

Madelung Deformity in a Collegiate Gymnast: A Case Report

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Objective: To present the case of a 21-year-old female collegiate gymnast with acute left wrist pain.

Background: Madelung deformity is a developmental abnormality of the wrist. It is characterized by anatomic changes in the radius, ulna, and carpal bones, leading to palmar and ulnar wrist subluxation. It is more common in female patients and is usually present bilaterally. The deformity usually becomes evident clinically between the ages of 6 and 13 years.

Differential Diagnosis: Traumatic distal radius physeal arrest, congenital anatomic variant.

Treatment: The athlete was treated with symptomatic therapeutic modalities and nonsteroidal anti-inflammatory medication for pain. She was able to continue to participate successfully in competitive gymnastics, minimally restricted, with the aid of palmar wrist tape and a commercially available wrist brace to prevent end-range wrist extension.

Uniqueness: Madelung deformity can result in wrist pain and loss of forearm rotation, leading to decreased function of the wrist and hand. This patient was able to participate successfully in elite- and college-level gymnastics with no wrist pain or injury until the age of 21 years. Furthermore, she was able to continue to participate, experiencing only periodic pain, with the aid of taping and bracing support and without the need for reconstructive surgery.

Conclusions: Although rare, Madelung deformity is typically corrected surgically in athletes with chronic pain and disability. This case demonstrates an example of successful conservative management in which the athlete continued to participate in sport.

Key Words: traumatic physeal arrest, triangular fibrocartilage complex

In competitive gymnastics, the upper extremity is subject to tremendous torsional forces with axial loading due to repetitive weight bearing.¹⁻³ As a result, wrist pain is a common complaint among both male and female gymnasts. Of particular concern, the tremendous compressive forces gymnasts often incur at the wrists may lead to a premature, asymmetric closure of the cartilaginous distal radius physis in skeletally immature athletes.⁴ Epiphyseal plate changes at the distal radius have been reported in more than 42% of male and female preadolescent and adolescent gymnasts.¹ Such changes are thought to be the direct result of forces imposed during normal gymnastics activity. Closure of the plate may produce a characteristic skeletal deformity in which the carpus is wedged between a deformed distal radius and ulna. Termed an *acquired Madelung-like deformity* because of its similar appearance to the relatively uncommon developmental malformation, such an injury typically presents early in a gymnast's career, between the ages of 6 and 13 years.^{5,6} Additionally, it is more common in female than male gymnasts, usually presents bilaterally, and typically results in significant pain and disability.^{5,6} In this report, I describe unilateral, nondominant left wrist Madelung deformity in a female collegiate gymnast with no history of wrist injury or pain despite 17 years of competitive gymnastics participation.

REPORT OF A CASE

A 21-year-old female art major and competitive collegiate gymnast (height, 1.39 m; weight, 49.5 kg) experienced a pain-

ful sensation of instability and "giving way" in her left, non-dominant wrist while practicing an uneven parallel bar routine during a regularly scheduled team practice. The athlete had participated in competitive gymnastics since the age of 4 years and could recall no incidence of wrist pain before her college career. Furthermore, she could recall no previous injury to the left wrist but had received treatment to her right wrist more than 1 year earlier. The athlete had undergone 3 treatments during 1 week, consisting of ice and manual joint traction, for what had been assessed as a right dorsal capsular wrist sprain. During that week, her symptoms improved and treatment was discontinued without further complaint. She could not recall a particular mechanism of injury, but she did describe an abnormal sensation during the lower half of a typical giant swing. The athlete was evaluated immediately by the team's certified athletic trainer. Gross examination revealed bilateral palmar subluxation with associated radial and ulnar styloid process prominence. On evaluation, the athlete demonstrated no remarkable carpal instability compared with the contralateral side; however, she did note deep dorsal wrist tenderness that was significantly worsened with palpation. Additionally, the athlete demonstrated a loss of approximately 5° of pronation and 10° of supination compared with the contralateral side. She was removed from practice and referred to the team orthopaedist for further evaluation.

