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Case Report

Pediatric Bowstring of Postoperative Trigger Thumb and Fingers, Overview Complications

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Abstract

A Female 6 years-old had Operatived pulley release for trigger thumb left hand. Although his triggering was relieved girl continued to have pain. The Quick D.A.S.H. functional score of upper limb was 35.00/100. It was believed he might have persistent adhesions and a second exploration was done 6 months later. A portion of the A2 pulley was also released, and a tenolysis was performed. When seen again 3 years later severe bowstringing had developed. This bowstringing caused both a painful pulling sensation in girl's palm and the inability to fully extend the thumb. By manually depressing the tendon, however, extension could beachieved. Proximal pulley reconstruction was therefore recommended. Active motion was started 2 weeks later. At 10 weeks she had regained full flexion and extens. Absence of the bowstringing was quite evident and the Quick D.A.S.H. functional score of upper limb was 80.00/100. This study have recoment anatomy hand, Fingers and Thumb. Focus hand tendon, pulleys system.

Pathologic changes, Pulley disorders, Complications, Risk Factors Diabetes, tobacco..

Keywords: Congenital Trigger Thumb; Bilateral Trigger Thumb and Variable Pulley of Thumb; Bowstringing; Oblique Pulley; Unullar Pulley

Introduction

Trigger finger is a common musculoskeletal condition, with a lifetime risk of 3% in the general population [1]. Corticosteroid injections are the mainstay of treatment, helping to resolve symptoms in 40%-90% of patients. In cases where nonsurgical treatment fails or there are severe symptoms (e.g., flexion contractures), surgical release of the A1 pulley may be considered. Although it is known that releasing the A1 pulley can significantly reduce pain and improve hand function, complications such as infection and nerve damage can occur. Postoperative complications are associated with prolonged recovery times, delayed resumption of work, and costs associated with additional interventions [2].

In the literature, reported complication rates vary widely from 0% to 43% [3]. This is mainly due to inconsistent definitions of complications, as some studies consider only objective events (e.g., infection, nerve damage) as a complication, while others Other studies also included patient-reported complications (e.g., joint stiffness or pain). In a previous study, we used the recently proposed tool of the International Consortium on Health Outcomes Measures in Hand and Wrist (ICHAW) to classify variables. symptoms in a large sample of patients who underwent A1 pulley release. We found that 17% of patients had complications. Although most complications are mild, 2% of patients require repeat surgery. Although these findings contribute to a better understanding of the incidence and severity of postoperative complications, an in-depth understanding of the risk factors for these complications is needed. to enhance the clinical application of these results.

Previous studies have identified several risk factors for postoperative complications, including male gender [4], smoking [2], and diabetes [2,5]. While most studies primarily examined patient characteristics, only a few evaluated clinical characteristics. For example, the number of preoperative steroid injections and the time between the last injection and surgery have been studied primarily in relation to postoperative infection [5]. Considering that these factors can be taken into account during preoperative management, a better understanding of these risk factors is essential to improve patient counseling and potentially target target modifiable risk factors. Therefore, this study aimed to identify patient characteristics, clinical characteristics, and preoperative patient-reported outcome measures associated with complications following A1 pulley release surgery. Additionally, we evaluated whether these risk factors differ based on the severity of the complication.

This study reports the results of surgical treatment to release A1 pulley after trigger thumb surgery at Vietnam National Hospital for Pediatric.

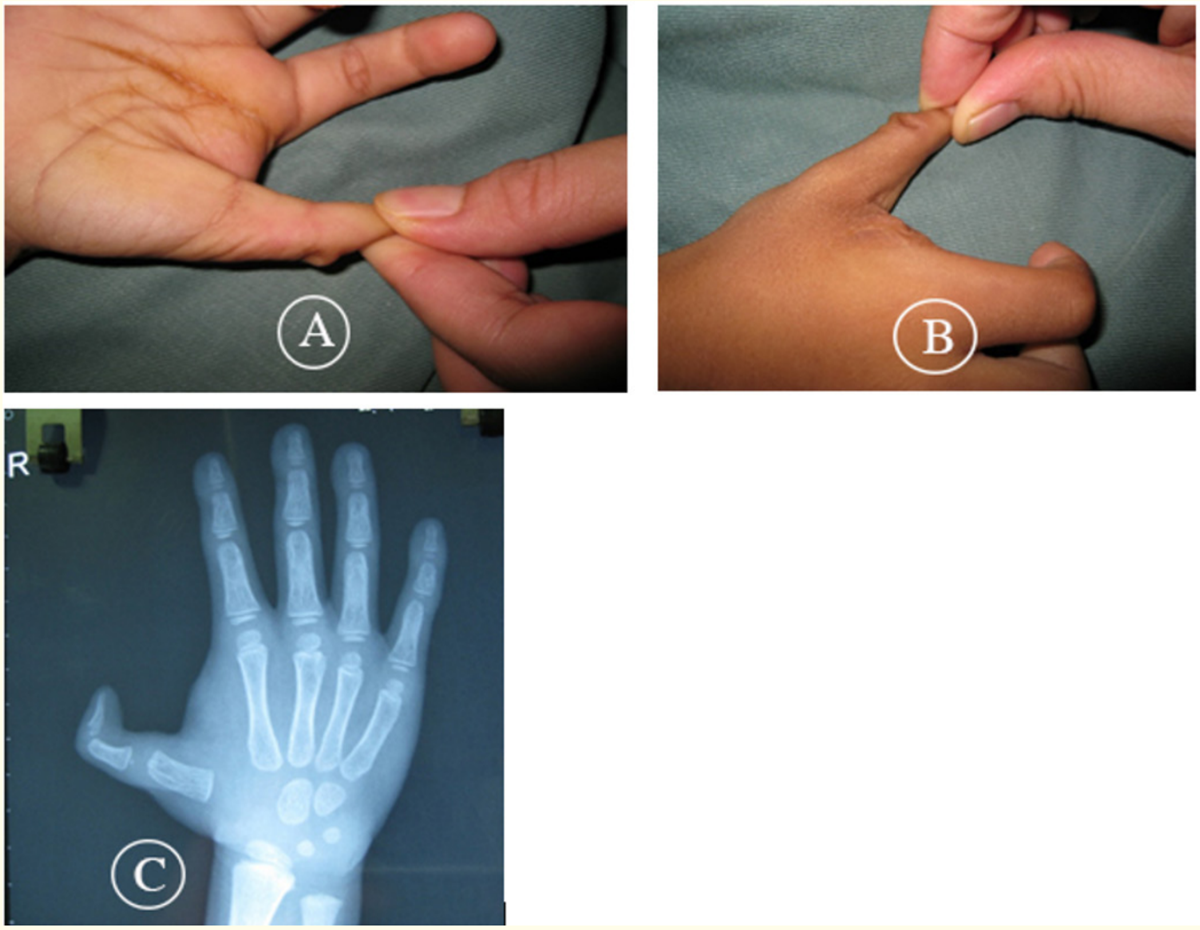
Case Report

A Female 6 years-old had Operatived pulley release for trigger thumb left hand in June of 2012 after failure of conservative treatment. The flexor tendons appeared normal. Although his triggering was relieved girl continued to have pain. The Quick D.A.S.H. functional score of upper limb was 35.00/100. It was believed he might have persistent adhesions and a second exploration was done 6 months later. A portion of the A2 pulley was also released, and a tenolysis was performed.

