Managing Swan Neck and Boutonniere Deformities

Kate Elzinga, MD[a,*], Kevin C. Chung, MD, MS[b]

KEYWORDS

• Boutonniere deformity • Swan neck deformity • Extensor tendon mechanism
• Extensor tendon tenotomy • Mallet finger • Oblique retinacular ligament

KEY POINTS

- The extensor mechanism of the finger is an intricate, highly coordinated structure formed by extrinsic and intrinsic muscles and retinacular ligaments. A disruption in any of its components can lead to pathologic flexion or extension deformities at the interphalangeal joints.
- Corrective splinting is generally the first line of treatment of swan neck and boutonniere deformities of the fingers.
- Surgical intervention aims at rebalancing the extensor tendon forces across the proximal and distal interphalangeal joints. To be successful, joints must be supple and free of arthritis.
- Complete correction of swan neck and boutonniere deformities is difficult to achieve, but the function and esthetics of the interphalangeal joints of the fingers can be greatly improved with splinting and operative interventions.

INTRODUCTION

The extensor mechanism of the finger is a complex, intricate, highly coordinated structure formed by extrinsic and intrinsic muscles and retinacular ligaments (**Fig. 1**). Swan neck and boutonniere finger deformities result from extensor tendon imbalances. They can present acutely, most commonly in the setting of trauma (sharp laceration, blunt avulsion, burns) or as a progressive deformity (secondary to arthritis). Swan neck deformities are more common than boutonniere deformities.

A swan neck deformity presents with hyperextension at the proximal interphalangeal joint (PIP) and flexion at the distal interphalangeal joint (DIP). The PIP hyperextension impairs the patient's ability to make a fist. Surgical correction can be pursued to restore the patient's hand function.

A boutonniere deformity is defined by flexion at the PIP and hyperextension at the DIP. Grasp and fist are preserved and the patient typically retains good hand function, but the deformity can be aesthetically displeasing. Surgical improvement should only be attempted with caution after thorough patient education. Improving PIP extension can impede PIP flexion, resulting in a poor functional outcome.

Before any tendon rebalancing to correct a swan neck or boutonniere deformity, passive range of motion must be optimized. Hand therapy is important for all patients with these injuries. Corrective splinting, range of motion exercises, and education are essential elements of the patient's care.

Radiographs are taken to ensure that there is no arthritic change present in patients who will be

Disclosure Statement: The authors have nothing to disclose.
[a] Section of Plastic Surgery, University of Calgary, Foothills Medical Centre, Room 382, 1403 - 29 Street Northwest, Calgary, Alberta T2N 2T9, Canada; [b] Section of Plastic Surgery, The University of Michigan Medical School, The University of Michigan Health System, 1500 East Medical Center Drive, 2130 Taubman Center, SPC 5340, Ann Arbor, MI 48109-0340, USA
* Corresponding author.
E-mail address: kate.elzinga@ahs.ca

