Pseudo-Volkmann Contracture: A Case Report and Review of the Current Literature

Abstract

**Background:** Unlike the usual Volkmann contracture as a complication of pediatric forearm fracture, pseudo-Volkmann contracture is not a sequela of ischemia, but rather of a mechanical entrapment of the flexor myotendinous units in the fracture or adhesions.

**Methods:** PubMed search of the English literature was performed using the terminology entrapment and fracture and pseudo-Volkmann.

**Results:** Thirteen articles were identified that described cases of pseudo-Volkmann contracture in pediatric both-bone forearm fractures. Totally, 26 cases were reported in the English literature. Additionally, we describe two more cases in detail.

**Discussion:** Pseudo-Volkmann contracture is well described but uncommon. It most commonly involves the ring finger flexor digitorum superficialis but can occur in all fingers. This entrapment can be identified acutely with intentional examination by confirming full passive motion of the fingers after preferred treatment of both-bone forearm fractures in the pediatric patient. When contracture is identified on examination, surgical intervention to clear the entrapment from the fracture is effective and produces excellent results.

Pediatric forearm fractures can be complicated by compartment syndrome and Volkmann ischemic contracture. Tsuge¹ classified the ischemic contracture into mild, moderate, and severe. Despite surgical intervention, the patient rarely recovers full function.

In contrast, pseudo-Volkmann contracture as a complication of pediatric forearm fractures is not a sequela of ischemia, but rather of a mechanical entrapment of the flexor myotendinous units in the fracture or adhesions. In pseudo-Volkmann contracture, there is an absence of ischemic clinical findings, such as pain out of proportion at the time of injury or treatment, and no ischemic muscle found at the time of surgical treatment. Clinical findings include the inability to extend the fingers passively or actively when the wrist is in extension. The patient is able to extend the fingers fully when the wrist is flexed. This condition has an excellent prognosis for full recovery if diagnosed and treated promptly.
treated early. When treated after the patient develops joint contractures, a good outcome is more difficult to achieve.1-4

This phenomenon is reported in the literature using terminology of entrapment of the flexor muscles and pseudo-Volkmann contracture. Review of the literature reveals these conditions to be the same. Although the clinical entity is still uncommon, it may be more prevalent than previously thought. Hopefully, this clinical entity will gain improved recognition because diagnosis continues to be delayed and early intervention results in excellent results.

Two recent cases and a review of the literature are presented.

### Methods

We defined pseudo-Volkmann contracture as the inability to extend the flexor tendons. Review of the literature reveals these conditions to be the same. Although the clinical entity is still uncommon, it may be more prevalent than previously thought. Hopefully, this clinical entity will gain improved recognition because diagnosis continues to be delayed and early intervention results in excellent results.

