Journal of Orthopedic Research and Therapy

Research Article

Jakubietz MG, et al. J Orthop Res Ther 2016: JORT122.

Femoral Fracture due to Accidental Fall among the Elderly Admitted to a Teaching Hospital

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Citation: Jakubietz MG, Meffert RH, Schmidt K, Gruenert JG, Jakubietz RG (2016) Acute A4 Pulley Reconstruction with a First Extensor Compartment Graft: A Novel Technique. J Orthop Ther. JORT122.

Received Date: 23 November, 2016; **Accepted Date:** 09 February, 2017; **Published Date:** 16 February, 2017

Abstract

Background

The integrity of the flexor tendon pulley apparatus is crucial for unimpaired function of the digits. While secondary reconstruction is an established procedure in multi-pulley injuries, acute reconstruction of isolated, closed pulley ruptures is a rare occurrence. There are three factors influencing the functional outcome of a reconstruction: gapping distance between tendon and bone (E-space), bulkiness of the reconstruction, and stability. As direct repair is rarely done, grafts are used to reinforce the pulley. An advantage of the first extensor retinaculum graft is the synovial coating providing the possibility to be used both as a direct graft with synovial coating or as an onlay graft after removal of the synovia when the native synovial layer is present.

Method

A graft from the first dorsal extensor compartment is used as an onlay graft to reinforce the sutured A4 pulley. This technique allows reconstruction of the original dimensions of the pulley system while stability is ensured by anchoring the onlay graft to the bony insertions of the pulley.

Results

Anatomical reconstruction can be achieved with this method. The measured E-space remained 0mm throughout the recovery, while the graft incorporated as a slim reinforcement of the pulley, displaying no bulkiness.

Conclusion

The ideal reconstruction should provide synovial coating and sufficient strength with minimal bulk. Early reconstruction using an onlay graft offers these options. The native synovial lining is preserved and the graft is used to reinforce the pulley. Although this technique has only been employed in special cases it has shown promising results.

Keywords: Pulley rupture; Bowstringing; A4 pulley; First extensor compartment; Onlay graft

Introduction

The functional relevance of the flexor tendon pulley system is well known, but indications for acute reconstruction are rare. While secondary reconstruction is an established procedure in multi-pulley injuries, acute reconstruction of isolated, closed pulley ruptures remains challenging. As these injuries mainly occur in advanced-level sport climbers, surgical reconstruction is done rarely. The indication for surgery also depends on the availability of a hand surgeon understanding the relevance of this injury [1].

The pulley system is part of the fibro-osseous tendon sheath, which tethers the tendon to the palmar curvature of the bone. This enables the transfer of a translational force generated from the muscle-tendon unit into a rotational moment on the phalanx effectively flexing the digit. In a biomechanical evaluation by Peterson et al., the A2 pulley was found to be the single most important pulley for flexor tendon function. However, near-normal hand function could only be achieved when both A2 and A4 were present [2,3]. Bowstringing results in an increased requirement of muscle activation to reach the same amount of finger flexion. This precludes full finger flexion and also alters kinematics of the adjacent joints. Ultimately the equilibrium between flexor and extensor tendons will be influenced, resulting in loss of range of motion. According to an algorithm presented by Schöffl et al. singular A4 pulley injuries rarely justify surgical intervention [4,5]. On the other hand, Bouyer et al. have shown that isolated ruptures of the A4 pulley proved to be a poor prognostic factor for regaining preinjury performance levels [6]. Surgical reconstruction of the A4 pulley is only advocated in cases of multi-level pulley injuries and outcomes seem to be disappointing. As Chow has shown in cadaveric testing, insufficiency of the proximal A4 pulley has considerable effects on the range of motion of the PIP joint, while effects on MCP or DIP joints were not significant [7]. The functional integrity of the pulley system can be shown by physiological E-space ensuring system efficiency. There are three factors influencing the functional outcome of a reconstruction: gapping distance between tendon and bone (E-space), bulkiness of the reconstruction, and stability. If flexor bowstringing was corrected, patients were much more likely to regain preinjury sport performance [7]. For patients with an E-space less than 2 mm, the incomplete nature of correction compared with the healthy finger did not influence the functional result [7]. While loop techniques may yield superior mechanical strength of the repair, they are not anatomical and may interfere with function of the extensor tendon apparatus [8]. Grafts from the extensor retinaculum have been advocated as the more anatomical choice [9,10]. Nevertheless Bouyet described in the largest series extensor tendon bowstringing at the donor site in more than 25% [7]. Therefore other donor sites should be considered. The first extensor compartment is well known to hand surgeons from deQuervains disease. This extensor compartment displays a strong ligamentous portion of both sufficient width and length in regard to pulley reconstruction. The biomechanical properties of the ligament justify its use for SL ligament reconstruction and should be considered sufficient for flexor tendon pulley reconstruction. Donor site morbidity is low. Bowstringing after release is generally rare in the first extensor compartment. Iatrogenic injury to the superficial branch of the radial nerve is preventable. An advantage of the first extensor retinaculum is the synovial coating providing the possibility to be used both as a direct graft with synovial coating or as an onlay graft after removal of the synovia when the native synovial layer is present.