Before the scheduled consultation with the team orthopaedist, the athlete was not allowed to impact load or grip with



A, Left wrist anterior-posterior radiograph. B, Clenched-fist anterior-posterior radiograph revealing radial bow deformity and Madelung deformity.

her upper extremity but did continue to participate otherwise in regularly scheduled gymnastics practices. After the initial injury, the dorsum of the left wrist became moderately swollen and increasingly tender to palpation. A treatment protocol was instituted twice daily for pain and inflammation control and consisted of ice-bag application, cold whirlpool immersion, transcutaneous electric nerve stimulation therapy, and oral nonsteroidal anti-inflammatory medication. Manual joint traction was also attempted but subsequently discontinued because of increased pain.

Three days after the injury, plain radiographs were obtained, and the athlete was evaluated by the team orthopaedist. Plain anterior-posterior, lateral, oblique, and closed-fist anterior-posterior radiographs revealed a Madelung deformity with a widened distal radioulnar joint (Figure). Physical examination revealed palmar subluxation with associated prominence of the radial and ulnar styloid processes, marked pain with passive pronation, and manual subluxation of the distal ulna volarly but no limitation in motion compared with the opposite side. Tenderness was evident on the ulnar side of the wrist over the dorsum of the triangular fibrocartilage complex and the dorsal aspect of the distal radioulnar joint. Results of tests for carpal instability, including scapholunate dissociation, were negative. The unusual appearance of the athlete's distal radioulnar joint, both grossly and on radiographic investigation, prompted the team orthopaedist to refer the athlete to the institution's team hand surgeon for further evaluation.

Ten days after the initial injury, the team hand surgeon evaluated the athlete. Before evaluation, the athlete continued to receive the symptomatic treatment protocol as described and continued to avoid upper extremity impact loading and gripping activities during practice; however, significant dorsal wrist pain persisted. The team hand surgeon concurred with

the team orthopaedist's diagnosis of a Madelung deformity and a proximal radial bow deformity. Most significantly, the widened distal radioulnar joint had allowed the lunate to migrate proximally and come to rest between the distal radius and ulna. Because of the persistent pain despite considerable activity restrictions and symptomatic treatment, a short-arm cast was applied for 10 days to more adequately allow the joint an opportunity to heal.

The athlete was again evaluated by the team hand surgeon 3 weeks after the initial injury. When the cast was removed, examination revealed only slight improvement in pain. At this time, the team hand surgeon discussed the possibility of reconstructive surgery to correct the deformity and potentially allow the athlete to return to competitive gymnastics without restriction. However, the athlete had significant reservations regarding surgical intervention for a number of reasons. First, she did not want to further disrupt her ability to participate in her art courses. Second, she was somewhat apprehensive that surgery would affect her ability to draw and sculpt as she had before the injury. Even though the involved hand was non-dominant, the athlete still used it extensively during her artwork. She feared that surgery could possibly alter her abilities and adversely affect her opportunities to gain employment in the future. Third, as a senior class team member, she did not wish to forgo her final season of eligibility because of surgery and extensive rehabilitation and attempt to compete during a fifth year. Since the athlete had no carpal instability, the team hand surgeon concluded that continuing to participate without surgical intervention posed no significant threat to further injury; however, the athlete's sensation of pain would most likely persist and even worsen with continued participation in competitive gymnastics. Based on this information, the medical staff, the athlete, her parents, and the gymnastics coaching staff agreed to attempt conservative management.

The medical staff made the decision to restrict the athlete from uneven parallel bars and floor exercise for the duration of her competitive career. Relative team strength on these events meant that the athlete had no realistic opportunity to contribute to the team scores in either event. As such, the medical staff deemed participation in those events to be unnecessary and counterproductive to the athlete's performance on the balance beam and vault. The athlete was allowed to return to the balance beam immediately and was gradually released to vault. Because of the tremendous forces transmitted through the wrists during the "block" of the vault when the gymnast forcefully strikes the apparatus with both hands and pushes off, this event proved particularly painful. The athlete noted sharp pain when her wrist was forced into extension as she blocked the apparatus during the performance of her vault. To prevent forceful end-range left wrist extension, a palmar-fan tape job was constructed of two 1½-in (3.81-cm) Johnson & Johnson Zonas tape anchor strips (New Brunswick, NJ) around the distal third of the forearm, 3 strips of 2-in (5.08-cm) Johnson & Johnson Elastikon tape placed fan shaped palmarly, and a continuous closure strip of 2-in (5.08-cm) Jay-lastic stretch tape (Jaybird & Mais, Inc, Lawrence, MA). Additionally, a leather wrist brace (Lion Paw, RBJ Athletics, Spanish Fork, UT) was used over the tape job. This combination of taping and bracing proved effective in preventing end-range left wrist extension while still allowing the athlete adequate mobility to successfully perform her vault.