After operation girl continued to complain of pain in girl's palm although girl's thumb regained full motion without triggering. The cause of his persistent pain was never established and it was believed girl might have mild reflex sympathetic dystrophy (RSD). Girl was treated with a TENS unit and it took nearly a year for girl pain to resolve. He continued to complain of a pulling sensation but examination at 1 year revealed only a small amount of bowstringing and no surgery was recommended.

When seen again 3 years later severe bowstringing had developed (Figure 1). This bowstringing caused both a painful pulling sensation in girl's palm and the inability to fully extend the thumb. By manually depressing the tendon, however, extension could be-achieved (Figure 1). Proximal pulley reconstruction was therefore recommended.

At operation, significant loss of the A2 pulley was found (Figure 2). A slip of the palmaris longus was passed around the phalanx deep to the extensor mechanism to reconstruct the A2 pulley (Figure 3). Active motion was started 2 weeks later. At 10 weeks he had regained full flexion and extens. Absence of the bowstringing was quite evident and the Quick D.A.S.H. functional score of upper limb was 80.00/100.



Figures 1: A, B. Clinical and C. Radiography.

Anatomy, phisiology and functional restoration of the thumb

The human thumb is considered one of the fundamental differences between us and the rest of nature. Charles Bell [6] wrote qualitatively about its importance: "the length, strength, free horizontal movement and perfect mobility of the thumb depend on the strength of the human hand." Quantitative descriptors have evolved to meet the need for impairment ratings and post-injury compensation assessments. Thumb function is often listed as 40% of the total usability of the hand. Slocum and Pratt [7] obtained a numerical result of permanent impairment by assigning percentages to hand function as follows: grasping ability, 50%; pinch, 30%; and hooks, 20%. Since the thumb is involved about half of the time in grasping and pinching functions, it is assigned a relative value of 40% (0.5 x [50% + 30%]) [7]. This percentage gives an idea of the value of the thumb, but this number can certainly change. A number like this can be useful for compensation and reimbursement, however, evaluating a percentage according to strict criteria is not helpful in evaluating a specific individual for finger reconstruction. thumb. The value of the thumb depends on each person's profession, interests, aesthetic needs and psychosocial attitudes. Therefore, there can be many different approaches to the same anatomical thumb defect, each targeting a different reconstructive target.

The importance of the thumb lies in its ability to provide the human hand with grasping functions. Napier [8] described the concepts of precision and grip strength in 1956 and Landsmeer [9] expanded on these concepts in 1962. These discussions were groundbreaking because they used term designed to describe the function of the hand and thumb based on purpose or activity. A typical example is illustrated in the process of removing a lid from a jar. Initially, the lid is tightly closed and requires an "electric grip", with the thumb located in the plane of the hand. Once the cap is loosened, the thumb moves out of the plane of the hand and faces the other fingers, thereby providing "accuracy" and speed. The thumb provides strong opposition to the stability, mobility, and precise placement of the other digits. These tasks require thumbs of appropriate length and strength. Along with aesthetic considerations, these elements form the foundation of any reconstruction plan.

Functional anatomy

Flexion, extension, abduction, adduction, anterior advancement, retropulsion, and circumcision have all been used to describe the movements of the thumb [10]. Opposition requires many separate movements at each of the three joints of the thumb, the mechanism of which remains controversial. Additionally, pronation and supination movements are required to bring the thumb bulb into a position opposing the fingers. Opposition then requires simultaneous abduction, flexion, and pronation.

The joints of the thumb are controlled by (at least) nine separate muscles that are classified as intrinsic or extrinsic muscles. The extrinsic muscles originate in the forearm and pass through the wrist to distribute tendons to the thumb. The intrinsic muscles arising in the hand form a cone surrounding the base joint and metacarpal bones, providing not only motor function but also stability. The intrinsic and extrinsic muscles work efficiently and cooperatively to balance the thumb in a variety of complex positions and functions.

The thumb has three joints, each maintaining a balance of mobility and stability in an inverse relationship. Maximum mobility and minimum stability are seen in the trapezius joint. These relationships are reversed at the distal joints, with maximum stability and minimum mobility seen at the interphalangeal joints. All three joints of the thumb contribute to the complex spectrum of movements that the thumb is capable of, each limited by the intrinsic limitations of the joint surface and the tendons, muscles and ligaments around.

Trapezoidal joint

The basal joint (carpal or trapezoidal joint) gives the thumb a wide range of motion. It is described by Eaton and Littler [11] as two opposing saddles with perpendicular longitudinal axes. These two "saddles" allow the perpendicular movements of flexion-extension and adduction-adduction to occur at the same joint. This joint also allows approximately 10 to 20 degrees of rotation. The joint surfaces are in close contact during full flexion and adduction, while there is little contact during full extension and abduction. Maximum rotation occurs at the midpoint of flexion-extension and abduction-adduction, sometimes referred to as the "lax" position.

The balance between mobility and stability at the basilar joint is provided by a number of ligaments and tendons. There are four main ligaments. The first of these is the anterior cruciate ligament, which extends from the beak of the first metacarpal base to the tubercle of the trapezius. This structure remains relatively stable with movement. The intermetacarpal ligament extends to the base of the first and second metacarpals, becoming taut when fully abducted [12]. The lateral radial ligament (dorsal radial ligament) connects the dorsal tubercle of the trapezius to the posterior aspect of the first metacarpal, and tightens with the first metacarpal during flexion and adduction. The last of the four major ligaments is the posterior cruciate ligament, which runs from the dorsoulnar tubercle of the trapezius to insert with the anterior cruciate ligament on the beak of the metacarpal base. Flexion and abduction are limited by this ligament [12]. There are several opinions regarding the importance of each of these ligaments, however it appears that the first interphalangeal ligament and the anterior oblique ligament are the most important in providing stability to the wrist joint. (CMC) [11]. In addition to the effects of the basilar joint ligaments, the tendons of the extrinsic muscles contribute to the stability of the CMC and metacarpophalangeal (MCP) joints [12].

Metacarpophalangeal Joint

Moving from proximal to distal, the thumb joints exhibit increased stability but at the cost of fewer degrees of freedom. The MCP joint of the thumb provides important stability in precision grip functions and grip strength [12]. Because of its important stabilizing role, the MCP joint of the thumb is significantly different from that of other fingers. It essentially provides a "hinge" function, although some rotation, abduction, and adduction occurs. The joint itself is considered a condyle, although the condyle of the first metacarpal is less spherical than the other metacarpals, thus limiting lateral movement. Flexion at the MCP joint of the thumb ranged from 5 to 100 degrees, with an average of 53 degrees. Abduction and adduction, as noted previously, are limited and range from 0 to 20 degrees with an average of 10 degrees. The pronation that occurs in flexion at the MCP joint is first produced by differences in condylar projection: the radial condyle projects slightly more than the ulnar condyle. This swivel works in concert with the CMC joint to help create the pulp-to-pulp clamping force needed for precise grip.