#### Table 1

Reported Cases of Pseudo-Volkmann’s

| Article | No. of Patients | Age at Fracture (yr) | Fracture Type | Initial Treatment | Time to Recognition/Recovery (mo) | Entrapped Tendon | Surgical Treatment | Recovery |
|---------|----------------|---------------------|---------------|------------------|-----------------------------------|-----------------|--------------------|----------|
| Watson and Blair5 | 1 | 4 | BBFF | CR cast | 5 d, 3 mo | FDP I in rad | Myotenolysis | Full |
| Kolkmann et al6 | 1 | 9 | BBFF (Greenshock) | IM nail | 0 d, 0 d | FDP MRS in uln | Open release, IM ulna | Full |
| Akita 2005 JHS | 1 | 13 | BBFF | CR cast | 4 wk, 10 wk | FDS M in rad | PT (not help)—myotenolysis | Full |
| Deeney et al3 | 7 | 8 | BBFF | CR cast | 2 d, 2 d | FDP MR in uln | MUA | Full |
| 14 | BBFF | CR cast | 2 d, 14 d | FDP MR in uln | MUA | Full |
| 12 | BBFF | CR cast | 12 d, 12 d | FDP IMR in uln | Myotenolysis | Full |
| 11 | BBFF | CR cast | 17 d, 17 d | FDP MRS in uln | Myotenolysis | Full |
| 6 | BBFF | CR cast | 10 mo, 10 mo | FDP MR in uln | Myotenolysis | Full |
| 13 | BBFF | CR cast | 10 mo, 10 mo | FDP RS in uln | Myotenolysis | Full |
| 10 | BBFF | CR cast | 16 yr, 16 yr | FDP MR in uln | Myotenolysis, tendon transfer | Myotenolysis | Full |
| Jeffer7 | 2 | 12 | BBFF (Greenshock) | CR cast | 2 mo, 5 mo | FDP R in uln | Myotenolysis | Full |
| 9 | BBFF (Greenshock) | CR cast | 5 d, 9 mo | FDP R in uln | Myotenolysis | Full |
| Fernandez and Segal8 | 2 | 13 | BBFF (open) | CR cast, IM rod | 6 wk, 4 mo | FDP S in uln | Myotenolysis | Full |
| 8 | BBFF | CR cast | 6 wk, 6 mo | FDP SR in uln | Myotenolysis | Full |
| Littlefield et al2 | 5 | 15 | BBFF | CR cast | 9 wk, 13 mo | FDP I, FPL in rad | Release and lengthen | Full |
| 16 | Distal ulna | CR cast | Unknown, 5 y | FDP/FDS MRS in uln | Release and lengthen | Myotenolysis | Full |
| 11 | BBFF | CR cast | Unknown, 2 yr | FDP/FDS RS in uln/pin site | Myotenolysis | Full |
| 20 | BBFF | CR cast | Unknown, 2 mo | Unknown, 3 yr | FDP/FDS IMRS in DR | Myotenolysis | Full |
| 17 | BBFF | CR cast | 2 yr, 2 yr | FDP R in uln | Myotenolysis | Full |
| Rayan et al9 | 1 | 12 | BBFF | CR cast | 0 d, 6 wk | FDP R in uln | Myotenolysis | Full |
| Shaw et al10 | 2 | 5 | BBFF | CR cast | 0 d, 6 wk | FDP R in uln | Myotenolysis | Full |
| Hendel et al11 | 1 | 7 | BBFF | CR cast | 2.5 wk, 2.5 wk | FDP MR in uln | Myotenolysis | Full |
| Hendel et al12 | 1 | 8 | BBFF | CR cast | 9 yr, 9 yr | FDP R in uln | Myotenolysis | Full |
| Brogan et al13 | 1 | 12 | BBFF | CR—>ORIF | 0 d, 0 d | FDP R in uln | Immediate myotenolysis | Full |
| Song et al14 | 1 | 12 | BBFF | CR, IM rod | 2 wk, 3 wk | FDP R in uln | Full |
| Stevanovic 2012 | 2 | 13 | BBFF (open) | IM nail | 1 wk, 1 yr | FDS IMR in volar scar | Full |
| 16 | BBFF | ORIF | 6 mo, 6 mo | FPL, FDP/FDS IMRS, ulnar nerve in uln/scar | Myotenolysis, neurolysis, small finger, partial ulnar nerve palsy | Slight tenodesis |

BBFF = both-bone forearm fracture, CR = closed reduction, DR = distal radius, FDP = flexor digitorum profundus, FDS = flexor digitorum superficialis, FPL = flexor pollicis longus, I = index, M = middle, ORIF = open reduction and internal fixation, R = ring, rad = radial shaft, S = small, uln = ulnar shaft
fingers fully (contracture) because of the mechanical entrapment of the finger flexors associated with pediatric forearm fractures in the absence of signs of ischemia.

