PULLEY AVULSION

Closed traumatic ruptures of finger flexor tendon pulleys began to be recognized specifically over the past several decades. This injury, although rare in the general population, is seen more commonly in rock climbers. It can be iatrogenic as in trigger finger release caused by excessive loss of the proximal pulleys. As the flexor tendon moves away from the center of rotation of the metacarpophalangeal joint, the flexion moment arm is increased. Thus the flexors gain an increased mechanical advantage over the extensors resulting in limited digital extension.

Rock climbing

In climbing movements, the fingers produce tension on a hold to support a proportion of the body mass while the elbow and shoulder joints flex to pull the body upward. The isometric contraction of the finger flexors is interrupted when reaching towards the next hold. Finger flexor strength has been shown to be a determinant of performance in rock climbing.

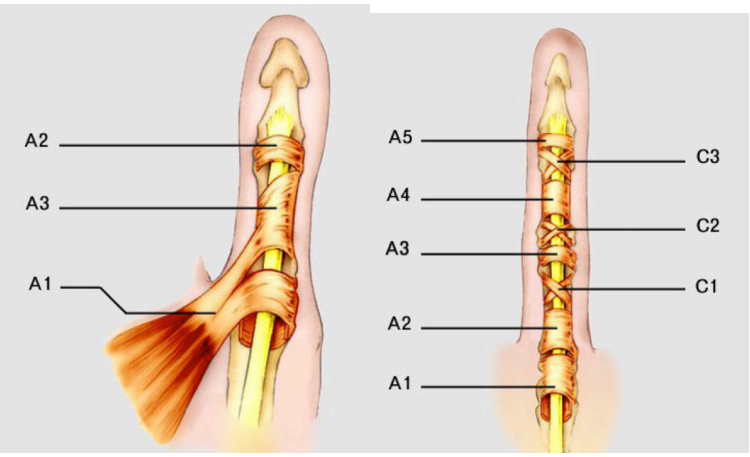
Bollen identified one style in particular, known as “crimping” which is of particular relevance to injury patterns among climbers. It is thought that over 90% of climbers use this grip style regularly. Crimping involves placing the fingertips on the hold with the distal interphalangeal joint (DIP) held extended while the proximal interphalangeal joint (PIP) and the metacarpophalangeal joint are held flexed.

Prevalence

67 world-class climbers at the first ever rock climbing: 26% of the climbers, mainly affecting the ring finger. It was noted that the climbers considered firm taping with non-stretch zinc oxide tape around the affected part of the finger allowed continued training in the presence of injury and made the injury “feel better”.

Evidence of A2 pulley injury was present in 50% of the climbers. 26% of these showed evidence of bowstringing.

Relevant Anatomy



Flexor Tendon Pulleys

A1 pulley: - Arises from volar plate of MP joint, beginning 5 mm proximal to the MP joint and ending at the base of the proximal phalanx;

Average length of A1 pulley is 1 cm;

Proximal edge of the 1st annular pulley lies about 2 cm from the proximal finger crease;

Distal edge of A1 pulley lies about 1 cm from the proximal finger crease;

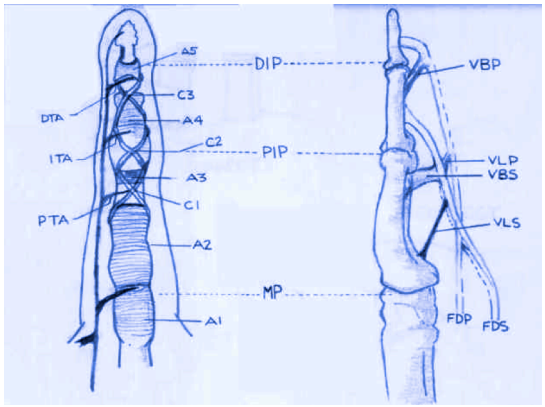
Note that the proximal phalangeal crease which lies over the mid portion of the proximal phalanx

A2 pulley:

A2 pulley begins and ends in the proximal half of the proximal phalanx;

arises from periosteum of proximal half of the proximal phalanx[PP]

Total length is 20 mm, along the mid portion of the PP Of all of the flexor tendon sheaths, this is probably the most important;



Distal to the A2 pulley, a digital arterial ladder branch
provides arterial inflow to the vinculum to FDS
and long vinculum FDP;

A4 pulley: - arises from periosteum of mid-portion of middle phalanx;
- this is the second most important flexor tendon sheath pulley (after the A2);
- when the FDS tendon is lost, the A4 pulley becomes most essential;
- there is an avascular zone of the FDP underneath the A4 pulley;

Pathology

The force in the tendons was simultaneously increased until avulsion of the tendons or osseous failure occurred. The force in the tendons, the excursion of the tendons, and the force at the fingertip were measured. Damage to the pulleys and bowstringing of the tendons were visualized with a fiber optic camera.

Subtle bowstringing of the flexor digitorum profundus tendon occurred only after two consecutive pulleys had ruptured (either the A2 and A3 pulleys or the A3 and A4 pulleys). Rupture of all three pulleys was required to produce obvious bowstringing. Isolated rupture of the A2 or A4 pulley did not result in detectable bowstringing of the flexor digitorum profundus tendon.

The A1 pulley always remained intact.