Stability of the MCP joint is provided not only by the surrounding tendons but also by the dense ligaments, the medial and posterior plates of the joint capsule, and the surrounding muscles. The collateral ligaments and lateral collateral ligaments provide important lateral and radial support.

Interphalangeal joints

The most distal joint of the thumb is the least mobile and least complex. The interphalan-geal (IP) joint is a trochlear joint that functions as a hinge [12]. It has a supporting ligament structure similar to the IP joint of the finger. The long extensor and flexor tendons of the thumb provide additional support. In addition to the flexion and extension observed at this joint, there is also a small degree of rotation produced in a similar fashion to the MCP joint.

Motors of the thumb

The coordination of the intrinsic and extrinsic muscles provides flexible grip function using all three thumb joints. The functions of the extrinsic muscles, innervated by the radial and median nerves, complement those of the intrinsic muscles innervated by the ulnar and median nerves.

The membranous (synovial) system.

Bunnell [13] notes that the tendon sheath is an adaptation that allows the tendon to contract at an angle. "It glides around a curve on a thin film of synovial fluid between two smooth synovial-lined surfaces, just as a metal surface in a machine glides on a thin film of oil," Bunnell notes. that the tendon sheath has two layers of synovial membrane, the visceral covering the tendon and the apical layer lining the fascial tunnel (retinaculum) through which the tendon glides. Lundborg and Myrhagc [14] noted a well-vascularized membrane with folds and the pockets at the edges of the pulleys are important for the bending and extension of the shell. They could not demonstrate continuity of the synovial cell layer on the friction surface of the A2 pulley. Chondrocyte-like cells were observed in the superficial layers of this pulley. In some avascular areas in the palmar portion of the tendon, visceral synovial tissue was absent on histological sections. Furthermore, in some scattered areas on the palmar surface there are areas with cartilage differentiation similar to that found in the A2 pulley. Lundborg and Myrhage [14] concluded that the friction surface of the pulley is avascular and that friction and sliding in the digital sheath system takes place between two vascular structures, specifically the palmar surface of the tendon folds and the inner surface of the pulley. These avascular gliding surfaces are nourished by diffusion from the synovial fluid. Histological studies by Lundborg and Myrhage [14] demonstrated that the vascular plexus of the synovium is continuous on the outside of the rigid pulleys and that by this arrangement the pulleys respond to the mechanical forces involved. involves flexing the finger and the synovial membrane avoiding compression and friction. Therefore, microcirculation is not harmed. The authors [14] further noted that synovial fluid acts as a lubricant, as well as a diffusing agent to the vascular friction surfaces of tendons and pulleys.

The findings of Lundborg and Myrhage are compared appropriately with those of Cohen and Kaplan [15], who in a recent study of gross, microscopic and ultrastructural (microscopic) e) of the flexor tendon sheath, it was noted that the sheath consists of an uninterrupted layer of the apex. The synovium is reinforced externally at intervals by dense collagen bands (retinal system). Cohen and Kaplan [15] further noted that the intrathecal contents are covered independently by a second, similar layer of synovial membrane and that these two layers are continuous proximally, the origin of the tendon holes and tendon insertion points.

The synovial cells lining the pulleys and covering the tendons are numerically, but not morphologically, distinct from the synovial cells of the membranous (synovial) portion of the sheath. The thickness of the synovial layers is greatest in the spaces between the pulleys and is thin or thin below the annular pulleys and on the tendon surfaces away from the tendons and dead-end pockets.

Discussion

Bowstringing is a rare hand injury that involves finger trigger movements. Each finger in your hand has three bones, called the proximal, middle, and distal phalanges. You also have tendons that connect the muscles to the bones and five flexor tendon pulleys that connect the tendons to the knuckles. These pulleys are called A1-A5, where A1 is the pulley closest to the palm and A5 is the pulley closest to the fingertips (Figure 2). To improve your understanding of bowstrings, here is a description of each pulley.

- **First annular pulley (A1):** This joint pulley attaches near the head of the metacarpal bone in the palm of your hand and extends to the base of the first knuckle.
- **Second annular pulley (A2):** This pulley extends from the bottom of your finger to your top knuckle, where the proximal and distal phalanges meet on the palm side of your hand.
- **Third annular pulley (A3):** The A3 pulley is the smallest of the joint pulleys and extends across the middle knuckle of your hand, called the proximal phalangeal joint.
- **Fourth annular pulley (A4):** The A4 pulley is in the midsection of the middle phalanx, meaning it's between the two knuckles closest to your fingertips.
- **Fifth annular pulley (A5):** This joint pulley is below your fingernails, meaning it's near the joints of your fingertips.

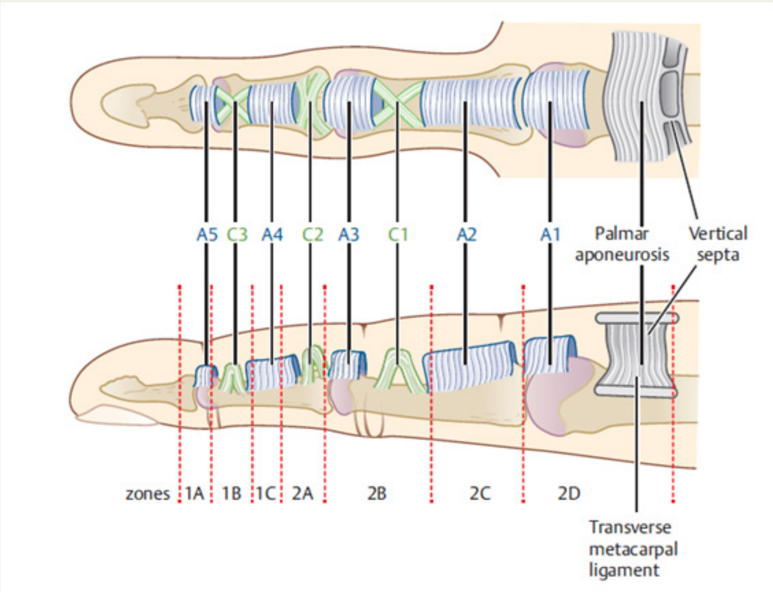


Figure 2: Location of the annular pulleys in a finger. Note the A2 and A4 pulleys are largest and critically located among all pulleys.

A bowstring occurs when a pulley malfunctions or breaks, causing pain and stiffness in the finger. It usually involves a pulley located in the middle finger, such as A2 or A4. These pulleys activate the most of the five pulleys when you bend your fingers, so feeding the bowstring in relation to these pulleys can cause increased stiffness or immobility of the finger. Although chordee can also occur in other tendons, such as the wrist or forearm, the term is most commonly used to refer to conditions of the fingers (Figure 3).

Causes of bowstringing

Bowstringing can result from excessive external stress on the fingertip that causes one or more of the essential flexor tendon pulleys to rupture. (Figure 4). This external stress result from putting an.