Clin Plastic Surg 46 (2019) 329–337
https://doi.org/10.1016/j.cps.2019.02.006

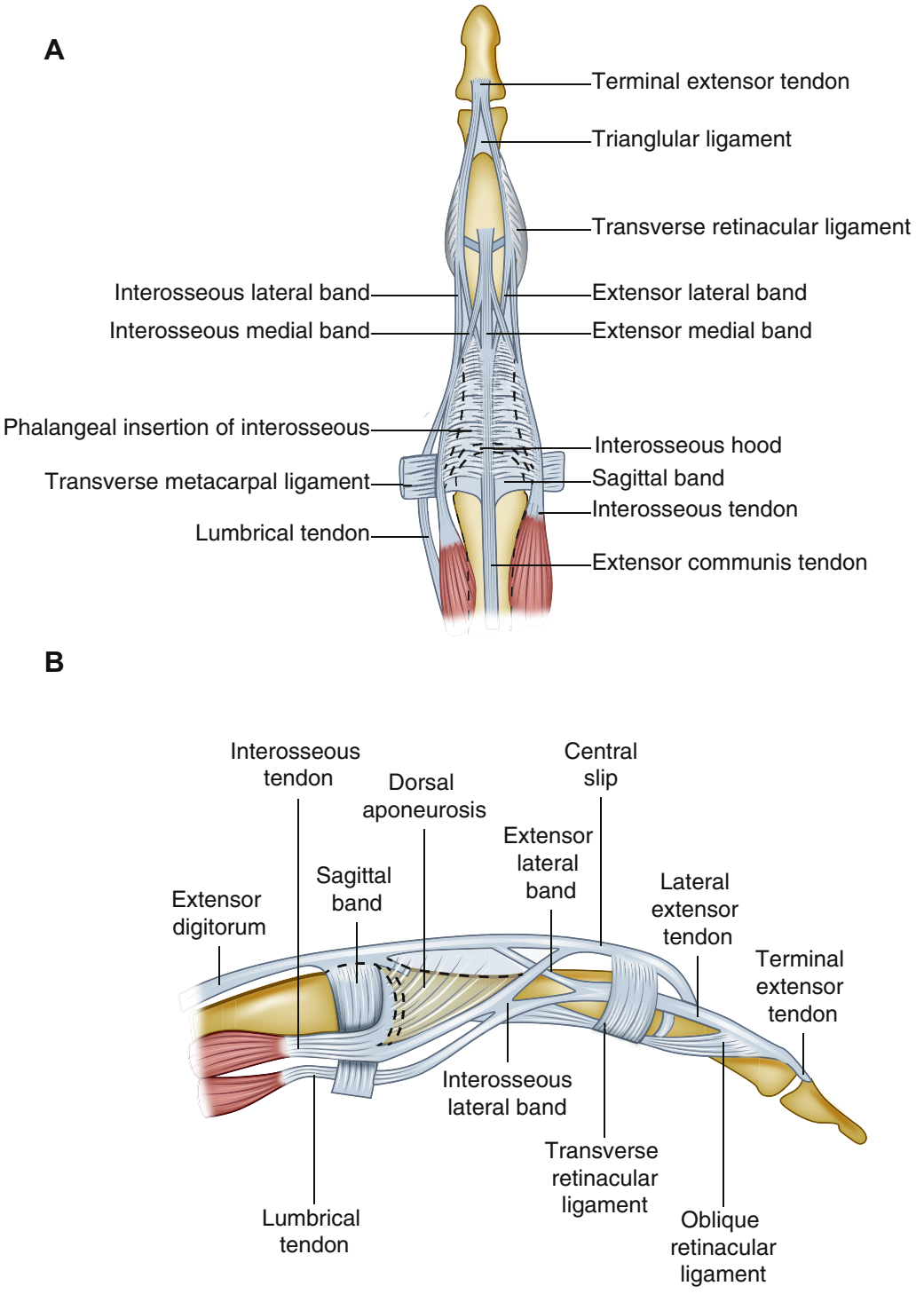

Fig. 1. The extensor tendon mechanism, shown here from a posterior (*A*) and lateral (*B*) view, is formed by extrinsic (extensor digitorum communis) and intrinsic (lumbrical and dorsal interosseous) muscles and retinacular (spiral oblique and transverse retinacular) ligaments. It permits extension through the interphalangeal joints.

undergoing soft tissue reconstructive procedures. When there are signs of arthritis, arthroplasty and arthrodesis are preferred treatments.

ANATOMY

The extensor mechanism of the finger is formed by extrinsic muscles (extensor digitorum communis) and intrinsic muscles (lumbrical and the dorsal interosseous muscles). As it passes over the dorsal proximal phalanx, the extensor digitorum communis trifurcates into a single central slip and 2 lateral bands (radial and ulnar). The central slip inserts onto the dorsal base of the middle phalanx and is responsible for PIP extension. The lateral bands join the lumbrical and dorsal interosseous muscles to form the conjoint lateral bands. The conjoint lateral bands travel distally and insert onto the dorsal base of the distal phalanx, providing DIP extension.

The triangular ligament is located over the distal proximal phalanx. It counteracts the pull of the oblique retinacular ligament (ORL). It functions to maintain the conjoint lateral bands dorsally over the proximal phalanx. An injury to the triangular ligament can result in lateral and volar subluxation of the distal conjoint lateral bands to cause a swan neck deformity.

The retinacular ligaments, the ORL, and the transverse retinacular ligament coordinate the motion of the extensor mechanism by facilitating simultaneous PIP and DIP flexion and simultaneous PIP and DIP extension.

The ORL travels volar to the axis of the PIP and dorsal to the axis of the DIP. It is functionally present in 40% to 50% of the population.[1] It originates from the volar middle third of the proximal phalanx and the flexor sheath, travels deep to the transverse retinacular ligament dorsally, and inserts on the lateral terminal extensor tendon distally.[2]

When the PIP flexes, the ORL is relaxed, permitting DIP flexion. When the PIP extends, the ORL tightens, and the DIP extends.

The transverse retinacular ligament begins from the lateral flexor tendon sheath at the PIP and terminates at the lateral border of the conjoint lateral bands. When the PIP flexes, it pulls the lateral bands volarly over the PIP. With PIP extension, it limits the dorsal translation of the lateral bands (**Fig. 2**).

SWAN NECK RECONSTRUCTION

Swan neck deformities can arise from pathology at the metacarpophalangeal (MCP) joint, PIP, or DIP. Causes include volar MCP subluxation, a lax PIP volar plate, a flexor digitorum superficialis laceration, intrinsic muscle contracture, or a mallet finger. Treatment is aimed at the cause of the deformity.