A PubMed search of the English literature was performed using the terminology entrapment and fracture, and pseudo-Volkmann. Inclusion criteria were articles in English that described finger flexion contracture as a result of mechanical entrapment of the finger flexors associated with ulna or radius fracture. Titles and abstracts were reviewed for suggestion of this clinical description. All applicable articles were further reviewed to confirm clinical entity of pseudo-Volkmann based on the earlier description. The references in the relevant articles were reviewed for additional relevant publications.

Exclusion criteria included the following: (1) Volkmann ischemic contracture from compartment syndrome, (2) fractures in which soft tissue blocked adequate reduction, thus requiring open treatment to treat fracture rather than to treat contracture or limited finger motion, (3) adhesions of the extensor compartment, (4) flexor tendon rupture resulting in the inability to flex fingers, and (5) nerve dysfunction as the primary indication for treatment, subsequently demonstrating nerve and tendon entrapment. We considered all of these to be separate clinical entities that result in open treatment not related to finger flexion contractures.

The publications were then reviewed to obtain the following information: patient’s age at time of fracture, fracture pattern, initial fracture management, time of pseudo-Volkmann diagnosis, fingers affected, time of treatment of contracture, intraoperative findings, method of treatment, and outcome of treatment were all collected from the articles.

Two recent cases of pseudo-Volkmann contracture that were treated are reported as illustrative cases. No outside funding was used.

### Results

Thirteen articles reported on cases of pseudo-Volkmann contracture, having finger flexion contracture as a result of mechanical entrapment of the finger flexors associated with pediatric both bone forearm shaft fracture in the absence of signs of ischemia. Totally, 28 cases were reported in the English literature (including 2 cases at our institution, which are described in detail below). Table 1 shows each case.

Of the 28 cases, 25 reported a both-bone forearm fracture (BBFF), 1 was a distal ulna fracture, and 2 were distal radius fractures. Age ranged from 4 to 28 years, with a mean age of 11 years. Diagnosis delayed an average of 16 months, ranging from no delay to 16 years; treatment delayed an average of 20 months. Fifty-four fingers were involved in 28 patients, with the ring finger being most commonly involved, and the middle finger being the second most common (Table 2). All fingers were included at least one time. Twenty-three cases involved the flexor digitorum profundus only, three cases involved flexor digitorum profundus and superficialis, and two cases involved the flexor digitorum superficialis alone. One case involved entrapment of both the flexor tendon and the median nerve. Of the cases reported that involved bone, 19 showed entrapment at the ulna, four at the radial shaft, and two at the distal radius. Most cases were treated with myotenolysis with excellent results. Two of the 28 patients had mild tenodesis effect after release. Twenty-six of the 28 patients had full range of motion (ROM) restored after intervention. There are two cases reporting resolution of symptoms with manipulation under anesthesia at 2 and 14 days after occurrence.

### Illustrative Cases

#### Case 1

A 13-year-old girl sustained an open BBFF. The laceration was volar, the deformity was seen in apex anterior, and both bones had a short oblique fracture pattern. She underwent irrigation and débridement with intramedullary nail fixation. Her pain was well controlled, and her compartments were soft. She had transient decreased sensation of her index finger only. One week after the surgery, she was noted to have difficulty flexing her index finger and making a fist. Therapy was initiated at 4 weeks postoperatively as a result of incomplete extension of all her fingers. At 8 weeks, she could only extend her wrist 10° before finger flexion occurred; some puckering of the skin at the scar of the volar open wound was observed. Despite improvement with therapy, at 1 year, she was unable to fully extend the proximal interphalangeal (PIP) joint of each finger with the wrist fully extended (Figure 1, A and B). She was referred to us. The contracture with the wrist maximally extended included the index (PIP, 40°), long (PIP, 60°), and ring (PIP, 25°) fingers. She underwent myotenolysis of flexor digitorum superficialis of index, long, and ring fingers, which

| Digit        | N<sup>a</sup> |
|--------------|--------------|
| Thumb        | 2            |
| Index finger | 6            |
| Middle finger| 13           |
| Ring finger  | 24           |
| Small finger | 9            |

<sup>a</sup> Number of times finger is involved in all cases.