Clinical

1. Avulsion of the FDS of FDP tendons was ruled out, as flexion against resistance was possible.
2. There was visible and palpable ‘bowstringing’ (bulging of the flexor tendons away from the phalanges) at the PIP joint, pointing to rupture of one or more of the flexor pulleys.
3. The climber described the injury as occurring suddenly while holding onto a ‘pocket’ hold with only the middle and ring fingers. The climber’s feet slipped and caused sudden

increased strain on the fingers, with immediate pain, swelling and subsequent bruising experienced locally on the affected finger.

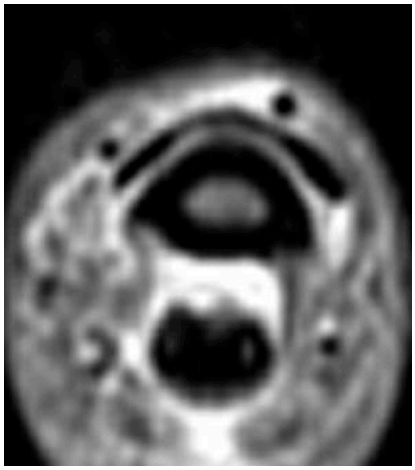
4. Incidence of pain, sometimes accompanied by swelling on the volar aspect of rock climber's fingers, often centered near the PIP joint was a common complaint

5. All presented with significant flexion contractures of the proximal interphalangeal joint and bow stringing of the flexor tendons.

Ultrasound and magnetic resonance imaging are used to differentiate between a pulley strain, partial rupture, complete rupture, or multiple ruptures.

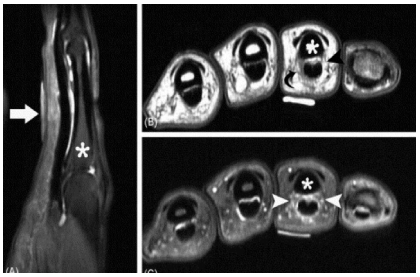
Grade I to III injuries (strains, partial rupture, single ruptures) are treated conservatively with initial immobilization and early functional therapy under pulley protection. Grade IV injuries (multiple ruptures) require surgical repair.

Tenosynovitis



Pulley rupture

Pulley rupture



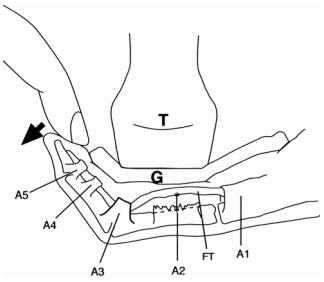
Investigation:

1. X ray: Identify soft tissue swelling

Any associated bone injury

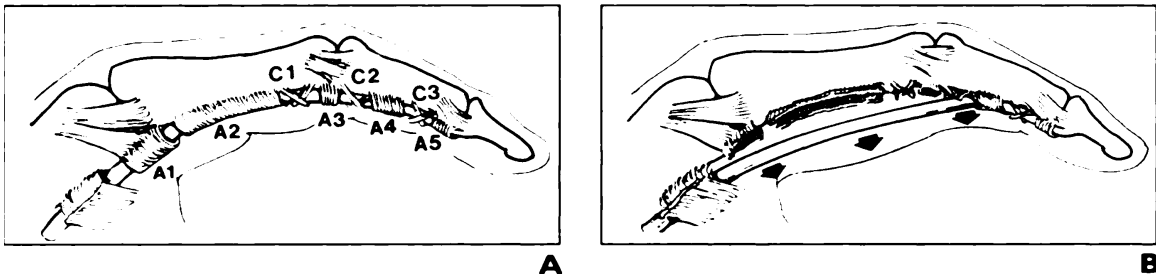
The radiographic changes included formation of thickenings of the proximal

phalangeal cortices at the attachment of the distal edge of the A2 flexor pulley.



2. Ultrasound: Dynamic with finger flexion

3. MRI gold standard



Treatment

The rare injury of closed rupture of the A2 and A3 flexor pulleys was treated using two non-encircling techniques of pulley reconstruction.

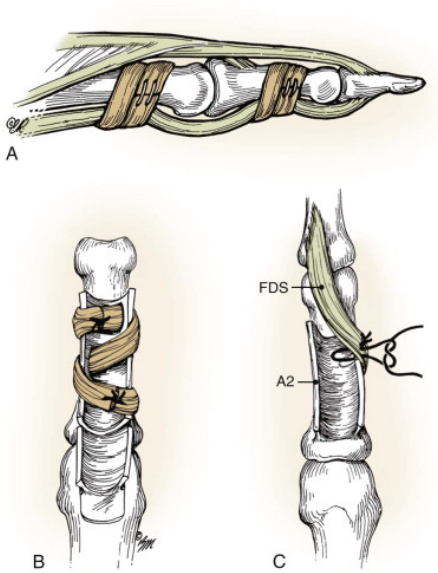
Treated with an extensor retinaculum graft or Palmaris longus. At a mean follow-up time of 48 months, the average PIP flexion was 97%, the power grip strength 96%, the pinch grip strength 100% and the thickening 94% of the uninjured side.

In both groups, finger extension was unrestricted. All climbers returned to their previous standard and all non-climbers regained full finger dexterity in their previous job.

Technique

Methods of reconstruction of pulley system. **A,** Free tendon graft pulleys encircling the phalanx deep to the extensor mechanism at proximal and middle phalanges. **B,** Free tendon graft pulley can be constructed by suturing graft material to the rim of the destroyed pulley. This can take the form of an interweave into the rim, or, if the rim is

inadequate, the graft can be sutured through drill holes in the bone (not shown). **C,** Tail of FDS tendon, when left attached to its insertion, can be sutured over implant to the periosteum or to the rim of the original A2 pulley.



Reference

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