Chronic mallet injuries are the most common cause of a swan neck deformity. The extensor tendon disruption at the DIP leads to DIP flexion and PIP hyperextension as the lateral bands migrate volarly. Swan neck deformities are first treated with splinting. The DIP is splinted in extension (neutral to 10° of hyperextension), and the PIP is splinted in a dorsal blocking splint with 40° to 60° of flexion.[3] The splint is worn full time for 8 weeks and then weaned off during the day over the following 6 weeks. It is worn at night for 3 months.

If nonoperative measures fail, surgical treatment options for a chronic mallet injury include[4]:

- Direct zone 1 extensor tendon repair and/or DIP skin imbrication
- Central slip tenotomy for extensor mechanism rebalancing by the retracting central tendon that pulls on the terminal tendon through the lateral bands
  - Indicated for an extensor lag less than 35° to 40° at the DIP where the extensor tendon is attenuated but remains in-continuity
- Spiral ORL creation using a free tendon graft
  - Indicated for extensor lags over 45° at the DIP or when there is no tendon continuity between the extensor tendon and the distal phalanx
- Salvage procedures
  - Arthrodesis at the DIP

Tenodermodesis

A K wire is placed to maintain the DIP in full extension for 6 weeks. An elliptical resection of skin and scarred extensor tendon is excised over the DIP. The skin and extensor tendon are sutured together.

Central Slip Tenotomy

If the extensor tendon is intact, but is attenuated and elongated over the DIP, release of the central slip at its insertion onto the dorsal base of the middle phalanx will permit the extensor tendon mechanism to move proximally, thereby tightening the extensor mechanism distally and improving extension through the DIP. A midlateral approach is typically used. The lateral bands are protected as the central slip is released from its deep surface. The triangular ligament is preserved to prevent a boutonniere deformity.

Postoperatively, the DIP is splinted in extension and the PIP is splinted in a dorsal blocking splint in