Bowstringing often presents in athletes, especially those who rely heavily on their hands. Rock climbers, for example, often carry their full body weight in their fingers, which may cause flexor tendon rupture. Baseball pitchers may also be susceptible to this type of injury, as they use their fingers to perform intense repetitive actions. Bowstringing can occur over time because of repeated wear on the trigger pulley system. As a result, some patients experience a slow progression of symptoms over many years (Figure 5).

Common bowstringing symptoms

In cases where the bowstring is too heavy when the individual has multiple pulleys torn, the tendons may protrude through the skin. In these cases, the tendon appears like a bowstring between its remaining attachment points. Other cases of bowstring ligation

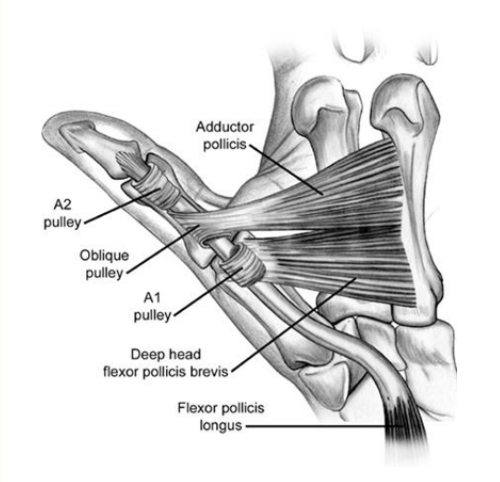


Figure 3: Annular and Oblique pulley on thumb.

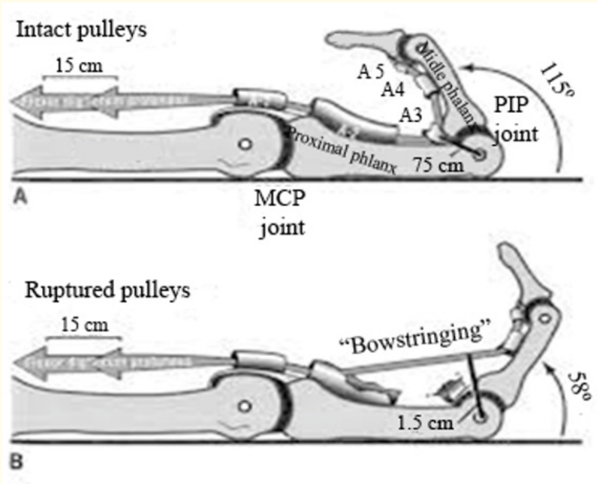


Figure 4: Ruptied pulleys excess weight on a pulley, angling the phalanges and joints away from a joint’s center of rotation, or a combination of both occurrences. Bowstringing can also occur when deep cuts to the hands and fingers sever a pulley.

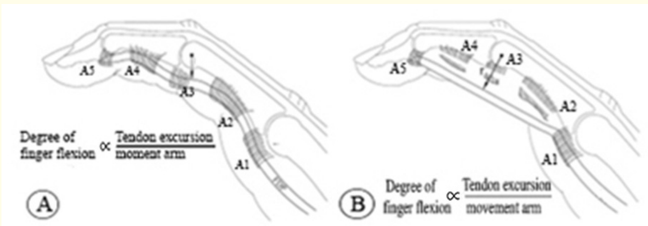


Figure 5: A-B. Biomechanics of the flexor tendon pulley system. The amount of finger flexion is proportional to tendon excursion and the moment arm (r). A. The intact pulleys keep the flexor tendons close to the axis of rotation of the finger joints, thereby maximizing total finger flexion. B. The moment arm (r) increases with pulley insufficiency leading to maximum tendon excursion before full finger flexion can be obtained. The flexor digitorum superficialis has been excluded for simplicity.

may have less obvious symptoms, such as general swelling or pain in the fingers. If you’re worried that you’re experiencing strain, compare your experience with the following symptoms

- Hearing loss at the time of injury.
- Pain or tenderness on the palm side of the finger.
- Swelling of the affected area.
- Pain when squeezing fingers.
- Pain or difficulty extending the finger fully.
- Pain or difficulty when trying to bend the fingers.
- Pain or difficulty when trying to curl your fingers into a fist.

If you have an injury, you can check to see if it is related to symptoms in the tendons and pulleys. To do this, use your uninjured hand to hold straight the two knuckles closest to the palm on the injured finger, then try to bend just the fingertips. Next, use your uninjured hand to hold all fingers in a straight position and try to bend the affected finger toward the palm. If you have difficulty with one of these activities, your injury may lead to the need for a ligation. Medical doctors may use an ultrasound machine to confirm this diagnosis.

Treatment options for bowstringing

Treatment options for bowstring ligation depend on which pulley is malfunctioning. A2 pulley ruptures and most A4 pulley ruptures are best treated with surgery. Surgery may also be necessary in cases of extensive rupture or delayed treatment. Rope repair surgery involves using a tendon graft taken from the patient’s wrist to reconstruct the torn pulley. To accomplish this, the surgeon may wrap the tendon graft around the tendon and bone at the site of the pulley rupture. You can usually treat a tear or partial rupture in the A1, A3, or A5 pulley with nonsurgical interventions, such as splinting or physical therapy.

Another treatment option is to wear a bracelet over the injured pulley as a splint. Rest is also an important part of any strain treatment plan. For example, if you sustain a mild pulley injury while playing sports, your specialist may advise you to stop the activity until your finger no longer feels pain or swelling. For people recovering from more serious pulley tears, especially those requiring surgery, recovery can last several months, with certain activity limitations for up to a year.

Treatment of acute flexor pulley injuries is mainly conservative, especially for level I, II, and III injuries. Rest, ice, anti-inflammatory medications and orthotics are the first measures. External tape or loops have also been shown to reduce tendon strain and limit flexion at the PIP joint, thereby reducing pulley loading and re-injury [16].

Corticosteroid injections should be avoided in the treatment of suspected pulley injuries because they may cause rupture or slow healing. In complex injuries (grade IV), in which multiple pulleys are ruptured simultaneously or where injuries to the psoas muscles or collateral ligaments are involved, surgery is preferred. The goal of surgery is to prevent flexor contractures and reduced range of motion caused by the flexor tendons. For blunt injuries, primary repair of the pulley remnant is ineffective; Therefore, efforts have focused on reconstruction strategies.

Several variations of pulley reconstruction have been described, but all techniques follow the 2 basic principles of noncircular reconstruction or the circumferential method (Figure 6). Weaving the tendon or graft over the residual pulley is an example of a non-circumferential technique, and circumferential looping of the graft around the phalanx is characteristic of the encircling technique. With the wrap-around technique, the graft is placed deep to the extensor mechanism on the proximal phalanx and superficial to it on the medial phalanx during A2 and A4 reconstruction, respectively. Palmaris longus tendon tissue and extensor retinaculum tissue are the grafts of choice, and regardless of graft type, good results have been reported for both methods with similar levels of recovery to pre-injury levels. when climbing mountains [17,18].