During the season, the athlete occasionally noted periodic increases in pain. During such times, she would be restricted

from performing vault during practice until the pain subsided. Typically, such episodes would last 2 to 3 days. The athlete continued to receive symptomatic treatment consisting of ice-bag application, cold whirlpool immersion, and transcutaneous electric nerve stimulation therapy throughout the season with favorable results. Despite the injury, she was able to successfully complete the season having competed in every meet. Additionally, by season's end she had distinguished herself as one of the team's most consistent performers on both balance beam and vault. Finally, the athlete has been able to return to art classes and participate at her previous levels of ability in both drawing and sculpture with no complaints of pain.

DISCUSSION

Madelung deformity is described as an idiopathic, progressive curvature of the radius that results in a characteristic anterior subluxation of the hand with respect to the distal radioulnar joint.^{4,6,7} The disorder was initially described by Madelung in 1878, before the advent of modern radiography.⁸ Many authorities, including Madelung himself, credited Dupuytren with the first reference to the disorder.⁶⁻⁹ The disorder is relatively uncommon, occurring in less than 2% of the general population, and is most prevalent in female patients, at a ratio of 3 to 5:1 compared with male patients.⁹⁻¹³ Typically, the deformity is present bilaterally and seldom manifests clinically before the age of 7 years.^{9,13,14} Some authors suggest that the typical middle to late adolescent onset of the disorder may be linked to the adolescent growth spurt.^{6,8} Vickers and Nielsen⁸ contended that the long-standing and progressive radial deformity gradually worsens until it is suddenly exacerbated by the increased growth rate, often occurring concurrently with a premature physal fusion.

Individuals who present with the disorder are usually limited in pronation and supination of the involved extremity, although the source of that limitation remains controversial.^{6,8} On gross examination, the athlete usually presents with a characteristic palmar migration of the carpus and hand with respect to the distal radius and ulna. Additionally, he or she often complains of pain on the ulnar side of the wrist, which can sometimes mimic or occur concurrently with a triangular fibrocartilage complex lesion, making radiographic investigation essential.^{1,5} Radiographic findings most often associated with Madelung deformity include increased dorsal and radial bowing of the distal radius, a triangular-shaped carpus, an exaggerated volar and ulnar tilt of the distal articular radial surface, and positive ulnar variance.^{4,6,8,10-12,14,15}

Cause

The etiology of the disorder remains unclear, but all hypothetical causes produce a local growth disturbance at the ulnar and volar parts of the distal radial epiphyseal plate.¹³ Madelung deformity is commonly classified into 4 groups: idiopathic, dysplastic, genetic, and posttraumatic.^{4,6,8,9,12,16} Some have suggested that idiopathic Madelung deformity is probably not a true classifying group but rather a lack of conclusive implication of 1 of the remaining 3 causative groups.^{8,9} Dysplastic Madelung deformity is associated with dyschondrosteosis, multiple hereditary exostosis syndrome, diaphyseal acclasis, and onychoosteodysplasia, or HOOD syndrome.^{4,11,12,17} Dysplastic Madelung deformity is a form of mesomelic dwarfism; therefore, the deformity is usually accompanied by short

forearms and legs.^{8,9,11,16-18} Genetic Madelung deformity has been clinically associated with Turner syndrome; however, it has also very infrequently accompanied other genetic disorders as well.^{4,6,12}