### Table 2

| Digit | N<sup>a</sup> |
|-------|--------------|
| Thumb | 2            |
| Index finger | 6            |
| Middle finger | 13           |
| Ring finger  | 24           |
| Small finger | 9            |

<sup>a</sup> Number of times finger is involved in all cases.
were adhered to the volar scar and each other (Figure 1, C). A culture was obtained because of her open fracture and remained negative. Full passive extension was obtained with 90° of wrist extension intraoperatively (Figure 1, D). At 1 week postoperatively, she had full extension and flexion of her fingers with 70° wrist extension. By 1 month, she had full finger flexion and extension at 90° of wrist extension (Figure 1, E). She later presented with newly occurring limited flexion of her thumb consistent with an extensor pollicis longus (EPL) contracture. She underwent implant removal and was found to have a partial EPL rupture adjacent to the prominent radial intramedullary implant. The implant was removed, and the EPL was debrided tenolysed. She achieved full mobility.

Case 2
A 16-year-old female patient sustained BBFF and underwent open reduction and internal fixation at another institution. She presented to us after 6 months with a significant flexion contracture of the thumb interphalan-geal joint, which worsened with wrist extension and resolved with wrist flexion (Figure 2, A and B). Her other fingers were also involved but less severely. She also had ulnar nerve dysfunction with 50% subjectively decreased sensation, interossei wasting, and clawing of the ring and small fingers. She had intact median motor function; however, she reported mildly subjectively decreased median nerve sensation. Her findings had not changed with therapy. She underwent plate removal, myotenolysis of the flexor pollicis longus (FPL), and flexor digitorum profundus to each finger. The video shows FPL adherent and limiting thumb extension (Video 1, http://links.lww.com/JG9/A31). Her muscles appeared pink and viable, without signs of previous ischemia. A neuroma in continuity of the ulnar nerve was identified, and we performed a neurolysis; it was not found to be entrapped in bone. Her median nerve was intact. Full passive motion of FPL with wrist extension was achieved intraoperatively as shown in the video (Video 2, http://links.lww.com/JG9/A32). Intraoperative findings in response to treatment confirmed clinical entity of pseudo-Volkmann contracture, independent of ulnar nerve lesion. Postoperatively, she had an unchanged neurovascular examination and full thumb extension (Figure 2, C and D). She did have a residual minor contracture of the small finger with wrist extension, but this not bothersome to the patient, and she was very happy with her result.

Discussion
Pseudo-Volkmann contracture, from flexor tendon entrapment or adhesions, was generally considered a rare complication following pediatric forearm fractures, although recognized more commonly in distal radius fractures. This phenomenon occurs not as a result of compartment syndrome–related ischemia but rather of a mechanical entrapment of the flexor myotendinous units in the fracture, local trauma, or adhesions. Recently, there has been an increase in the publication of this phenomenon, suggesting that it may not be as rare as previously suggested.

This underscores the need for providers to examine every patient with BBFFs for limited finger mobility so that prompt surgical treatment can be pursued.
Clinical findings include the inability to extend the fingers passively or actively when the wrist is in extension. However, when the wrist is flexed, the fingers are able to extend fully. Although these examination findings also occur in mild Volkmann ischemic contracture, in pseudo-Volkmann contracture, there is an absence of ischemic clinical findings, such as pain out of proportion at the time of injury or treatment, and no ischemic muscle found at the time of surgical treatment.1-4

Extensor tendons can be entrapped similarly; however, this does not mimic Volkmann ischemic contracture. With the two cases presented here, there are 28 cases reported in the English literature to date, with the largest series reporting on 7 patients. The classic presentation is a pediatric patient with a BBFF treated with closed reduction and casting who demonstrated the inability to fully extend one or more digits during wrist extension in the absence of compartment syndrome. Delay in the diagnosis continues to be problematic. Fortunately, full or near full recovery after surgical release is possible, even in some patients who present many years after their injury.2,3,7,8,10 Although delayed presentation may occur as an adult, skeletally mature BBFFs are treated with open reduction, thereby minimizing the risk of this phenomenon except by adhesions.

