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Review article

Finger flexor pulley injury of sport climbers – Literature review



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ABSTRACT

Introduction: Sport climbing has grown in popularity in recent years. During this activity, the main exercise is made by the upper limbs which carry the largest load. Almost half of all climbing injuries concern fingers with most frequent injuries of flexor tendon pulleys.

Aim: The aim of this work is to present risk factors, clinical picture, current diagnostic methods and treatment of finger flexor pulley injury of sport climbers.

Material and methods: The attempt was made to characterize finger flexor pulley injury of sport climbers. Using keywords 'pulley,' climbing,' rupture,' injury' we performed a review of relevant articles based on a PubMed search, focusing on last five years.

Results and discussion: The amount of mechanical load that climbers apply to each finger depends on several hand grips specific to sport climbing. Repetitive loading of the pulleys with high forces can bring on injury and overuse syndromes. The grading system for flexor pulley injuries was proposed by Schöffl et al. to help guide and correlate therapeutic options.
Conclusions: The main causes of pulley injury include the lack of proper warm-up before training, a lack of stretching and cool down the body's muscles after workout, too short time intervals between each workout and repetitive overuse. The diagnosis of pulley disruption is based on the injury history, clinical examination and visualization by ultrasound or a magnetic resonance imaging. Grade 1–3 pulley injuries can be managed conservatively, grade 4 injuries require a surgical repair.

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1. Introduction

Sport climbing is one of the most popular extreme sports, where the main exercise is made by the upper limbs which carry the largest load. This kind of effort is associated with a unique subset of injuries to the hand and upper extremity.¹ Twenty percent of all climbing injuries are to the flexor tendon pulleys, which are sensitive to ruptures and sprains.²

The digital flexor sheath is a complex structure through which the flexor tendons of the fingers run and is composed of membranous and pulley components.³ The pulley system function is to maintain the flexor tendons close to the bone. It enables direct transfer of the translational force developed in the flexor muscle – tendon unit into a rotational moment of the phalanges.⁴ The pulley system of the second to the fifth fingers contain five annular (A1–A5) and three cruciform pulleys (C1–C3)⁵ (Fig. 1). The fibro-osseous A2 and A4 pulleys are mechanically stronger than the A1, A3, A5 volar plate pulleys, which are more flexible and allow for compression during flexion without impinging on the tendons.^{4,6}

The amount of mechanical load that climbers apply to each finger depends on several hand grips specific to sport climbing.⁷ There are three most characteristic hand grips in climbing (crimp, half crimp and slope) and the maximal vertical forces differed significantly according to the grip technique^{8,9} (Fig. 2). Climbers are often using the crimp grip position where the force produced by the grip is the biggest and it is the most effective way to hold small ledges.⁹ In this position bowstringing of the flexor tendons applies big forces to the flexor tendon pulleys, especially A2 pulley with forces of approximately 380 N.^{7,10} Repetitive loading of the pulleys

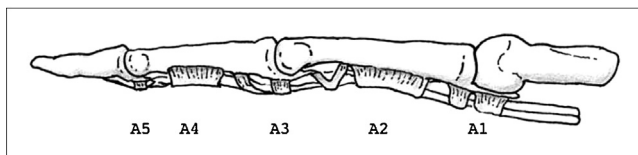


Fig. 1 – The finger flexor pulley system according to Lin et al.⁴

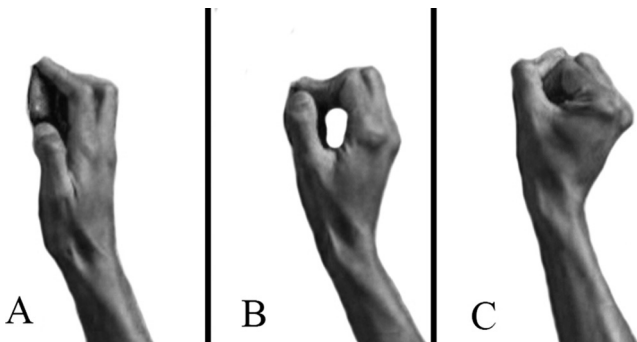


Fig. 2 – Three hand grips in climbing (A – slope, B – half crimp, C – crimp) according to Amca et al.⁹

with high forces can bring on injury and overuse syndromes.^{6,11}

2. Aim

The aim of this work is to present risk factors, clinical picture, current diagnostic methods and treatment of finger flexor pulley injury of sport climbers.