Whereas the preceding 3 categories are heritable and not preventable, posttraumatic Madelung deformities are preventable because the disorder typically develops from long periods of overuse or abuse or both. Posttraumatic Madelung deformity is of particular concern in competitive gymnasts.^{1,2,4,5,19,20} The impact loading to the upper extremity required during gymnastics participation, coupled with the long duration of training most gymnasts undergo, tends to close the radial epiphyseal plate prematurely, ultimately leading to a Madelung or a Madelung-like deformity.^{5,6,9} Interestingly, some disagreement exists as to whether or not a posttraumatic episode with no associated genetic or dysplastic factors can actually produce a Madelung deformity. Lamb,¹⁰ Vender and Watson,⁴ De Smet et al,¹ and Mandelbaum et al² all referred to such a condition as a "Madelung-like" deformity, being careful to distinguish it from a true Madelung deformity. Most other authors make no such distinction.^{6,8,9,12-16} The prevalence of wrist pain in gymnastics is so great that the term *gymnast's wrist* has come into widespread acceptance. However, the subject of this case report is unique in that most gymnasts with a Madelung or a Madelung-like deformity are usually diagnosed as having the disorder early in their career and are either forced to discontinue participation because of pain or undergo surgical reconstruction to continue participation.^{1,2,4,5,19}

Treatment

Madelung deformity is typically treated with either rest or surgical reconstruction, depending largely on both the specific needs of the athlete and the relative severity of symptoms. A number of surgical procedures have been developed to correct the condition; however, in the absence of symptoms, surgical repair is not necessary.¹⁰ Furthermore, surgery is typically discouraged in adolescents and young adults because symptoms tend to subside with age, thus making surgery among the general population necessary only in cases of persistent significant pain.^{8,10,18} However, among symptomatic athletes who wish to prolong their athletic careers, surgical intervention provides the best chance to return to participation without pain or chronic sensations of instability.^{1,4}

Surgical repair usually consists of shortening or resection of the distal ulna or a wedge osteotomy of the distal radius or both.¹³ Although techniques vary considerably, each can be categorized into 1 of 3 groups.¹⁴ The first group includes techniques applied to the radius alone, such as epiphysiodesis, corrective osteotomy, and physiolysis.¹³⁻¹⁵ The second group involves repairs or reconstructions limited to the ulna, including epiphysiodesis, ulnar head excision, shortening osteotomy, distal ulnar resection, and creation of a pseudarthrosis with or without fusion to the radius.^{14,21} The third group involves some combination of the above techniques.

Most recent investigators found significant decreases in pain, improved range of motion, and improved grip strength after surgical correction. In one investigation, 18 patients who were dissatisfied with conservative treatment measures chose to undergo surgical correction.¹⁴ Of the 18, 9 cited pain as their primary motivator for surgical reconstruction. After surgery, 2 of those 9 continued to have pain, whereas the re-

mainder noted significant decreases in pain. Additionally, statistically significant improvement in range of motion and grip strength was apparent in all subjects. In another work by Vickers and Nielsen,⁸ 17 patients underwent surgical correction, 14 primarily to reduce pain and 3 to improve appearance. All patients with complaints of pain experienced significant relief within the first 6 months after surgery; however, only 4 indicated that pain was completely alleviated. Furthermore, all patients noted substantial improvements in range of motion, particularly in supination. No long-term complications were noted in any cases.

CONCLUSIONS

Madelung deformity is a rare condition that affects the structure and function of the distal radioulnar joint. Although the disorder is commonly linked to several heritable factors, most authors suggest that trauma may also be a factor. At the same time, competitive gymnastics requires repeated impact loading of the upper extremity, thus exposing the athlete to increased risk of wrist trauma due to the tremendous torsional and compressive forces sustained during sport participation. Typically, athletes with a symptomatic deformity either undergo surgical correction or cease competitive athletic participation. This particular case demonstrates a successful conservative care approach in which activity was limited to only essential training and competitive gymnastic movements. Additionally, local modality treatments and protective taping and bracing were used to manage and prevent pain as much as possible. Furthermore, the case is particularly unique because the athlete participated through all levels of competitive gymnastics (including the elite level) without complaint for 17 years before developing severe pain during her senior season in college. Although surgical reconstruction is regarded as the solution for symptomatic Madelung deformity among athletes who wish to continue to participate, conservative management should be considered a viable option before the athlete decides to discontinue participation.

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