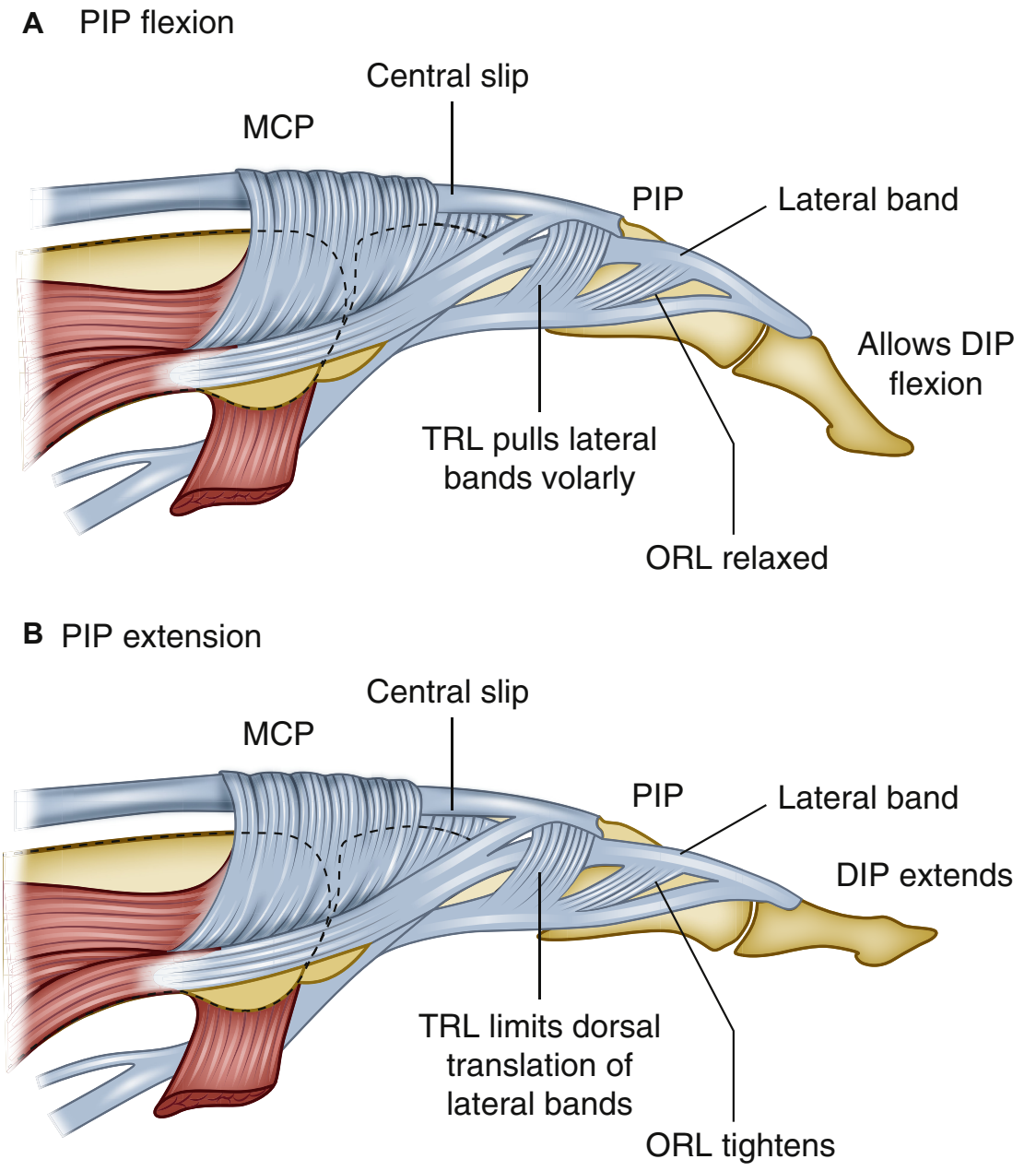

Fig. 2. When the PIP flexes, the transverse retinacular ligament (TRL) pulls the lateral bands volarly (aiding PIP flexion) and the oblique retinacular ligament (ORL) relaxes (permitting coordinated DIP flexion) (*A*). With PIP extension, the TRL limits the dorsal translation of the lateral bands (preventing PIP hyperextension) and the ORL tightens (permitting coordinated DIP extension) (*B*).

20° of flexion to maximize the tension on the extensor mechanism at the DIP. The dorsal blocking splint is worn for 2 weeks. PIP hyperextension should be avoided. The DIP extension splint is worn for 4 weeks. It is removed several times during the day so the patient can perform active range of motion exercises. From weeks 4 to 8 postoperatively, the DIP extension splint is worn at night.

On average, 36° (range 30°–46°) of extensor tendon lag at the DIP can be corrected with this technique.[5] An improvement in the PIP hyperextension seen in a swan neck deformity also occurs when the insertion the central slip is divided.

Spiral Oblique Retinacular Ligament Creation

Creation of an ORL restores flexion across the PIP and extension across the DIP. A lateral band[6] or a tendon graft is used. Palmaris or plantaris tendons are most commonly used. The new "ligament" is positioned volar to the PIP and dorsal to the DIP. The tendon graft is fixed distally to the distal phalanx with a suture anchor or a pull-out button, then placed between the flexor tendon sheath and the neurovascular bundle volar to the PIP and secured to the proximal phalanx with a suture anchor or pull-out button (**Fig. 3**). K wires or splints are used to hold the PIP in 10° to 15° of flexion and the DIP in extension. Active motion exercises are started within 3 to 7 days of the reconstruction.

The ORL creates a dynamic tenodesis. When the PIP is actively extended, the DIP will also extend. Equivalent outcomes have been reported for both lateral band and tendon graft reconstructions.[7] Pull-out sutures and bone anchors were also equivalent. On average, the DIP extensor lag improved by 30° for those treated after a soft tissue injury.[7] There was minimal improvement in the extensor lag, however, for those with distal phalanx fractures.

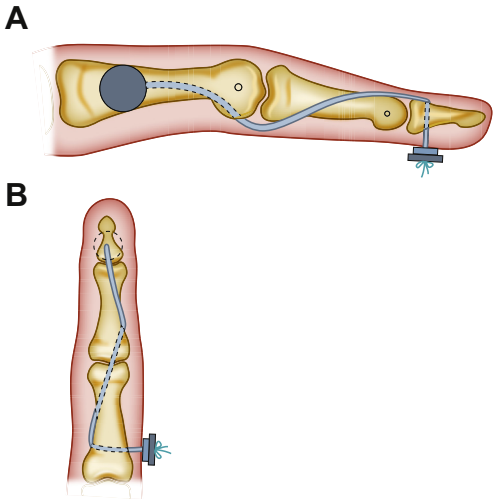

Fig. 3. In a spiral oblique retinacular ligament reconstruction, a free tendon graft is passed volar to the axis of rotation of the PIP and dorsal to the axis of rotation of the DIP joint (*A-B*). This corrects the PIP hyperextension and the DIP flexion of a swan neck deformity.

Arthrodesis

For a painful DIP with arthritic changes visible on radiographs, DIP arthrodesis is recommended. Splints can be applied to help determine the optimal angle of fusion for each individual patient, typically in neutral to slight flexion. Headless compression screws, K wires, tension band constructs, interosseous wiring, plates and screws, and staples can be used. Clinical union takes 8 weeks on average.[8]

Proximal interphalangeal joint pathology can lead to a swan neck deformity. In rheumatoid arthritis, stretching of the volar plate commonly occurs as a result of inflammation of the synovial pannus, which leads to PIP hyperextension. The lateral bands move dorsally, leading to slack in the extensor mechanism and DIP flexion. When the PIP remains flexible in all positions of the MCP, treatment options for the PIP include splinting, volar plate advancement, dermadesis, flexor digitorum superficialis tenodesis, and ORL reconstruction. If there is additional intrinsic muscle tightness, an intrinsic release is added to the treatment plan. If the dorsal PIP skin is tight, a Z-plasty or full-thickness skin graft can performed. Lateral band mobilization and dorsal capsule release of the PIP can help correct the PIP hyperextension (**Fig. 4**). If the central slip has shortened, a step-cut lengthening can be beneficial (**Fig. 5**).