3. Material and methods

The attempt was made to characterize finger flexor pulley injury of sport climbers. Using keywords 'pulley,' 'climbing,' 'rupture,' 'injury' we performed a review of relevant articles based on a PubMed search, focusing on last five years.

4. Results and discussion

4.1. Risk factors

A considerable amount of damage caused during the climb is a lack of fitness or overtraining.¹² Climbers without appropriate training experience, try a maximum workout to catch up climbing technique, strength, endurance and precision movements.¹³ The main causes of pulley injury include the lack of proper warm-up before training, a lack of stretching and cool down the body's muscles after a workout, too short time intervals between each workout and repetitive overuse which after a longer period of time can lead to serious damage.^{14,15} Most commonly significant pulley damage takes place during performing a difficult move in the crimp position or when climbers have shock loaded their fingers as they lose their footing.^{16,17}

4.2. Signs and symptoms

The main symptoms for pulley injury are a sudden onset of pain and swelling over the affected pulley or pulleys and there can be acute hematoma formation.¹⁸ Muscle loss of power and function and the normal course of the tendon is shortened. An increase in the functional length of the tendon resulting in an active flexion deficit.⁵ Loud pop is heard occasionally during the injury.²

4.3. Classification

The grading system for flexor pulley injuries was proposed by Schöffl et al. to help guide and correlate therapeutic options. Grade 1 injuries are pulley strains with no dehiscence between bone and tendon in the MRI or ultrasound. The complete rupture of an A4 pulley and partial rupture of the more essential A2 or A3 pulley are graded with grade 2. The complete rupture of the A2 or A3 pulley is rated grade 3. Grade 4 injuries include complex lesions with multiple pulley injuries or single pulley injuries combined with lumbricalis muscle damage or collateral ligament rupture^{2,19} (see Table 1).

Table 1 – The grading system for flexor pulley injuries and therapeutic guidelines according to Schöffl et al.²

	Grade 1	Grade 2	Grade 3	Grade 4
Injury	Pulley strain	Complete rupture of A4 or partial rupture of A2 or A3	Complete rupture A2 or A3	Multiple ruptures, as A2/A3, A2/A3/A4 or single rupture (A2 or A3) combined with lumbricalis muscle or ligament damage
Therapy	Conservative	Conservative	Conservative	Surgical repair
Immobilization	None	10 days	10–14 days	Postoperative 14 days
Functional therapy	2–4 weeks	2–4 weeks	4 weeks	4 weeks
Pulley protection	Tape	Tape	Thermoplastic or softcast ring	Thermoplastic or softcast ring
Easy sport – specific activities	After 4 weeks	After 4 weeks	After 6–8 weeks	4 months
Full sport – specific activities	6 weeks	6–8 weeks	3 months	6 months
Taping through climbing	3 months	3 months	6 months	After 12 months

4.4. Diagnosis

The diagnosis of a pulley disruption is based on the history (pop loud) and on clinical examination, where a painful flexor tendon bowstringing can be palpated during resisted finger-flexion.²⁰ To confirm the diagnosis the bowstringing of the tendon it is necessary to visualize by ultrasound or MRI.²¹ Radiographs are recommended to exclude fractures or osseous tears of the palmar fibrocartilage and chronic overuse fractures in the epiphysis.²²

4.5. Treatment

The treatment depends upon what pulley is damaged and the degree of damage. Grade 1–3 injuries can all be managed conservatively.^{2,17,19} Initial immobilization and early functional therapy under pulley protection are recommended.² Adjunctive treatments such as ultrasound, laser therapy, magnetotherapy or local cryotherapy fasten return to an active climber sports.¹³ Local cortisone injection and prolonged resting period help regaining initial sport activity level. Finger taping during climbing is necessary while returning to training after pulley injury. Taping over pulleys decreased bowstringing by 2.8% and absorbed 11.0% of the force of bowstringing.²³ Grade 4 injuries require a surgical repair by the loop and a half, single-loop, double-loop or double-anchor repair technique.²⁴ Minimally invasive double-anchor technique make the circumferential dissection and soft tissue trauma associated with the single- and double-loop repairs no longer necessary.²⁵

5. Conclusions

1. The main causes of pulley injuries include the lack of proper warm-up before training, lack of stretching and cool down the muscles after workout, too short time intervals between each workout and repetitive overuse.
2. The diagnosis of a pulley disruption is based on history, clinical examination and visualization by ultrasound or MRI.
3. Grade 1–3 pulley injuries can be managed conservatively, grade 4 injuries require surgical repair.

Conflict of interest

None declared.

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