Technique

A functionally highly demanding surgeon presented with an isolated A4 pulley rupture acquired during sport climbing. MRI showed a completely torn A4 pulley of the left fourth finger, the tear was close to the radial insertion, while the pulley itself became entrapped under the deep flexor tendon (Figure 1).

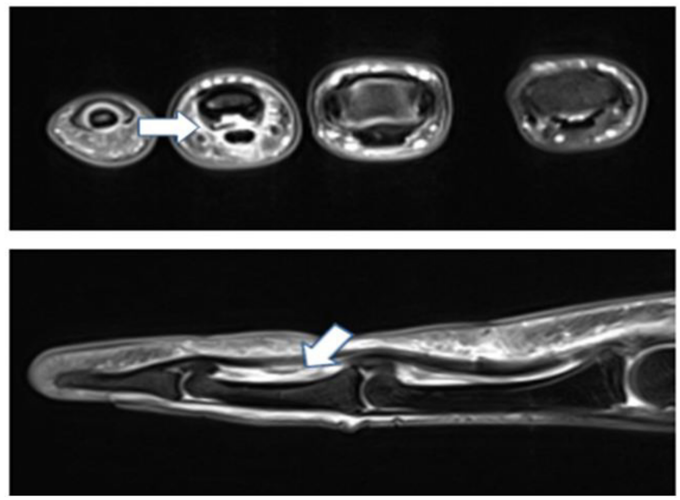

Figure 1: MRI imaging of the torn A4 pulley, displaying pulley entrapment under the deep flexor tendon resulting in increased E-Space.

This resulted in an enhanced E-Space (4mm), indicative for an inferior functional result in the future. Conservatively treated this may lead to chronical synovitis, described as flap irritation phenomenon (FLIP) [11,12]. To avoid such late sequela and expedite return to work as a microsurgeon, reconstruction was scheduled. Since we regard the properties of the first dorsal compartment as advantageous it was used as an onlay graft, anchored to the bony insertion of the pulley, reinforcing the pulley system (Figure 2).

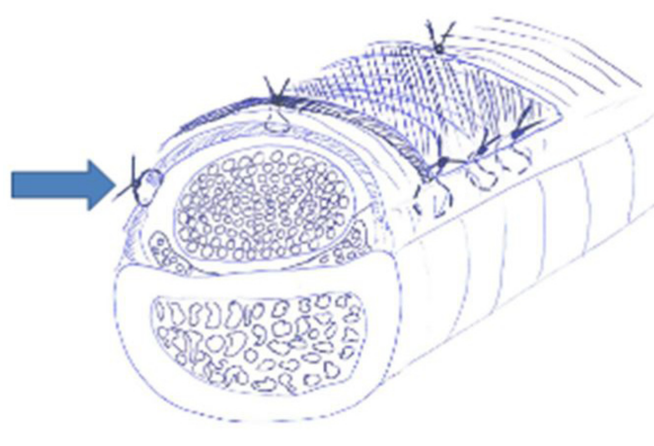

Figure 2: Lateral sutures of the pulley (arrow), suturing of the onlay graft to the bony insertion of the pulley.

