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Case report

Stress Fracture of the Ulna in an Elite Ice Dancer

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Abstract
Stress fracture of the ulna is a rare overuse injury often arising from repetitive excessive forearm rotation. Here we report the first case of ulnar stress fracture in a female ice dancer. Diagnosis was made by history and physical examination, with the aid of imaging studies (plain x-ray, computed tomography, and magnetic resonance imaging), and biomechanical analysis of forearm pronation and supination. Following identification and modification of the causal technical element, the ice dancer was able to continue training and competing without cessation of activity. Treatment was with a 30-day course of capacitively coupled bone stimulation to promote fracture healing, confirmed on radiography and magnetic resonance imaging. Such injuries to ice dancers may be prevented at the planning stage of technical elements in the dance program if coaches place more attention on the potentially deleterious effects of difficult positions the lifted dancer must sustain to reward points on the technical elements score.

Key words: Figure skating, ice dancing, overuse injury, stress fracture.

Introduction

Stress fracture was first described by a Prussian military doctor in 1855 after observing metatarsal bone fractures in soldiers. Stress fractures account for 10% of sports injuries, with 0.7-15.6% of athletes presenting with stress fractures. In a study of 320 cases of stress fractures in athletes, it was reported that the tibia was most often involved (49%), followed by the tarsus (25.3%), the metatarsus (8.8%), the femur (7.2%), the fibula (6.6%), and the pelvis and spine (<1%) but rarely the upper extremities (Matheson, 1987). The first case of a diaphyseal ulnar fracture was reported in a worker (Kitchin, 1948). Though an uncommon injury, diaphyseal ulnar stress fracture has been reported in athletes from various sports: volleyball (Mutoh, 1982); body building (Hamilton, 1984); weight lifting (Chen, 1991); tennis (Bollen, 1993); polo (Clarks, 2002); softball (Bigosinski, 2010), break dance (Chen, 2008) and in a young recruit during honor guard training (Lin, 2012).

Case report

A 24-year-old female ice dancer (international level and member of the Italian National Team) presented to the outpatient sports rehabilitation clinic of our institute in November 2013 because of dull persistent pain in the left forearm that had worsened over the previous 10 days. Physical examination disclosed a tender swelling (diameter, about 1 cm) over the middle third of the ulna. Palpation along the forearm and resisted pronation elicited tenderness. The athlete reported having sustained no acute injuries during the previous months and that the pain had begun to worsen starting in late September. On further questioning, she described a technical element in the free dance segment which prompted suspicion as a potential triggering factor of the pain. A stationary lift is a required element of the competitive ice dance program. In the stationary lift, the lifting partner (male) rotates in place for six seconds while executing and mantaining the lifted position of the female partner. During this time the lifted partner (female) must mantain a "difficult position" for 3 seconds. By definition the ring position is one of the "difficult positions" which is executed by holding the body as a ring with the head and a foot almost touching, maximum half a blade length between the head and the blade (Figure 1). She had begun practicing this specific stationary lift in early August, having repeated the technique about 500 times between August and current presentation. The number of repetitions of the technical element was within the range of similar or identical technical elements she had practiced during previous training seasons.

Figure 1. The stationary lift in its first version with the lady that grabs the blade with the left hand.

Additional diagnostic tests were performed. Plain x-rays revealed cortical thickening of the middle third of the ulnar diaphysis. Magnetic resonance (MR) images were acquired in a 1.5 Tesla MR system using a surface coil (Avanto, Siemens Medical Solutions, Forchheim, Germany): PD fat suppressed sequences in the coronal

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plane, axial and sagittal T1-weighted and axial T2-weighted sequences, and axial and coronal short-tau inversion recovery (STIR) sequences. The MR scans confirmed focal thickening of the cortical bone in the middle ulnar diaphysis, more pronounced on the lateral side, a hypointense oblique cortical fracture line on the T1-weighted image, and intense bone marrow and periosteal edema (Figure 2). These findings were strongly suggestive of stress fracture. Thin slice computed tomography (thickness, 1 mm) of the left forearm showed cortical thickening, indicating bone remodeling at the stress fracture site but no other concomitant bone disorders and ruled out focal neoplastic or infectious lesions. A diagnosis of stress fracture of the middle third of the ulnar diaphysis was confirmed.

Figure 2. MR images in the coronal plane of the ulnar shaft at presentation.

To determine whether mobility asymmetry in forearm pronation/supination was present, the athlete underwent quantitative biomechanical analysis at the motion analysis laboratory of our institute. Under the protocol for assessment of forearm pronation/supination, 11 passive reflecting markers were placed over anatomical landmarks as in Figure 3. The motion analysis was performed using an optoelectronic system (Smart-D, BTS Bioengineering, Milan, Italy) which enables the computerized registration of motion in the three-dimensional space, using six cameras working at a sample rate of 100 Hz. The trajectory of each marker was reconstructed and an integral reference frame for each forearm and for each shoulder was created (Figure 4) using dedicated software Smart-Analyzer (BTS Bioengineering, Milan, Italy). The forearm pronation/supination angles were measured for each side as the motion of the elbow reference frame about the shoulder reference frame. Pronation/supination movements were repeated 5 times for each side to ensure repeatability of the results. The range of motion of supination of the left elbow was 156.3° and that of the right elbow was 154.8°.

