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Original Research

Percutaneous Surgery for Trigger Finger Treatment Using a Novel Surgical Device: An Experimental Study on Fresh Cadavers

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Purpose: Trigger finger, a stenosing tenosynovitis of the flexor tendon at the A1 pulley, can cause pain and impair daily activities. Despite common surgical interventions, postsurgical complications are frequent, prompting the search for less invasive techniques.
Methods: An experimental study was conducted on fresh cadavers to compare three techniques: the first using a PulleyCut without ultrasound guidance, the second using a PulleyCut with ultrasound guidance, and the third using a percutaneous needle technique. The complete release of the A1 pulley, integrity of the A2 pulley, flexor tendons, and neurovascular bundles were assessed.
Results: The new device group and the ultrasound-guided group demonstrated 100% complete release of the A1 pulley, whereas the needle group achieved only 38% success. There were no A2 pulley injuries in any group. Flexor tendons were injured in 7% of cases in the new device group and 77% in the needle group. A neurovascular injury occurred in the needle group.
Conclusions: Compared with the percutaneous needle technique, the new device proved safe and effective for A1 pulley release, minimizing damage to flexor tendons and neurovascular structures. Ultrasound did not provide significant advantages, suggesting that the new device can be confidently used without ultrasound assistance. The PulleyCut represents a promising percutaneous technique for trigger finger treatment, demonstrating superiority over the needle technique in terms of efficacy and safety. These results encourage future clinical investigations to validate its practical application.
Type of study/level of evidence: Therapeutic IIc.

Trigger finger, or stenosing tenosynovitis of the flexor tendon at the A1 pulley, is one of the most common causes of hand pain and disability, leading to varying degrees of limitations in daily functioning.[1] Initially, conservative treatment is attempted; however, when unsuccessful or in cases of recurrence, surgical intervention is recommended.[2] Surgical treatments, either open or percutaneous, generally yield high success rates. Complications arising from open surgery occur in 6% to 30% of patients, primarily related to postoperative wound healing. These complications include persistent pain, painful hypertrophic scars, adhesions, finger flexion contracture, paresthesias, and infections.[3]

The concept of percutaneous release for trigger finger aims to minimize the scarring complications associated with open surgery. Initially reported in 1958 by Lorthioir,[4] percutaneous release using a fine instrument (retinaculotome) demonstrated successful outcomes in 52 fingers without complications. Other authors have described various percutaneous methods with satisfactory results.[5–8] However, there is limited evidence regarding specific instruments for trigger finger treatment, their effectiveness, and safety. Percutaneous release using needles is the most widely practiced percutaneous technique, but owing to a tendency to cause multiple longitudinal lacerations in the flexor tendon and owing to uncertainty regarding complete A1 pulley opening, this technique presents a higher risk of recurrence, neurovascular injuries, adhesions, and finger flexion contracture.[9]

To enhance the minimally invasive surgical technique for A1 pulley release, we developed a specific surgical device, a

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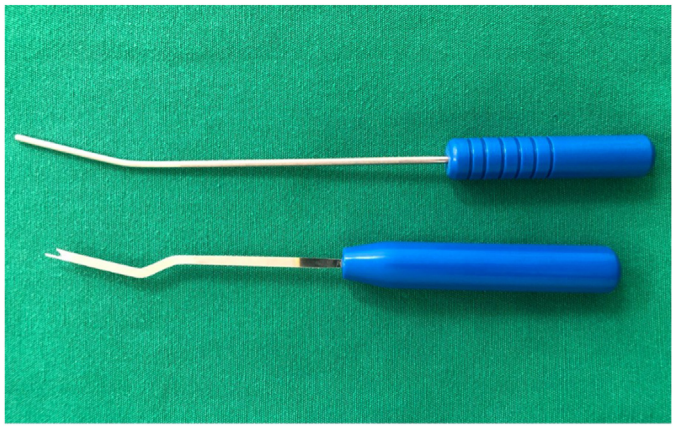

Figure 1. PulleyCut retinaculotome and spacer.

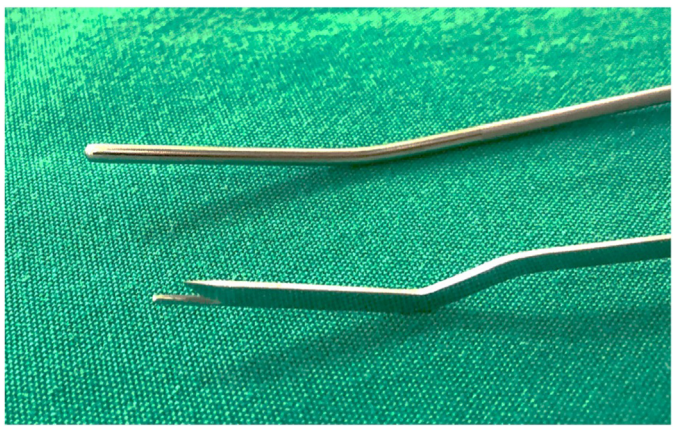

Figure 2. Detail of the blade and spacer.