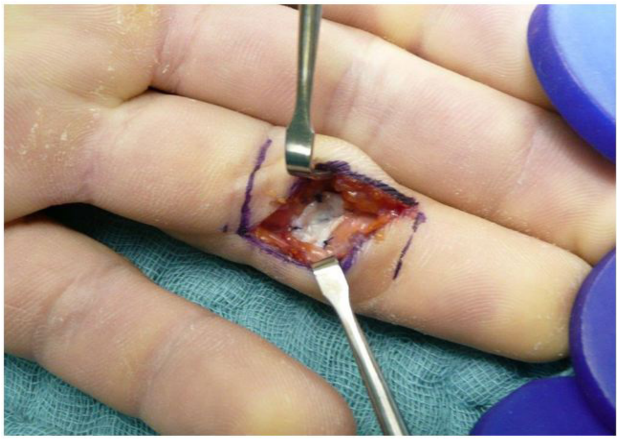

Figure 3: Intraoperative resemblance of the onlay graft. Exposure through a diagonal incision only (Limited Brunner) by request.

Three stitches on each side were employed. The proximal and distal borders of the pulley were additionally anchored to the graft to ensure better incorporation (Figure 2). Throughout the procedure care was taken not to place suture material in direct proximity to the gliding areas such as tendon or synovial layer. Then the needle was removed and gliding of the tendon tested prior to closure. A splint was administered for 7 days followed by a thermoplastic ring for 5 weeks. Active and passive range of motion exercises were initiated after 7 days. Return to climbing was allowed after 6 weeks, however the crimp position was avoided for 6 months. Return to surgery began 2 weeks postoperatively, mainly in microsurgery. Physically more demanding cases requiring full grip strength were begun 6 weeks postoperatively. The measured E-space remained 0mm throughout the recovery and ever since, while the graft did incorporate as a slim reinforcement of the pulley, displaying no bulkiness (Figure 4).

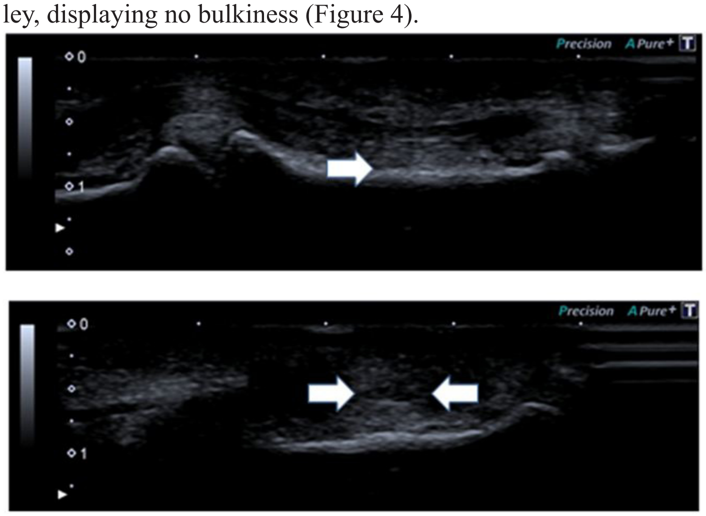

Figure 4: 2 years postoperative Ultrasound, single arrow displaying E-Space of 0mm, double arrow showing width of the graft as well as slim appearance

Full finger flexion at the DIP was reduced for 4 months. No impairment of ROM regarding flexion and extension of the PIP and DIP remained. Only the inability to passively hyperextend the DIP joint persisted. Due to unrelated reasons climbing level increased compared to the preoperative level. After residual swelling of the digit had resolved the tightly fitted wedding band could be worn again.

