, the patient then attended a hospital and had plain film radiographs of her elbow. A fracture was noted within the radial head (Figures 1 and 2). Computerized tomograms illustrated a transverse chisel fracture (Mason type I) through the radial head (Figure 3). She was then referred to a rehabilitation clinic for an active mobilization and muscle strengthening programme for her right upper limb.

Follow-up six months later revealed that the patient had 95% subjective improvement in pain about the elbow joint. However, she still experienced a 5 degree loss in active extension at end range in contrast to the left elbow due to mild pain. Active flexion was full but evoked mild tenderness at the medial aspect of her olecranon. Active supination and pronation were full and pain free.

Discussion

Physics of mechanical sound energy

The possibility of fracture should always be considered after profound trauma. There are many diagnostic devices at our disposal that help confirm our suspicion of fracture. However their limitations, and therefore their ultimate clinical utility, must be recognized.

There are several important points that this case report illustrates. First, any patient with intense pain after a traumatic fall can be expected to present with the possibility of fracture. Second, when the history involves severe trauma, diagnostic imaging such as conventional radiographs, computerized tomography or bone scintigraphy should be implemented to identify occult fracture. Third, the use of tuning forks and therapeutic ultrasound to confirm a suspected fracture may produce false negatives which could potentially lead to an erroneous diagnosis and ultimately, mismanagement.

The basis for the implementation of these tools lies in the nature of mechanical vibratory energy upon osseous tissue. When utilizing tuning forks, it is thought that the fractured bone vibrates, resulting in irritation of the overlying periosteum which then evokes pain.[1] The application of ultrasound functions in a similar way.[2,3,4,5]

It has been established that bone and the overlying periosteum have different acoustic impedances.[2,3,4] Due to the physics of wave energy (ultrasound) and the structures involved, the periosteum will oscillate and absorb ultrasonic energy from both the ultrasound head (above) and from the reflected sound waves from the bone (below).[2,4,5] The hypothesized theory for the production of pain arises from the mechanical shearing effect upon the periosteum from the ultrasonic energy.[5]

Additionally, the shear waves in the vicinity of the periosteum cause heat to be generated due to the varying acoustic impedances.[2,4] Inadequate circulatory cooling mechanisms about the periosteum, allow for the accumulation of heat, ultimately resulting in periosteal pain.[2]

These physical phenomena are more pronounced when there is the presence of damaged periosteum arising from a fracture.[5] In contrast, intact periosteum, or periosteum that has already formed a significant callus, does not absorb sound energy to the same degree. Hence, the production of periosteal pain is minimized.[5]

Tuning fork tests

Many authors have suggested implementing tuning fork tests to aid in the diagnosis of stress fractures.[6,7,8] In one study, Lesho[9] found that when tuning forks were applied to tibial stress fractures and the results compared to bone scintigraphy, sensitivity and specificity were found to be 75% and 67%, respectively. However, Lesho[9] still felt that the tuning fork test was not sensitive to rule out stress fractures on the basis of a negative test. Kazemi and Roscoe[10] determined the sensitivity and specificity to be 87% and 50%, respectively, for both 128 and 256 Hz tuning forks in a sample population of 46 patients presenting with simple fractures. The positive and negative predictive values were 89% and 44%, respectively.

Figure 3 Computerized tomography of right elbow joint. (Arrow: fracture of the radial head (Mason Type I)

Of the four radial head fractures that were determined through radiographs, only two were positively identified through application of the tuning fork tests.[1] The investigators ascertained that a positive determination of a fracture was increased if the tuning fork was placed directly over the fracture site. Therefore, accurate positioning of the tuning fork was paramount in producing true positives.

Ultrasound tests

Many therapists have conventionally employed ultrasound in the therapeutic range for the treatment of soft tissue injuries. However, several investigators have recently advocated the utilization of therapeutic ultrasound in a diagnostic manner to determine the presence of fractures. Nitz et al.[11] assessed the use of ultrasound (2.0–3.0 W/cm^2, 30 seconds) in diagnosing medial tibial plateau stress fractures and found 100% sensitivity and 80% specificity. In a case study, DeLacerda[12] found that continuous ultrasound (2.0 W/cm^2) induced pain when it was applied to a suspected stress fracture of the fibula. The stress fracture was confirmed two weeks later with plain film radiographs. It was also noted that pulsed ultrasound did not induce any pain over the site of the stress fracture.