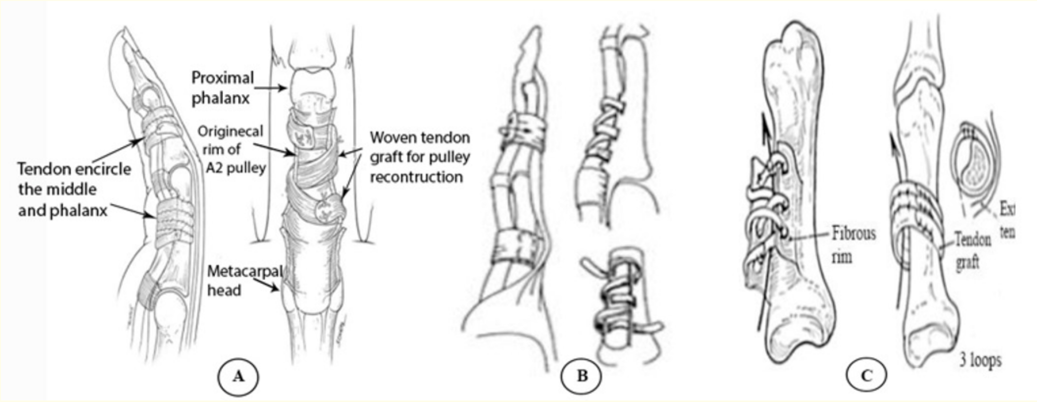


Figure 6: A-C. Some Pulleys Shaping techniques

A1 and oblique pulley

This study identified a distinct annular (Av) pulley located between the A1 pulley and the thumb oblique pulley. The thickness of the Av pulley is similar to the thickness of both the A1 and the oblique pulley. The A1, Av, oblique, and A2 pulleys have the following respective widths measured when extended: 4 to 8 mm, 4 to 8 mm, 3 to 5 mm, and 5 to 10 mm. Doyle and Blythe [8] reported that the A1, oblique, and A2 pulleys have the following widths: 7 to 9 mm, 9 to 11 mm, and 8 to 10 mm, respectively. Therefore, there are clear differences in the reported widths for the oblique pulley between the 2 studies. This difference can be explained by the fact that the width of the oblique pulley, reported by Doyle and Blythe [8] is almost equivalent to the width of both Av and the oblique pulley in our study, suggesting they considered them a single structure. In previous work, investigators reported that the proximal end of the oblique pulley is closely related to the tendon attachment of the adductor [8]. In fact, the Av pulley always starts at the musculotendinous junction of the adductor muscle (Figure 7,8). They reported that their anatomical study was based on observations in the operating room, cadaveric dissections, and thumb dips without actually indicating the total number of specimens studied. In contrast, a recent study by Schmidt and Fischer [19] showed that the original anatomical arrangement of the pulley system in the thumb described by Doyle and Blythe [8] was found in only 10%. their specimens. In 90% of the specimens, a Y-shaped fiber complex was identified between pulleys A1 and A2.

The study not only showed the existence of the Av pulley but also showed significant variation in its shape with three clearly defined types. It is of course possible that in a larger sample there will be other variants identified. Our observation that the oblique pulley is loose during flexion and tight during thumb extension is supported by biomechanical data. This suggests that the oblique pulley has no role in preventing contracture of the longus flexor tendon. Even when dividing the A1 or Av pulley or both, the tension in the oblique pulley is still higher in extension than in flexion. Our findings are also supported by the observation that contracture of the thumb flexor tendon occurs only when both the A1 and Av pulleys are divided; An intact oblique pulley alone cannot prevent ligamentous strain (Figure 7).

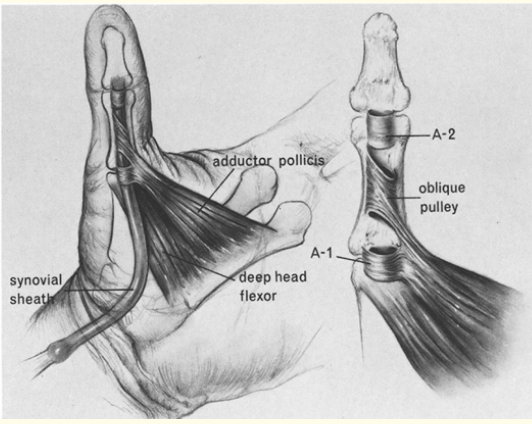


Figure 7: The thumb flexor bursa is a double-walled hollow tube that is sealed at both ends. The sheath starts at 2.0 cm. proximal to the radial styloid process and ends just distal to the interphalangeal joint. Above the housing and pressed against it are three fixed pulleys - two annular and one oblique. The first ring, located at the knuckle, is 7 to 9 mm long. wide and 0.5 mm. thick. The oblique pulleys go from ulnar-proximal to radial and range in size from 9 to II mm. wide at its medial aspect. The second annular pulley is located near the attachment site of the flexor pollicis longus and is 8 to 10 mm long. wide but quite thin.

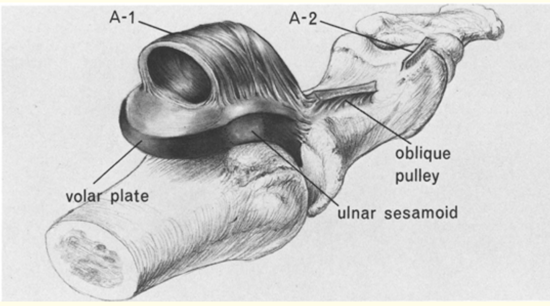


Figure 8: The first annular pulley at the level of the metacarpophalangeal joint arises primarily from the medial facet plate. One-third of its origin is from the base of the proximal phalanx. The oblique pulley arises from the ulnar side of the proximal phalanx base and runs obliquely across the phalanx to insert into the neck of the phalanx just proximal to the interphalangeal joint. The second annular pulley at the level of the interphalangeal joint arises from the bones and the liver plate. It is quite thin compared to the more substantial first annular pulley.

Previous biomechanical studies indicate that an intact oblique or A1 pulley can maintain normal thumb flexor tendon mobility and thumb function. Zissimos., *et al.* [20] performed sequential cutting of the thumb pulleys and measured the tension of the thumb flexor tendon during various joint movements. Their findings indicate that repair of the A1 or oblique pulley restores normal function of the thumb. Another study by Esplin., *et al.* [21] investigated intact and injured thumb pulleys in different anatomical locations. They concluded that an intact oblique or A1 pulley can maintain normal movement of the flexor pollicis longus tendon. These studies are based on previous descriptions of the anatomy of the pulley, making direct comparison with our study difficult. This study shows that ligation can be prevented as long as one of the A1 or Av pulleys remains intact. We show that in the classic version of activation, only the A1 pulley is divided, and there is anecdotal evidence that sometimes a large chord phenomenon can occur requiring pulley reconstruction (supposedly is the simultaneous division of both the A1 and Av pulleys) (D. Evans, MD, personal communication, October 2001). A follow-up study of 37 surgically treated trigger thumbs in patients under 15 years of age found that 25% had 1 to 2 mm of chordee [22].