Discussion

Although conservative treatment for isolated A4 pulley ruptures is generally recommended, reconstruction may be beneficial in individuals with high manual demands apart from sports related activities. As these injuries usually occur in young athletes, most treatment regimens focus on the return to sports at preinjury level. Especially in hand injuries it needs to be noted that athletes demands regarding hand function may not only vary significantly depending on the individual sport but may also be very different to functional demands of patients working in fields requiring high levels of digital skills. Therefore the conclusion that once preinjury level is regained treatment must have been sufficient cannot be applied to all patients. Preinjury level in climbing is a reference point for treatment of pulley injuries. This by itself is highly variable. Due to the nature of grading rockclimbs, routes of the same difficulty level may have completely different physical demands. As high level rockclimbers are motivated they will inevitably work around their weaknesses and might move towards other types of routes of the same difficulty level requiring less finger strength but more core strength and endurance.

The functional result in pulley reconstruction needs to be emphasized more than difficulty level even if athletes only judge success of treatment by posttraumatic climbing level [4,5]. A well-known sequela of pulley injury and resulting bowstringing is an extension deficit at the PIP joint. This may functionally be more relevant for a nonclimbing patient, while rock climbers may not be markedly impaired as finger flexion is unhindered. Emphasis has to be placed on regaining full range of motion based on minimal bowstringing, presenting as near normal E-space. Furthermore it has to be noted that treatment recommendations may also be based on the availability of a hand surgeon with sufficient knowledge regarding such injuries. The ideal treatment will reconstruct the original dimensions and biomechanical properties of the pulleys. While a too wide/loose reconstruction will result in persistent bowstringing, seen in an enlarged E-space, too tight reconstruction will interfere with tendon gliding. Dy et al reported the main reoperative procedure after pulley reconstruction being tenolysis [13]. Increased tendon gliding resistance is a well-known factor for less favorable results in flexor tendon repair. Thus authors also consider incising pulleys in order to reduce gliding resistance [14-16].

These considerations cannot be applied to pulley ruptures where flexor tendons are intact. Persistent loss of motion and decreased strength is caused by anatomical alterations of the course of the flexor tendon apparatus. Thus the functional absence of a pulley, while probably being tolerable in a slightly shortened flexor tendon after repair, will lead to more profound mechanical alteration in athletes with non-injured tendons [17,18] The ideal reconstruction will provide an equilibrium of stability and function. While grafts from the first extensor retinaculum have been used in our institution for several indications, the use for immediate singular A4 pulley reconstruction has not been reported. In most published series reconstruction was delayed. Fresh injuries are rarely treated as most athletes present later. In acute injuries, retraction of the pulleys has not occurred yet, thus possibly allowing primary repair. Direct repair is mechanically debatable as the orientation of fibres does not allow good placement of sutures. An unretracted pulley however provides beneficial information about the dimension of the pulley system. When reducing the tendon and adapting the pulley, the anatomical dimension can be restored while preserving the native synovial surface. Augmentation of the pulley is recommended as primary repair is mechanically not very stable. An onlay graft from the first extensor compartment anchored to the bony origin of the pulley will provide a stable reconstruction without excessive soft tissue impairment caused by looping techniques or weakening the bone through drill holes [8-10] (Figure 4). Looping techniques interfere with motion of the extensor tendons and use extra synovial grafts potentially causing tendon adhesions [9,13].

The ideal reconstruction should provide synovial coating and sufficient strength with minimal bulk. Early reconstruction using an onlay graft offers these options. The native synovial lining is preserved and the graft is used to reinforce the pulley [19,20]. As isolated, closed pulley ruptures are rare in hand surgery units, larger case series are not to be expected. Although this technique has only been employed in special cases it has shown promising results.