BOUTONNIERE RECONSTRUCTION

Boutonniere deformities arise from pathology at the PIP. Central slip injuries and attenuation of the triangular ligament result in a boutonniere deformity. The conjoint lateral bands migrate volarly over the radial and ulnar aspects of the digit, volar to the axis of the PIP. With force through the extensor mechanism, the PIP is subject to a pathologic flexion force. Over time, the conjoint lateral bands contract and create an extension force across the DIP. Proximal interphalangeal joint flexion and DIP hyperextension result. Gradually, the ORL and the transverse retinacular ligament also contract, worsening the DIP hyperextension.

For acute, flexible boutonniere deformities, the PIP is splinted continuously in extension for 6 weeks, with the DIP free to flex to stretch out the contracted lateral bands. Active DIP range of motion exercises are performed hourly to permit distal gliding of the lateral

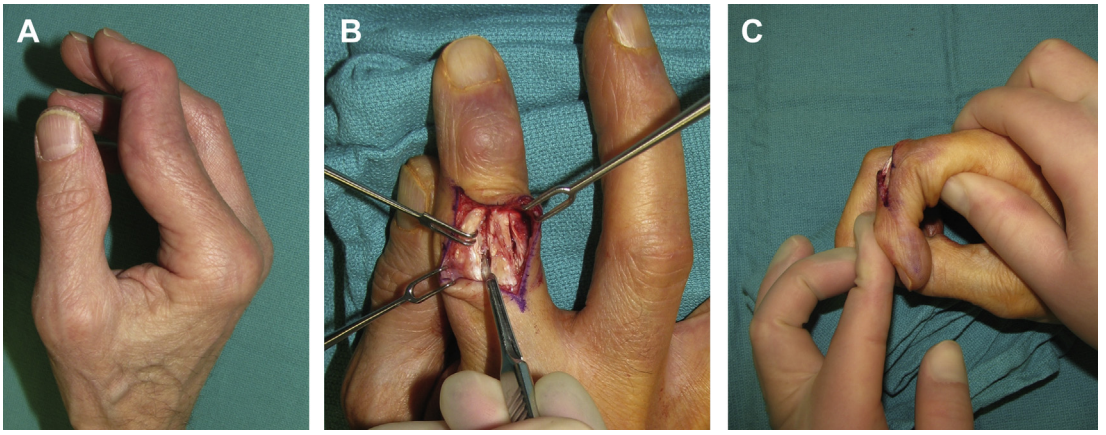

Fig. 4. PIP joint hyperextension (*A*) (preoperative image) can be improved by release of the lateral bands over the PIP (*B*) (intraoperative image, dorsal approach), allowing them to move volarly to the axis of the joint. The tight dorsal capsule of the PIP joint can be released to improve passive (*C*) (intraoperative image) and active PIP flexion.

bands and central slip, movement of the lateral bands back into their correct dorsal alignment, stretching of the tight transverse retinacular ligaments, and tightening of the triangular ligament. The splint is then weaned during the day and PIP active flexion exercises begin. The splint is worn at night for an additional 6 weeks.

For patients with chronic supple, passively corrected boutonniere deformities, splinting is the mainstay of treatment, surgery is rarely indicated. Orthoses are used to achieve full PIP extension. Dynamic or serial splinting or casting can be used. The full extension is maintained for 6 to 12 weeks with splints. Distal interphalangeal joint active and passive flexion exercises are performed throughout. If PIP extension cannot be achieved with therapy alone, operative release of contracted collateral ligaments and/or volar plate can be performed (**Fig. 6**).