Review of the literature shows that Pseudo-Volkmann contracture is most often a result of entrapment or adhesion of the flexor digitorum profundus on the ulna in a patient with a BBFF. This phenomenon has been commonly associated with a short, oblique fracture pattern of the ulna.3 Although any finger can be involved, the ring finger is commonly involved, likely because of its anatomic location on the ulna.7

In our series, case 2 had a contracture, numbness, and motor palsy on presentation that were concerning for Volkmann ischemia. However, the patient did not have pain out of proportion at the time of her fracture or after open reduction and internal fixation. Her sensory and motor abnormalities occurred at the time of her fracture. Intraoperatively, we identified a localized injury to her ulnar nerve without findings of entrapment or ischemic muscle. In this case, the intraoperative findings were helpful in making the diagnosis of pseudo-Volkmann contracture with ulnar nerve injury. In similarly presenting clinical scenarios, consideration can be given to advanced imaging studies or electrodiagnostic testing to help guide decision making.

We recommend exploration of specific nerves in the setting contracture with neurological abnormalities so that they may be appropriately addressed based on their pathology. Falsely attributing neurologic abnormalities to ischemic etiology may preclude appropriate management of a nerve injury. We further recommend thorough inspection of the muscles when undertaking surgical intervention for finger contractures following forearm fracture because accuracy of diagnosis has important implications for prognosis, surgical decision making, and medicolegal concerns.

Our two patients were both older than the average age reported in the literature. Despite myotenolysis of the involved tendons, our patient in case 2 had remaining mild contracture of the small finger. We propose that the incomplete recovery despite complete myotenolysis may be related to the older age of the child with a delay in diagnosis or local direct damage to the muscle. Previously, authors have used tendon lengthening to address this situation; however, given the mild nature of the residual contracture and the confounding ulnar...
nerve palsy, we elected not to pursue tendon lengthening. We advocate aggressive early intervention whenever possible to have the best prognosis for contracture and nerve injuries.

The diagnosis of finger contracture from musculotendinous entrapment, pseudo-Volkmann contracture, is often delayed until the cast is removed after fracture healed. To avoid this delay, several authors have recommended immediate evaluation of digital passive ROM of the fingers, in both wrist extension and flexion, after closed reduction to detect entrapment. Once ischemic Volkmann contracture from compartment syndrome is ruled out clinically, then a diagnosis of pseudo-Volkmann contracture can be made.

Hendel advocated testing extension the ring finger at weekly intervals. When stiffness or pain was present, aggressive physiotherapy was started, and extension lag was ultimately avoided. These patients were termed to be at an imminent risk of contracture, likely because of the development of adhesions.

Physical therapy has not been shown to adequately treat these contractures once established. If the contracture is diagnosed acutely, as with entrapment, then r-manipulation is indicated and may occasionally be successful at resolving entrapment. The success of remanipulation declines after 2 weeks. If full passive motion of the fingers after remanipulation is unsuccessful, surgical release must be performed. Usually, myotenolysis at the area of adhesion provides recovery of full ROM. Occasionally, lengthening of the musculotendinous unit is helpful to acquire full motion.

We agree with the recommendations of previous authors that each patient be confirmed to have full painless passive motion of the fingers and thumb at the time of initial fracture treatment. We also propose that full passive motion be confirmed at 1 week and at each subsequent appointment. Delay of diagnosis may be particularly detrimental in older patients because patients nearing adulthood may develop contracture of the myotendinous unit or the PIP joints more quickly and be more difficult to treat with a simple myotenolysis.

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