The function of the oblique pulley remains a matter of conjecture but our hypothesis is that it may have the effect of limiting hyperextension of the thumb interphalangeal joint in conjunction with the medial plate, especially in condition of medullary pinching and key pinching. Related evidence supporting this hypothesis is that the oblique pulley is a sturdy structure, it inserts on either side of the interphalangeal joint, and it exerts maximum tension when fully extended. In addition, the oblique pulley has the same function as the cross pulleys in other digits, i.e. facilitates the approximation of annular pulleys during bending. This theory is supported by the fact that the arrangement of the thumb pulley, A1-Av-obliqueA2, is similar to the arrangement of the other digits, A1-A2-C1-A3 [23].

Some of our samples show some horizontal fibers suggestive of a cruciform shape associated with oblique pulleys. The specific development of the oblique pulley may reflect the special balance of mechanical forces acting through the shell during normal activity and movement. In this case, the insertion of the guide into the bottom of the oblique pulley may contribute to the generation of mechanical stresses that determine its dimensions. It would be interesting to perform comparative anatomical studies in apes lacking an opposable thumb, in which the oblique pulley might be thought to be a less important structure.

The clinical significance of our findings is in the treatment of trigger thumb and pulley reconstruction. It has also been proposed that repair or rehabilitation of the A1 pulley or the Av pulley (both damaged) would be sufficient to restore normal motion of the thumb and prevent chordee tendon strain. long thumb fold. Future availability of DVRTs will allow further biomechanical studies to be performed. This will ultimately help evaluate the relative function of the A1 and Av pulleys in more detail.

Pathologic changes

Normal anatomy

The flexor digitorum tendon runs between the superficial and deep belly of the flexor digitorum muscle, then passes through the bony canal of the thumb to its attachment point at the base of the distal phalanx.

At the level of the metacarpal head, the tendon passes between the two sesamoid bones, the lateral bone lies within the combined tendon of the flexor pollicis brevis and abductor pollicis longus, and the medial bone lies within the tendon of the adductor longus. Each of the four medial digits has two flexor tendons, the flexor digitorum superficialis (FDS) and the deep (FDP) tendons. At the base of the finger, the tendons enter the fibrous tunnel formed by the palmar surface of the finger bones and the fibrotendinous sheath consisting of annular and cruciate pulleys (Figure 1). Inside the tunnel, the tendons are surrounded by a single synovial membrane that allows them to slide freely over each other as the fingers move. The fibrous capsule plays an essential role in preventing anteroposterior and lateral divergence of the tendon with the body of the finger. It also provides the points where tendon forces are applied during bending movements [24]. Soft, flexible cruciate pulleys allow flexion of the interphalangeal joints while thicker annular pulleys are more effective in holding the flexor tendons close to the palmar surface of the bones during movement. joint and muscle activity. The first annular pulley (A1) extends from the palmar plate of the metacarpophalangeal joint to the base of the proximal phalanx. The second part (A2) runs from the cranial part of the proximal phalanx to the junction of the proximal 2/3 and distal 1/3 of the proximal phalanx. The third annular pulley (A3), small, is located at the proximal interphalangeal joint. The fourth annular pulley (A4) is located in the medial part of the medial phalanx and the fifth pulley (A5) passes through the distal interphalangeal joint. Among the five types, the A2 pulley is the strongest and the A4 the least flexible [25]. From a pathophysiological standpoint, these two pulleys provide important resistance against displacement of the palmar tendons. They attach to the bones while the A1-, A3- and A5 pulleys arise from the palmar plate of the joint. As noted earlier, the primary function of the pulley is to stabilize the flexor tendons during flexion of the fingers and to prevent ulnar and radial displacement or palmar retraction. Displacement of the tendons reduces mechanical performance and reduces digital performance.

At the base of the proximal phalanx, the tendon of the FDS splits into two slides that pass either side of the FDP tendon to reach its deep aspect and insert into the middle phalanx. After passing superficially, the FDP continues straight and inserts into the base of the distal phalanx.

Normal US anatomy

flexor tendons

The flexor tendons can be accurately evaluated with longitudinal or transverse ultrasound. They appear as hyperechoic, fibrous structures running just above the bone surface and above the joint [26]. FDS and FDP tendons can be distinguished by their anatomical location. They can be clearly depicted against the high-resolution US background all the way to their distal insertion. Kinetic testing can be helpful in distinguishing the two tendons and assessing their integrity. Selective movements of the FDP can be assessed during passive extension and flexion of the distal phalanx, while the examiner holds the middle phalanx in an extended position. Simultaneous flexion of the distal and middle phalanges allows assessment of the gliding motion of the two flexor tendons. In the normal state, the synovial membrane surrounds the flexor tendons inside the finger fibula, and the thin inner synovial membrane is difficult to see on ultrasound.

Conventional annular pulleys can now be demonstrated using high-resolution ultrasound. They appear as thin, anisotropic bands covering the flexor tendons, and they are best seen on a transverse scan. In general, the rotating faces of pulleys have a hyperechoic, fibrous appearance due to the perpendicular incidence of the ultrasound beam, while their lateral faces are often hypoechoic due to anisotropy and can be seen to diverge on both sides of the flexor tendon. Dynamic scanning in the transverse planes during passive and active movement of the fingers can help differentiate the fixed pulley system from the sliding flexor tendons beneath it.

Pulley disorders

Annular pulleys can be damaged by acute injuries or chronic microtrauma.

Acute tears

Acute tears of the annular pulley are one of the most common injuries in elite climbers. They often involve the ring and middle fingers. Tears are commonly seen in free climbers who use grips in which the entire weight of the body is supported by one finger [27]. Excessive traction on the flexor tendons when the fingers are flexed will tear the pulleys and cause the anterior ligament to no longer lie in the plane of the bone. The A2 pulley ruptures more frequently than the A4 pulley, and an A2 tear may be related to an A3 pulley rupture. If undiagnosed, a complete pulley tear can lead to flexion contracture of the proximal interphalangeal joint with secondary osteoarthritis. In patients with acute tears, local swelling and pain often limit physical examination. Differential diagnosis, including other post-traumatic conditions, such as tenosynovitis or proximal interphalangeal joint sprain, can be difficult in these cases and imaging findings play a key role. However, if the torn pulleys are difficult to detect with imaging, the diagnosis of complete pulley rupture can be made indirectly by demonstrating palmar contracture of the flexor tendons. US, MRI [28] and CT can be used to evaluate digital pulley rupture.

When used properly, ultrasound has 98% sensitivity, 100% specificity, and 99% accuracy for detecting finger pulley injuries [29]. Scanning is performed in sagittal planes with the dorsum of the affected hand and fingers fully extended on the examination table. The transducer probe was placed over the proximal phalanx to image the A2 pulley and then moved distally across the middle phalanx to evaluate the A3 and A4 pulleys. In most patients, strong flexor muscle tone allows the tendon to contract even in a resting position. Ultrasound during active flexion can enhance visualization of tendon subluxation, but this is rarely required to establish a definitive diagnosis. During longitudinal dynamic ultrasound, the patient is asked to keep the finger slightly flexed with the metacarpophalangeal joint extended while the examiner tries to extend it by gently pressing the fingertip [29]. Transverse ultrasound confirms medial ligamentous strain of the flexor tendons but usually does not add any important information.