For boutonniere deformities unresponsive to splinting, surgical correction focuses on decreasing the extensor tone at the DIP and increasing the extensor force at the PIP. Full passive motion must be present before surgery. Joint releases, in particular volar plate release, must be

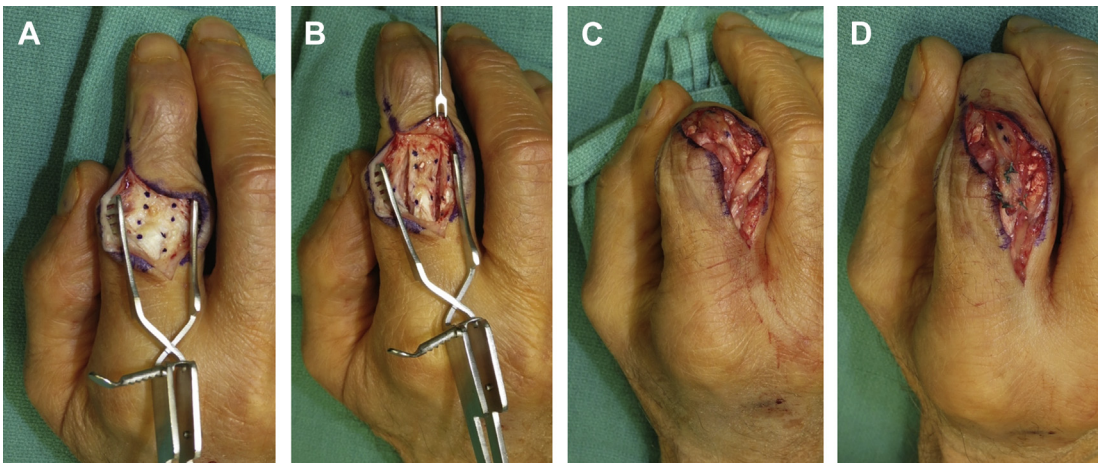

Fig. 5. PIP joint hyperextension can be corrected using a dorsal approach to the PIP joint. The lateral bands and central slip are identified and marked (*A*). The radial and ulnar lateral bands are mobilized away from the central slip (*B*), allowing them to move volarly. The central slip can be lengthened (*C*) to further correct the PIP hyperextension and sutured over the dorsal PIP joint in an elongated position (*D*).

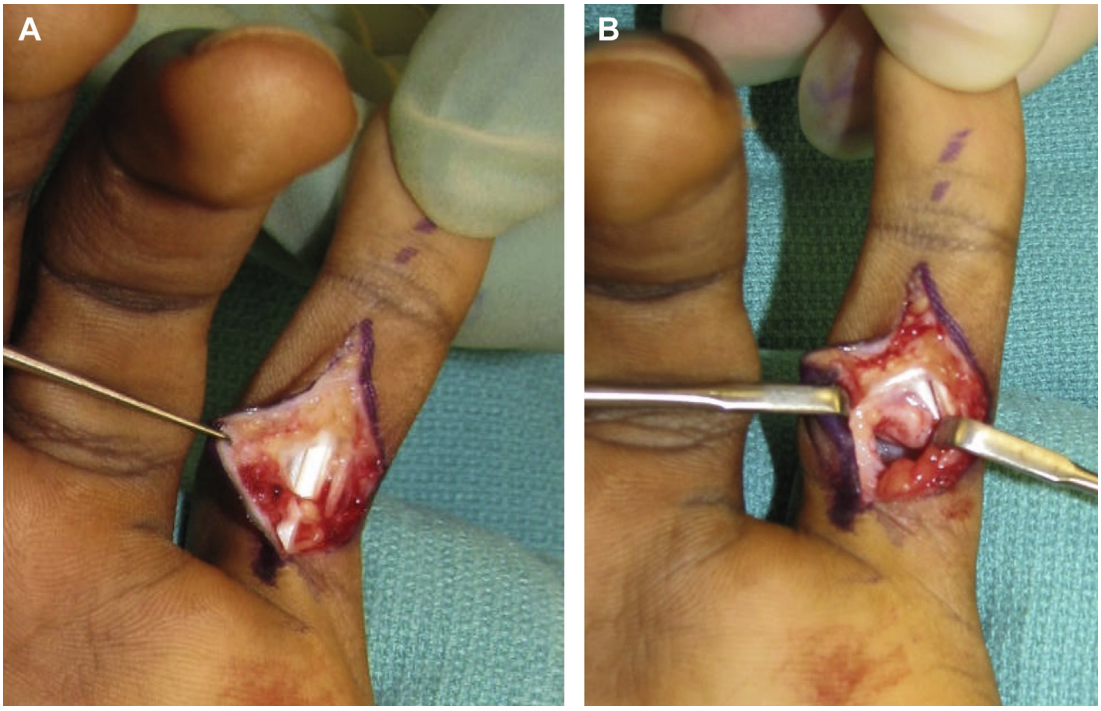

Fig. 6. A swan neck deformity can result from a tight volar plate. A volar approach to the PIP joint allows identification of the flexor tendons (*A*), their retraction, and then release of the underlying volar plate (*B*) and improved PIP extension.

performed before any tendon reconstruction. Surgical options include:

- Terminal tendon tenotomy
- Staged Curtis procedure

Boutonniere deformities do not typically limit function. The risks and benefits of surgical intervention must be thoroughly discussed with the patient. Despite surgical correction of a boutonniere deformity, 20° of persistent extensor lag is common at the PIP. Performing surgery for PIP extensor lags less than 30° may not result in marked improvement postoperatively. There is a risk of worsening PIP flexion by attempting to correct the extension of the PIP.