Bedford et al.[13] utilized ultrasound (0.5–1.5 W/cm^2, 1MHz) to assess 87 fractures of the upper and lower limbs. Ultrasound produced pain or severe tingling when it was applied to 80 of 87 fractures (provided the fractures were less than two weeks old). In phase two of this study, 50 patients with upper and lower limb fractures of greater than four weeks were examined. Of these 50 patients, approximately 32 patients with fractures were not correctly diagnosed with ultrasound. In the third part of this study, only 28 (28%) of 101 patients with scaphoid fractures were identified by ultrasound. Christiansen et al.[14] found that application of continuous ultrasound (0.5 to 2.0 W/cm^2, 30 seconds, 1MHz) over scaphoid fractures yielded a sensitivity and specificity of only 37% and 61%, respectively.

A study by Moss and Mowat[15] utilized continuous ultrasound (up to 2.0 W/cm^2, 0.75 MHz) and found that in 123 tests for stress fracture of the lower limb, there was only one false positive. Additionally, it was observed that recent stress fractures were painful to ultrasound, whereas older stress fractures were not, confirming the findings of Bedford et al.[13]

In contrast, Devereux et al.[16] showed that ultrasound only had a sensitivity of 57% and a specificity of 50% in determining stress fractures of the lower limb. Devereux et al.[16] also verified the observation that ultrasound-induced pain over the stress fracture site decreased with time. Lowdon[17] also employed ultrasound (up to 2.0 W/cm^2, 0.75MHz) to diagnose lower extremity stress fractures. In this study, radiographs were compared to ultrasound results. If these radiographs were negative, the ultrasound results were then compared to bone scintigraphy. From this methodology, the sensitivity and specificity for stress fracture detection by therapeutic ultrasound was determined to be 90% and 75%, respectively.[17] However, in 15 radiographs that exhibited evidence of stress fractures, ultrasound failed to detect all 15 of these fractures.[17]

Boam et al.[18] compared ultrasound (2.0 W/cm^2, 30 seconds) with bone scintigraphy to diagnose stress fractures. The utilization of bone scintigraphy yielded 35 stress fractures in a sample size of 78. In contrast, only 15 fractures were detected by ultrasound (sensitivity 43%). Overall, ultrasound yielded 22 false positives (specificity 49%) and 20 false negatives; the positive and negative predictive values were respectively, 41% and 51%. Based upon these findings, it was concluded that ultrasound was not a reliable tool for the diagnosis of tibial stress fractures.

A study by Giladi et al.[19] compared plain film radiography, bone scintigraphy and ultrasound in the diagnosis of stress fractures. They found that ultrasound had a sensitivity of 75%, specificity of 67% and accuracy of 71% in comparison to radiography, which had a sensitivity of 22%, specificity of 100% and accuracy of 62%. Ultrasound was more sensitive than radiographs, but was not considered accurate enough to serve as a substitute for bone scintigraphy for the determination of stress fractures.[19]

Fractured fragments of the skeleton have specific natural frequencies and are therefore responsive to vibrational energy.[20] The above studies utilized therapeutic ultrasound or tuning forks at fracture sites to cause these fractured bones to vibrate and effect periosteal irritation.[1,2,4,5] It is known that periosteum does not cover bone where articular cartilage is present, and thus is not found on bone within joint capsules, such as the radial head.[21,22] Consequently, it follows that the application of continuous ultrasound and tuning forks tests at fracture sites contained within joint capsules should not produce periosteal irritation, as illustrated in this case report.

Although most of the aforementioned studies have dealt with stress fractures and not simple fractures (as illustrated in this case report), both share similar characteristics. Both fractures can arise due to some form of trauma, which results in some periosteal and/or cortical disruption making detection much more difficult within a clinical setting.

Further, these studies and this case report have demonstrated that utilization of tuning forks and therapeutic ultrasound to determine the presence of fracture must be performed with care. The results derived should then be interpreted with caution.

Conclusion

This case report has illustrated several features involving the assessment of fractures. A patient who has undergone some aspect of severe trauma, should be expected to present with the possibility of fracture. When the history involves severe trauma, diagnostic imaging such as conventional radiographs, computerized tomography, bone scintigraphy or any other available diagnostic imaging should be implemented to determine the osseous integrity at the site of injury. Further, implementation of tuning forks and therapeutic ultrasound to determine the presence of a suspected fracture may produce false negatives especially if performed about a joint structure.

If the tuning fork or ultrasound tests are implemented to test for fracture, and the tests are positive, then it is likely that a fracture is present. Appropriate diagnostic imaging should then be undertaken for further assessment. If the tuning fork or therapeutic ultrasound tests are negative, appropriate diagnostic imaging should still be undertaken in any case. Therefore, performing these two tests in a clinical setting would be considered redundant, as diagnostic imaging would be obtained in either case.

As shown by this case report and by previous studies, tuning forks and therapeutic ultrasound are not reliable diagnostic tools. The results derived could lead to an erroneous diagnosis and therefore, mismanagement. These instruments should not be utilized as reliable diagnostic entities. If utilized, they must be used in association with other diagnostic imaging.

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