Maximum chord position helps determine which pulley has broken. In the case of an A2 pulley tear, maximum palmar displacement occurs over the proximal phalanx, whereas in an A4 pulley tear, the archwire is mainly observed over the middle phalanx. A hypoechoic rim surrounding the tendon (due to accumulation of capsular fluid) may be seen in the acute phase as a manifestation.

Tenosynovitis due to secondary trauma. Dynamic ultrasound obtained during finger flexion/extension movements shows smooth movement of the flexor tendons and is useful in evaluating the tendons.

Partial pulley tears are difficult to diagnose because they do not result in tendon displacement. Partially torn pulleys appear swollen and hypoechoic [30].

Although MR and CT can be used to diagnose DAP tears [28], ultrasound is less expensive, nontraumatic, and allows flexible evaluation. One of the advantages of ultrasound over CT is that it can detect synovial effusion. Ultrasound is as valuable as MRI in diagnosing complete tears of the digital pulley [31]. It can easily rule out other diseases, such as tenosynovitis of the flexor tendon or joint diseases, show the number of torn pulleys, and distinguish between partial and complete tears.

Chronic lesions

Chronic repetitive movements of the fingers during occupational or recreational activities can lead to thickening of the A1 pulley. Impaired movement of the flexor tendons beneath the thickened pulley can cause localized friction leading to tenosynovitis, tendon swelling, and continued compression of the tendon within the narrowed digital tunnel. Clinically, the patient exhibits what is called ''trigger finger,'' a term that refers to temporary locking of the finger in a flexed position, followed by pain upon extension. This condition usually affects middle-aged women, but it can also occur in people of both sexes who have diabetes.

Ultrasound shows diffuse hypoechoic thickening of the A1 pulley that may or may not be related to underlying flexor tendon abnormalities. Comparison with adjacent unaffected fingers on axial images may be helpful in establishing the correct diagnosis, especially when assessing pulley thickness. The affected tendons are often swollen. When scanned axially, they have a more circular cross-section than adjacent unaffected tendons [32]. In the acute phase, synovial effusion may be demonstrated in the proximal part of the pulley. In the sagittal planes, dynamic changes in the shape of the synovium can be observed with ultrasound during finger flexion and extension, but this test is rarely required to confirm the diagnosis. Color and power Doppler often demonstrate flow signals within the inflamed pulley. Although the diagnosis of trigger finger is essentially clinical, ultrasound can be a useful guide in deciding on appropriate treatment. Marked thickening of the A1 pulley often requires surgical release, whereas less obvious thickening can be treated conservatively with splinting, NSAIDs, and local steroid injections. The latter is often used without imaging guidance, but ultrasound can also be used for this purpose. Surgical excision of the A1 pulley usually reduces activation quickly and permanently, and it has no functional or clinically significant impact on finger movement. Ultrasound is also useful in diagnosing surgical complications, such as proximal A2 tears or infectious tenosynovitis.

Complications

Postoperative complications are associated with prolonged recovery times, delayed resumption of work, and costs associated with additional interventions [2]. Therefore, this study aimed to identify factors associated with complications after A1 pulley removal. Complications occurred in 16% of all patients, and although most complications were mild, 2% of all patients required repeat surgery. We found that ≥ 3 preoperative steroid injections and one steroid injection within 3 months before surgery were the most influential factors for complications, suggesting that clinicians should consider avoiding injections. steroids within 3 months before surgical A1 pulley release and reluctance to have >2 steroid injections.

The 16% complication rate we found is in the middle of the wide range described in the literature (0% - 43%) [33]. This wide range is mainly due to inconsistency in the definition of complications and the lack of a widely accepted classification system. In this study, we used the recently proposed ICHAW classification tool, in which complications are defined as any deviation from the usual course of treatment. The advantage of this classification tool is that it provides insight into the severity of complications based on the invasiveness of the intervention used. For example, although we found a high complication rate of 16%, it is important to acknowledge that 40% of all complications consisted of grade 1 complications (i.e., treatment with adjuvant hand therapy), braces or taking pain medication), which most can consider a slow recovery. However, although most complications are mild, 2% of patients still experience complications that require repeat surgery.

We found that ≥ 3 preoperative steroid injections were the most influential factor in postoperative complications. A plausible explanation for these findings may be that patients requiring multiple steroid injections represent a group with more severe and more difficult-to-treat disease. However, we found that multiple steroid injections were independently associated with complications after adjusting for symptom duration, presence of preoperative flexor contractures, and severity of muscle pain. version and functional score. hand function, which suggests that a higher number of steroid injections may also have a negative impact. affect the results after surgery. Furthermore, although steroid injections have been shown to be effective in the initial management of trigger finger [34], it has been found that success rates decrease after repeated injections [35]. . For example, one study reported resolution of symptoms in 49% of patients after one steroid injection, whereas this was achieved in only 23% of patients after the second injection and in 5% after ≥ 3 steroid injections [36]. Considering the increased complication rate and decreased efficacy after ≥ 3 steroid injections, these findings imply that hand surgeons should be reluctant to perform > 2 steroid injections.

In line with this, we also observed that steroid injections within 3 months before surgery were associated with postoperative complications. Interestingly, this association was observed only in more severe grade 2 and 3 complications. These results are consistent with previous studies reporting that a shorter interval between steroid injection and surgery is associated with postoperative infection. However, it should be noted that Straszewski., *et al*. [4] only observed a higher rate of deep infection if the steroid injection was performed within the previous 1 month.

These findings indicate that clinicians should at least avoid surgery for 1 month after steroid injection and perhaps even for 3 months.

An interesting finding of this study is that we found differences in complication rates between individual digits, with the highest incidence in the index and middle fingers. This is consistent with the findings of Bruijnzeel., *et al.* [37], who also found that treatment of the middle finger was associated with the occurrence of complications. One possible explanation for this finding is differences in functional anatomy. For example, because the index and middle fingers play an important role in fine motor skills, patients experience more difficulty due to impaired function of these fingers and therefore often opt for additional treatment. than.

In contrast to our study, previous studies found that some patient characteristics, such as diabetes in men [38] and current smoking [39] were associated with higher risk of complications. A possible explanation for these differences is that we evaluated risk factors for all types of complications, whereas other studies evaluated specific complications. For example, consistent with our findings, Stepan., *et al.* [40] demonstrated no association between diabetes and overall complications. However, Bruijnzeel., *et al.* [5] found that diabetes is strongly associated with specific complications, including recurrence and suture-related problems, such as suture abscesses. Furthermore, in contrast to the study by Bruijnzeel., *et al*. [5], we excluded patients with multiple trigger fingers in this study. Since previous literature has shown that multiple trigger fingers occur more frequently in patients with diabetes, are more difficult to treat, and have a higher risk of complications, it is reasonable that an association between Diabetes and complications may be more severe in patients with multiple trigger fingers.