Figure 3. 11 reflective passive markers positioned on the ice dancer anatomical landmarks for the elbow motion analysis.

After diagnosis confirmation the athlete underwent a 30-day course of capacitively coupled bone stimulation (Osteobit, Igea SpA, Carpi, Italy) for 8 consecutive hours per night. The capacitively coupled bone stimulation device consisted of a rechargeable battery-powered generator that supplies a current density of 25 mA/cm at the site of treatment. Two hydrogel electrodes were placed on the skin on either side of the fracture. Each adhesive electrode consisted of a layer of highly conductive material covered with saline on one side, and solid, biocompatible eletroconductive adhesive gel on the other side. The capacitively coupled electric field (CCEF) induces an electric field at the fracture site. The signal consists of 12.5 Hz bursts with a duty cycle of 50%. The active part of the burst is a sine wave at 60 kHz with an amplitude adjusted by a microprocessor according to the impedance of the body interposed between the two electrodes. Originally developed by Brighton el al., its effectiveness in bone healing has been variously demonstrated (Brighton, 1981; 1985; Brighton and Pollack 1985; Goodwin, 1999; Scott and King, 1994).

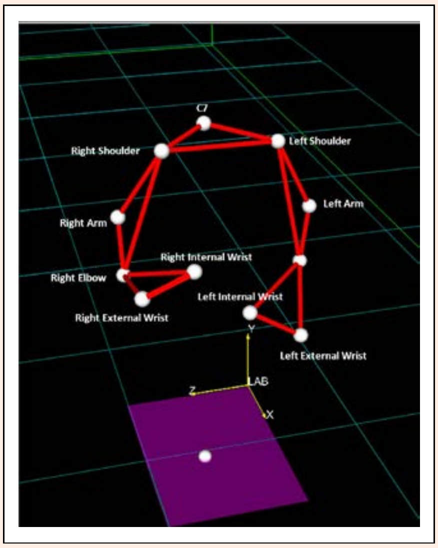

Figure 4. The biomechanical model reconstructed using Smart-Analyzer (BTS Bioengineering, Milan, Italy)

Figure 5. the modified stationary lift with the man that grabs the lady's blade so that she could hold the ring position.

The athlete was able to continue her training program. In agreement with the coach, the stationary lift was modified whereby the lifting partner would grab the dancer's blade before lifting her so that she could hold the ring position without placing stress on the left forearm (Figure 5). During the first 2 weeks of CCEF therapy, the athlete wore a tubular polyethylene brace with adjustable hook-and-loop closure straps. Repeat radiography on completion of CCEF therapy and MR 3 weeks later showed uniform remodeling of the cortical bone of the third middle of the ulnar diaphysis and a net reduction in bone edema (Figure 6).

Figure 6. MR images in the coronal plane of the ulnar shaft at two months. The remodeling over the middle-one third of the ulna and the absence of edema and periostal reaction after 2 months, confirm stress fracture of the shaft.

Discussion

Two relevant facts elicited from history taking were that, for the first time in her athletic career, the athlete had started to use her left hand instead of the right one to hold the boot blade for executing the ring position and that she would reach for the blade during the lift after rotation had begun rather than just before starting the technical element. In so doing, the torsional stress was probably exponentially greater. Biomechanical motion analysis did not show restricted mobility of the left forearm. This suggests two hypothetical causes for the fracture. Because the athlete had always executed the ring position with her right arm, it is likely that by using the left arm the mobility of the spine did not allow a similarly "natural" position, thus resulting in local overload of the left forearm to execute the ring position. Alternatively, the stationary lift, because of the mechanics of its execution, causes forearm overloading. Specifically, holding the boot blade after rotation has begun creates intense torsional stress and probably overuse with repeated movement. After modifying the technical element, so that the lifting partner would grasp and hold the blade, the athlete's pain symptoms gradually resolved. During week 3 of CCEF therapy, the athlete was able to take part in the Italian National Championships, and in the European Figure Skating Championships 3 weeks later.

Conclusion

This case report raises two issues in the prevention of sports-related injuries.

Some of the technical elements in ice dancing can overload the musculoskeletal structures due to the sometimes extremely difficult positions the skaters must repeatedly practice to control them. Matching parameters of the skater such as muscular flexibility and joint mobility with the difficulty of the technical elements along with the knowledge of the biomechanical requirements can help in cognizant of the possibility of an overuse injury.

Furthermore the International Skating Union rules permit a wide range of technical elements to be implemented at the discretion of the coach in order to create a program that is both technically challenging for the skater and aesthetically pleasing in order to obtain the highest scores. The ability to obtain this balance while maintaining the health of the skater is imperative.

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Key points

- The technical elements in ice dancing can overload joints and bones due to the positions held by the skaters.
- To project a competition program as much as possible safe regarding overuse injury prevention an accurate knowledge of physiological parameters of the ice dancer and of ISU rules is necessary.

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