References

1. Schöffl V, Hochholzer T, Winkelmann HP, Strecker W (2003) Pulleyinjuries in rockclimbers. Wilderness Environ Med 14: 94-100.
2. Peterson WW, Manske PR, Bollinger BA, Lesker PA, McCarthy JA (1986) Effect of pulley excision on flexor tendon biomechanics. J Orthop Res 4: 96-101.
3. Zafonte B, Rendulic D, Szabo RM (2014) Flexor pulley system: anatomy, injury, and management. J Hand Surg Am 12: 2525-2532.
4. Schöffl VR and Schöffl I (2006) Injuries to the finger flexor pulley system in rock climbers: current concepts. J Hand Surg Am 31: 647-654.
5. Schöffl VR, Einwag F, Strecker W, Schöffl I (2006) Strength measurement and clinical outcome after pulley ruptures in climbers.MedSci Sports Exerc 38: 637-643.
6. Bouyer M, Forli A, Semere A, Chedal Bornu BJ, Corcella D, et al. (2016) Recovery of rock climbing performance after surgical reconstruction of finger pulleys. J Hand Surg Eur 41: 406-412.
7. Chow JC, Sensinger J, McNeal D, Chow B, Amirouche F, et al. (2014) Importance of proximal A2 and A4 pulleys to maintaining kinematics in the hand: a biomechanical study. Hand (N Y) 9: 105-111.
8. Okutsu I, Ninomiya S, Hiraki S, et al. (1987) Three-loop technique for A2 pulley reconstruction. J Hand Surg Am 12: 790-794.
9. Arora R, Fritz D, Zimmermann R, Lutz M, Kamelger F, et al. (2007) Reconstruction of the digital flexor pulley system: a retrospective comparison of two methods of treatment. J Hand SurgEur 32: 60-66.
10. Gabl M, Reinhart C, Lutz M, Bodner G, Angermann P, et al. (2000) The use of a graft from the second extensor compartment to reconstruct the A2 flexor pulley in the long finger. J Hand Surg Br 25: 98-101.
11. Clark TA, Skeete K, Amadio PC (2010) Flexor tendon pulley reconstruction. J Hand Surg 35: 1685-1689.
12. Schöffl I, Baier T, Schöffl V (2011) Flap irritation phenomenon (FLIP): etiology of chronic tenosynovitis after finger pulley rupture. J ApplBiomech 27: 291-296.
13. Dy CJ, Lyman S, Schreiber JJ, Do HT, Daluiski A (2013) The epidemiology of reoperation after flexor pulley reconstruction. J Hand Surg Am 38: 1705-1711.
14. Cao Y and Tang JB (2009) Strength of tendon repair decreases in the presence of an intact A2 pulley: biomechanical study in a chicken model. J Hand Surg Am 34: 1763-1770.
15. Tang JB, Cao Y, Wu YF, Wang GH (2009) Effect of A2 pulley release on repaired tendon gliding resistance and rupture in a chicken model. J Hand Surg Am 34: 1080-1087.
16. Mallo GC, Sless Y, Hurst L, Wilson K (2008) A2 and A4 flexor pulley biomechanical analysis: comparison among gender and digit. Hand (N Y) 3: 13-16.
17. Leeflang S and Coert JH (2014) The role of proximal pulleys in preventing tendon bowstringing: Pulley rupture and tendon bowstringing. J PlastReconstrAesthet Surg 67: 822-827.
18. Moutet F, Forli A, Voulliaume D (2004) Pulley rupture and reconstruction in rock climbers. Tech Hand Up Extrem Surg 8: 149-155.
19. Roloff I, Schoffl VR, Vigouroux L, Quaine F (2006) Biomechanical model for the determination of the forces acting on the finger pulley system. J Biomech 39: 915-23.
20. Kleinert HE and Bennett JB (1978) Digital pulley reconstruction employing the always present rim of the previous pulley. J Hand Surg Am 3: 297-298.