Terminal Tendon Tenotomy

The extensor tendon is divided over the distal middle phalanx, proximal to the triangular ligament, which in essence preserves the ORLs by avoiding a chronic mallet finger. This corrects the hyperextension deformity at the DIP, but does not result in a mallet finger deformity, also likely owing to the chronically tight collateral ligaments and DIP capsule. A DIP extension splint is worn for 6 to 8 weeks between active range of motion exercises. The extensor mechanism migrates proximally, increasing the extensor tension at the PIP, thus correcting the flexion deformity of the PIP.

Staged Curtis Procedure

A staged Curtis reconstruction can be performed for stepwise correction of a boutonniere deformity (**Table 1**).

Local anesthesia is used, permitting the patient to actively test their range of motion during

Table 1
Curtis staged technique for the repair of the traumatic boutonniere deformity

Stage	Procedure
I	Tenolysis of the extensor tendon and freeing of the transverse retinacular ligament
II	Sectioning of the transverse retinacular ligament
III	Tendon lengthening of the lateral bands over the middle phalanx
IV	Repair of the central extensor tendon

Data from Curtis RM, Reid RL, Provost JM. A staged technique for the repair of the traumatic boutonniere deformity. J Hand Surg Am 1983;8(2):167–71.

the surgery. A dorsal curvilinear incision is used over the PIP. In the first stage, the transverse retinacular ligament is freed and an extensor tendon tenolysis performed. Extension is reassessed, if incomplete, stage II is performed, in which the transverse retinacular ligament is divided and the lateral bands move dorsally (**Fig. 7**). If full extension is still not achieved, stage III or IV is performed depending on the extensor lag. For an extensor lag of 20° or less, a Fowler tenotomy is performed for stage III. The extensor mechanism is divided distal to the triangular ligament (**Fig. 8**). For an extensor lag over 20°, stage IV is performed. The central slip tendon is transected and advanced distally for 4 to 6 mm. It is secured to the dorsal base of the middle phalanx with a suture anchor. The slack lateral bands are loosely sutured to the central slip tendon (**Fig. 9**).

Curtis reported a persistent 10° PIP extensor lag at 1 year follow-up, with an average of 31° of improvement.[9] A staged approach minimizes the risk of a loss of flexion postoperatively at the PIP.

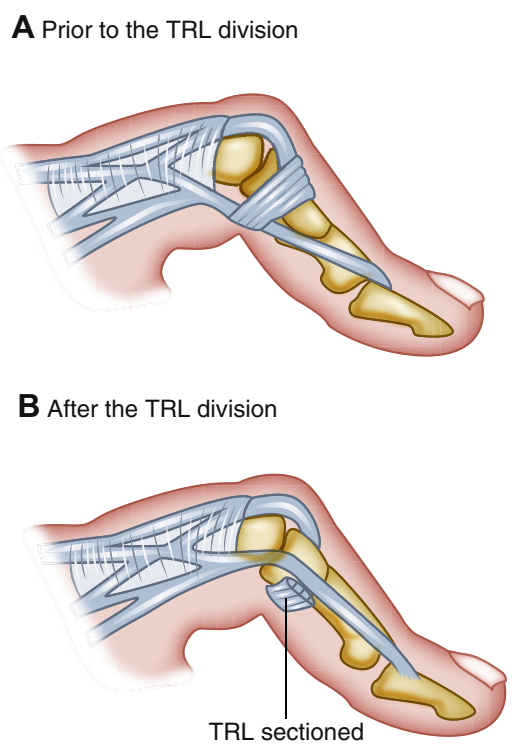

Fig. 7. During a staged Curtis procedure, tenolysis of the extensor tendon and transverse retinacular ligament is performed as stage I (*A*). The procedure proceeds to stage II if the boutonniere deformity persists after stage I. In stage II, the transverse retinacular ligament is released to allow dorsal movement of the lateral bands (*B*). TRL, transverse retinacular ligament.

