Stress fractures of bilateral clavicles in an adolescent gymnast

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In gymnastics, the upper extremities are used for weight-bearing, unlike other sports, and several characteristic injuries around the shoulder, such as rotator cuff injury, superior labrum anterior-posterior lesion, and stress changes of the proximal humeral epiphysis have been reported.\textsuperscript{6,7} Stress fractures are caused by repetitive mechanical stress and are common injuries in the lower extremities of physically active athletes; however, stress fractures of the upper extremities are less common.\textsuperscript{10} Stress fractures of the humerus and of the olecranon of the ulna have been reported in athletes that throw often such as baseball players and javelin throwers.\textsuperscript{10} By contrast, stress fractures of the clavicle, the distal radius, including the styloid process and the distal epiphysis, and the scaphoid have been reported as rare disorders for gymnasts who bear their body weight on the upper extremities.\textsuperscript{9,10,14} In the present report, we present stress fractures of bilateral clavicles in an adolescent gymnast. The patient and the family were informed that data from the case would be submitted for publication and gave their consent.

Case report

A 17-year-old boy, who was a gymnast ranked at the National High School Athletic Meet level, gradually felt pain on his left clavicle during gymnastics activities, especially when performing static balance poses on the rings, such as the Iron Cross and the swallow, without any history of major trauma. Despite a reduction in sports activities, the symptom did not improve. He visited us 1 month after he first felt pain. The patient was in good health, without bone or joint disorders, and had no family history of metabolic or endocrine disorders of the bone.

On physical examination, tenderness was detected at the proximal site of the left clavicle, although there was neither rest pain nor sensory disturbance in the left upper extremity. Active ranges of motion and muscle strength of the shoulder were not limited; however, he felt pain during elevation of the shoulder. A radiographic examination showed an apparent fracture line in the proximal clavicle (Fig. 1, A). On the axial plane of a computed tomography (CT) scan, a fracture was detected at the proximal portions on the left clavicle (Fig. 2, A). Although the patient did not feel pain in the right clavicle, a fracture was also detected at the proximal portion of the right clavicle (Fig. 2, A). On the serial sections of the frontal plane of the CT scan, fractures were detected at the proximal portions on both clavicles (Fig. 2, B and C).

We diagnosed the patient with stress fractures of bilateral clavicles. The patient was instructed to stop all gymnastics activities and reduce exercises of the muscles using both upper extremities. One month after being diagnosed with stress fractures of the clavicles, he had neither tenderness nor pain on the left.
Clavicular stress fracture during elevation of the shoulder. The patient was treated with physical therapy, muscle exercises, and stretching. To stabilize the scapula upon the thoracic wall during static balance poses on the rings such as the Iron Cross and the swallow, we instructed the patient to strengthen the serratus anterior muscle, the latissimus dorsi muscle, and the trapezius muscle by using a counter-weight exercise. Exercises using both upper extremities, including the shoulders, were allowed.

Callus formation was seen on the radiograph (Fig. 1, B) at 3 months after the diagnosis, and the patient started gymnastics-related exercises. He was able to return to the original level of his gymnastics activities 6 months after the onset of pain. Bone union at the fracture site was confirmed on the radiograph 1 year after the diagnosis (Fig. 1, C). He was still free from shoulder pain during gymnastics activities at his latest follow-up 2 years after initial onset.

**Discussion**

We present an adolescent gymnast who sustained bilateral proximal clavicular stress fractures without any major traumatic etiology and who was successfully treated with limitation of upper extremity usage and physical therapy.

Sports-related stress fracture of the clavicle is a very rare disorder and has been previously reported in a rower, a javelin thrower, a gymnast, a weight lifter, a diver, and a baseball player. Stress fractures of the clavicle occurred at the distal end, at the middle third, and at the proximal site. The mechanism of stress fracture of the distal clavicle in the weight lifter was speculated to be repetitive forces to the acromioclavicular joint during weight lifting associated with arthropathy of its joint. The mechanism of stress fracture of the middle clavicle in the diver was suggested to be repetitive axial loading stress to the clavicle while radiating the arm upwards to the clavicle to provide a smooth entry into the water.

By contrast, the cause of stress fractures of the proximal site of the clavicle, including in the present patient, is speculated to be repetitive mechanical forces to the clavicle by traction of muscles during rotating motion of the arm based on the shoulder joint and the shoulder girdle. The clavicle is secured between the acromioclavicular joint and the sternoclavicular joint that allow mobility in the axial, horizontal, and vertical planes. The axis of rotation is located close to the sternoclavicular joint.

The pectoralis major and the deltoid muscles produce downward force and the sternocleidomastoid and the trapezius muscles produce upward force. Stress fractures can be caused by downward force with the pectoralis major and the deltoid muscles and by upward force with the sternocleidomastoid and the trapezius muscles. The muscles of the pectoralis major, the clavicular part...
of the deltoideus, and the biceps brachii are considered to be important for performing an isometric flexion of the glenohumeral joint during static balance poses on the rings. Coordination of the shoulder muscles, such as the pectoralis major, latissimus dorsi, serratus anterior, trapezius, deltoid, biceps brachii, and the triceps brachii during performing static balance poses at ring height is important. Counterweight exercises closely reproduce the competitive movement of the ring and modify the muscle coordination during shoulder flexion by preserving the pectoralis major.

Therefore, the patient in the present case strengthened the muscles of the serratus anterior, the latissimus dorsi, and the trapezius using counterweight exercises. These exercises enabled muscle coordination during static balance poses on the rings, such as the Iron Cross and the swallow, by preserving the pectoralis major and by reducing the axial mechanical stress to the clavicle through stabilizing the scapula upon the thoracic wall.

Carson et al. reported the uncommon case of an epiphyseal lesion of the bilateral proximal clavicle in a 13-year-old male gymnast. By contrast, the patient in the present case was a 17-year-old male gymnast, whose stress fractures were located distal to the proximal epiphysis, and closed epiphysis of the bilateral proximal humerus was observed. Therefore, we diagnosed the patient with stress fractures of the proximal clavicle. The symptom of clavicular pain in athletes is very unusual, and stress fracture of the clavicle is rare disorder. When gymnasts complain of unusual clavicular pain, the possible diagnoses are injury of the proximal physis, bone tumor, pathologic fracture caused by malignant tumor, chronic osteomyelitis, and disorders of the lung, as well as stress fracture. When evaluation of the proximal portion of the clavicle is difficult radiographically, examination using a CT scan is recommended.

Conclusions

Gymnastics activities, especially static balance poses on the rings such as the Iron Cross and the swallow, deliver a large amount of mechanical stress to the shoulder and can cause stress fracture of the proximal clavicle, which is a rare disorder. The patient in this case was successfully treated conservatively with the reduction of sports activities and by strengthening the shoulder muscles to stabilize the scapula upon the thoracic wall.

Disclaimer

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References

3. Bernasconi S, Tordi N, Parratte B, Rouillon J-D, Monnier G. Surface electromyography of nine shoulder muscles in two iron cross conditions in gymnastics. J Sports Med Phys Fitness 2004;44:240-5.