Despite the strengths of our study, including the large study sample and standardized complications registry tool, several limitations should also be considered. First, the observational design was associated with a significant number of patients not completing the baseline questionnaire. Second, all medical records were retrospectively reviewed for information on complications, preoperative flexor contractures, and number of preoperative steroid injections, as this information was not routinely collected in our results measurement system. Although complications are generally described in a straightforward manner, it is possible to underestimate complications that are not documented, especially if the complication is mild or if the patient has sought care elsewhere. To account for the underestimation of the number of steroid injections, we excluded patients whose number of previous steroid injections was unknown. Although the absence of flexion contractures is not always accurately reported, we did not exclude these patients as this could lead to selection bias. However, the absence of preoperative range-of-motion measures and the underestimation of preoperative flexion contractures may lead to overestimation of limited range-of-motion complications. level 1. Third, a relatively large proportion of the variance in outcomes remains unexplained, suggesting that there may be other influencing factors that were not included in our analysis. For example, previous studies showed that general anesthesia and hypoglycemia were associated with postoperative complications [37]. However, contrary to the study of Everding., *et al.* [38]. where 59% of patients underwent additional procedures, we only included patients with single-digit A1 pulley release due to the nature of our database (ie, if a patient receiving multiple treatments at the same time, the patient will only indicated for racing including the most extensive treatment [41]). Therefore, because general anesthesia is a rare indication for single-digit A1 pulley release, we did not include this factor in our analysis. Another explanation could be that we combined different types of complications in the complication levels. It is plausible that factors associated with complications vary between specific complications. Future studies should examine factors that contribute to these specific complications.

This study demonstrates that ≥ 3 preoperative steroid injections and one steroid injection within 3 months before surgery are the most influential factors contributing to postoperative complications. These findings may assist clinicians in patient counseling and may guide preoperative treatment. We recommend that clinicians consider avoiding steroid injections for 3 months before A1 pulley surgery and should not perform >2 steroid injections.

Risk factors diabetes, tobacco

The routine practice of the NFSGVHS hand clinic is steroid injections as the initial treatment for trigger finger. Healthcare providers (HCPs) allow no more than 3 injections for the same digit to avoid the rare but potentially serious complication of tendon rupture [42]. Due to the large NFSGVHS catchment area, the waiting time for elective trigger finger surgery is several months. This 3-injection plan has been well received by patients and referring providers due to this wait time.

However, a recent article by Kerrigan and Stanwix concluded that the most cost-effective treatment strategy is two steroid injections before surgery [43].

Typically, trigger finger release is a short, outpatient surgery with a quick recovery. To minimize the risk of stiffness and scarring, NFSGVHS practice is to refer all postoperative hand cases to ≥ 1 manual therapy appointment on the same day as the first postoperative visit their.

Cost estimates

When complications occur, they can be costly for patients due to both time away from home and work as well as additional expenses. When current procedural terminology (CPT) codes are run through the VistA integrated billing system, based on the VHA Business Office Reasonable Costs, a complication can double the cost associated with the surgery. A1 pulley technique.

A flexor sheath incision and drainage (I+D) (CPT 26020) costs $8,935.35 (facility fee, $6,911.95 plus professional fee, $2,023.40), compared with a release open trigger finger (CPT 26055) at $8,365.66 (base fee, $6,911.95 plus professional fee, $1,453.71). According to a conversation with a financial services staff member at NFSGVHS (February 11, 2014), anesthesia bill ($490.56/15 minutes), planned level 3 emergency department visit (facility fee, $889 .22 plus professional fees $493.40) and inpatient hospital stays (floor bed per day $786.19) can cause costly infectious complications. The trigger finger can also be released through the skin. This is a reasonable option to avoid a trip to the operating room, but NFSGVHS surgeons prefer open surgery due to concerns about possible tendon and nerve damage caused by blind needle scanning [44,45]. Current studies show that complications from trigger finger release range from 1% to 31% [45,46]. Wound complications and joint stiffness are known complications [46-48]. In this study, 60% of the complications are infections and 80% of complications are wound complications. Six of the eight patients with wound healing complications received perioperative antibiotics. Three patients returned to the operating room for I+D of the flexor sheath. The results showed a statistically significant association between > 1 finger treated in the same surgery and postoperative complications (P= 0.027). A search of PubMed revealed no existing hand literature regarding this association.

Risk factors

Diabetes, tobacco use, type of incision, and number of fingers treated were evaluated as risk factors for complications after trigger finger surgery. Nicotine is widely accepted to increase the risk of wound complications [49]. Nearly 20% of the US population smokes, compared to 22% of the VA population and 32% of active duty military personnel [50]. One in four veterans is diagnosed with diabetes, a common risk factor for slow wound healing and infection [51,52]. No previous studies have compared incision type or multiple digits as risk factors for complications.

There is also a clear association between trigger finger and diabetes. Chronic hyperglycemia leads to collagen accumulation in the tendon sheath due to impaired collagen breakdown. Diabetic patients tend to present with multiple finger lesions and respond less favorably to steroid injections than nondiabetic patients [53]. Wound healing is also impaired in diabetics. All 6 wound infections in this study occurred in diabetic patients. Proposed causes for complications in wound healing include pathological angiogenesis, impaired fibroblast proliferation and migration, impaired circulation, reduced oxygenation, and immune responses. fluid defect at the injured site [54].

The trigger finger can develop into multiple digits. Once surgery is planned for 1 finger, the patient may request surgery on another finger on the same hand without attempting nonsurgical intervention. NFSGVHS plastic surgeons have raised the bar for providing multiple surgical procedures on the same hand in the same surgical visit to minimize recovery time and number of visits, especially when patients have to move far. This may be less convenient; however, the total cost to the patient and the healthcare system in the event of a complication is significant. Plastic surgery providers also run an alcohol prep pad over the incision site to prevent infection of the flexor sheath during suture removal.

Current recommendations to improve postoperative risks to patients and costs to the system include endorsing a more conservative approach to treating trigger finger than has been the case at NFSGVHS. The known less favorable response of diabetics to steroid injections combined with the high risk of postoperative infection creates a weak point for the treatment plan. Because of the low risk of a single steroid injection into the flexor sheath, this procedure is still recommended as a first-line treatment.

In the 5-year study, the threshold for surgical management and treatment of polydactyly during the same surgery was lower than what is currently practiced, with general consensus among hospital HCPs. The authors recommend that all patients begin steroid injections before surgery. Patients with diabetes are advised that the injection will cause temporary effects and hyperglycemia [55]. If they are resistant to injection, high-dose oral non-steroidal anti-inflammatory drugs and/or proximal interphalangeal joint splinting are indicated.

Verification of A1C values indicating better chronic blood sugar management is a protocol that HCPs from NFSGVHS will begin to follow. The recommended preoperative A1C value is between 6.5% and 8% in patients with diabetes.[56] A1C value > 7% is considered an independent risk factor for tendon sheath stenosis [57]. The total number of trigger finger surgeries could be reduced through improved resource utilization.

Conclusion

Although open trigger release is a relatively benign procedure, complications can still occur. Most are mild and can resolve without further surgery, but others are more serious. Our study helps further quantify these complications with a large sample size, while also identifying possible risk factors. It is important that physicians be aware of these concerns and that patients be fully informed before making a general decision and possibly undergoing surgery, no matter how simple and straightforward the procedure may be. How practical is it?

Limitation

Our study is retrospective, with a small number of patients and no control group. The surgical method follows classical techniques, and results are evaluated according to existing standards. However, although there are not many comparisons, conclusions are still drawn based on the actual results obtained in the study.

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