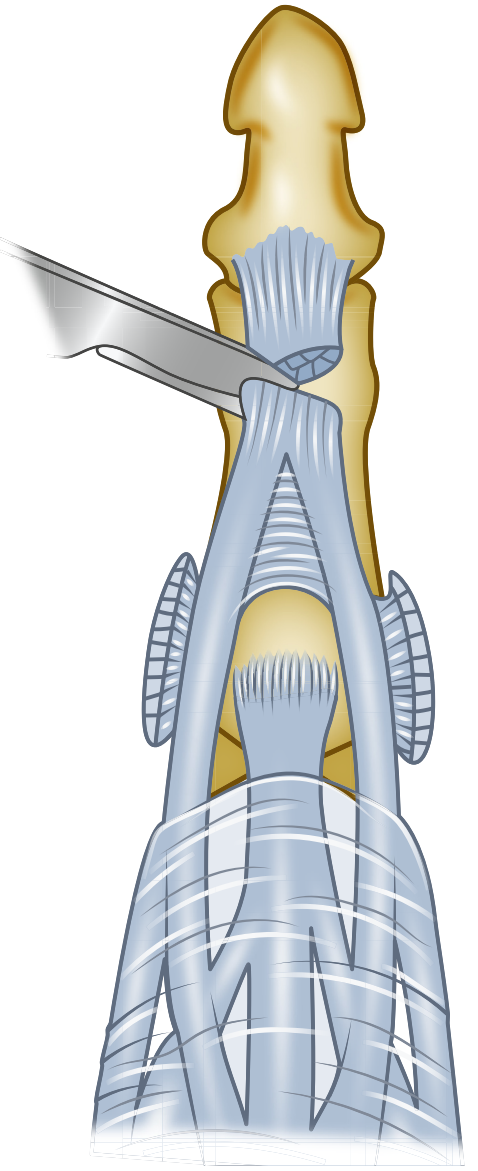

Fig. 8. A Fowler tenotomy is performed by releasing the extensor tendon distal to the triangular ligament over the distal middle phalanx. This procedure corrects extensor lags up to 20° at the DIP.

Arthroplasty or Arthrodesis

For patients with PIP arthritis, arthroplasty or arthrodesis are recommended to relieve pain. Distal interphalangeal joint arthritis can be surgically treated with arthrodesis.

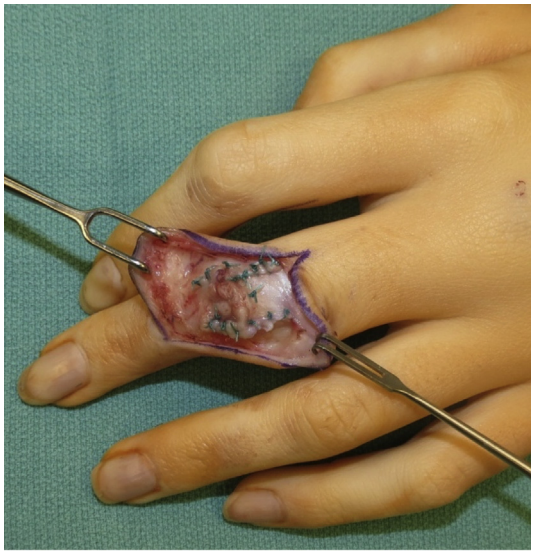

Fig. 9. For a boutonniere deformity with a loss of extension through the PIP, the central slip can be advanced and resecured to the dorsal base of the middle phalanx distally using a bone anchor. The lateral bands can be sutured to the radial and ulnar edges of the central slip with nonabsorbable sutures to improve their position over the dorsal PIP joint and thus their ability to extend this joint.

SUMMARY

Early recognition and treatment of extensor tendon injuries is best to prevent extensor tendon imbalances and resultant swan neck and boutonniere deformities. Once established, these deformities can require prolonged courses of splinting and, less commonly, surgery for correction.

REFERENCES

1. Shrewsbury MM, Johnson RK. A systematic study of the oblique retinacular ligament of the human finger: its structure and function. J Hand Surg Am 1977; 2(3):194–9.
2. Wehbé MA. Anatomy of the extensor mechanism of the hand and wrist. Hand Clin 1995;11(3):361–6.
3. Lutz K, Pipicelli J, Grewal R. Management of complications of extensor tendon injuries. Hand Clin 2015; 31(2):301–10.
4. Strauch R. Extensor tendon injury. In: Wolfe S, Hotchkiss R, Pederson W, et al, editors. Green's operative hand surgery, vol. 1, 6th edition. Philadelphia: Elsevier; 2011. p. 159–88.
5. Chao JD, Sarwahi V, Da Silva YS, et al. Central slip tenotomy for the treatment of chronic mallet finger: an anatomic study. J Hand Surg Am 2004;29(2):216–9.
6. Chung K. Operative techniques: hand and wrist surgery. 3rd edition. Philadelphia: Elsevier; 2017.
7. Oh JY, Kim JS, Lee DC, et al. Comparative study of spiral oblique retinacular ligament reconstruction techniques using either a lateral band or a tendon graft. Arch Plast Surg 2013;40(6):773–8.
8. Ruchelsman DE, Hazel A, Mudgal CS. Treatment of symptomatic distal interphalangeal joint arthritis with percutaneous arthrodesis: a novel technique in select patients. Hand (N Y) 2010;5(4):434–9.
9. Curtis RM, Reid RL, Provost JM. A staged technique for the repair of the traumatic boutonniere deformity. J Hand Surg Am 1983;8(2):167–71.