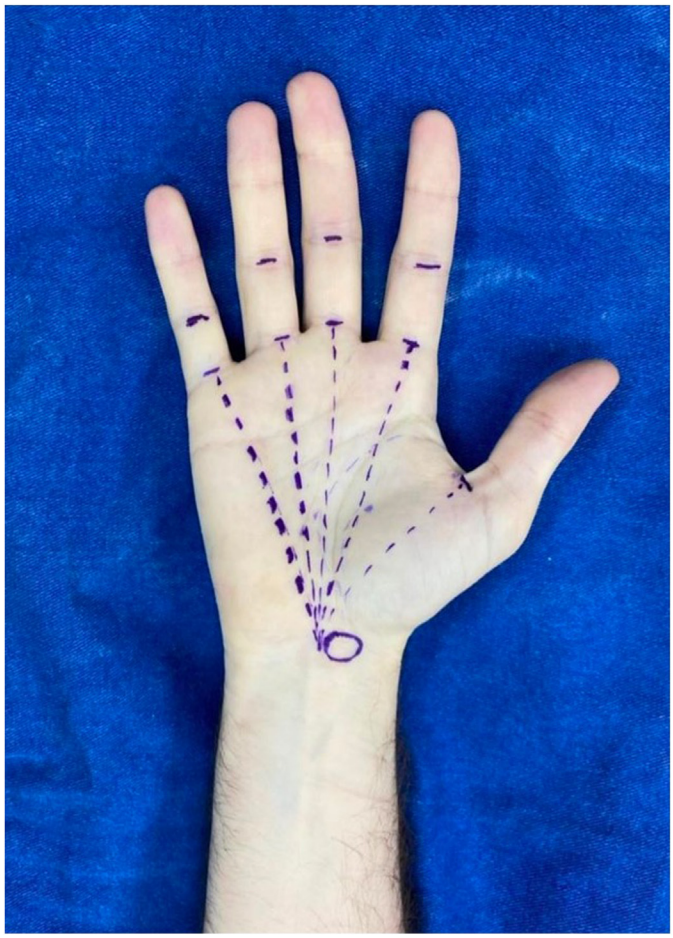

Figure 3. Topographical parameters with marked pathway and orientation of osteofibrous tunnels and flexor pulley A1 of the thumb and long fingers.

retinaculotome or pulley knife, named PulleyCut. In this study, our objective was to evaluate the efficacy and safety of this device and assess whether this minimally invasive technique is safe and enables complete A1 pulley opening. This experimental study utilized fresh cadavers and three techniques: a minimally invasive surgery technique with retinaculotome using anatomical topographic parameters, a minimally invasive surgery technique with retinaculotome assisted by ultrasound, and a percutaneous technique using a needle.

Materials and Methods

This experimental study was conducted in a hand surgery center, with approval from the institution's ethics committee. All cadavers were treated in accordance with ethical principles governing scientific research.[10]

Percutaneous release of the A1 pulley was performed on 40 fingers from eight hands of fresh adult cadavers. The fingers were randomly divided into three groups in a 1:1:1 ratio. In the first group (G1), a minimally invasive surgery approach was used for A1 pulley release, employing the new surgical instrument on 14 fingers (3 thumbs and 11 long fingers) following anatomical topographic guidance.[11] In the second group (G2), A1 pulley release was performed using the minimally invasive technique with the PulleyCut surgical device guided by ultrasound on 13 fingers (2 thumbs and 11 long fingers) (Figs. 1, 2). The ultrasound device used was the Butterfly iQ+TM, developed by Butterfly Network, Inc. In the third group (G3), A1 pulley release was carried out through percutaneous technique using a 40 mm × 12 mm caliber needle on 13 fingers (3 thumbs and 11 long fingers).

Intervention

Technique for group 1: topographic parameters

1. We marked the path of the osteofibrous tunnel, connecting points immediately medial to the scaphoid tubercle to the center of the palmar digital crease of the finger. In the case of the thumb, the center is precisely marked on the axis of the flexor tendon (Fig. 3).[11]
2. To demarcate the proximal limit of the A1 pulley, we measured the distance from the palmar digital crease to the proximal interphalangeal fold, corresponding to the length of the A1 pulley. We marked this measurement proximally from the palmar digital crease to determine the proximal limit of the A1 pulley (Fig. 4).
3. We marked the entry point for the retinaculotome 3–5 mm proximal to the previous marking of the proximal limit of the A1 pulley (Figs. 4, 5).
4. We made a transverse incision of 8 mm, with blunt dissection until the proximal limit of the A1 pulley was visualized (Figs. 5, 6).

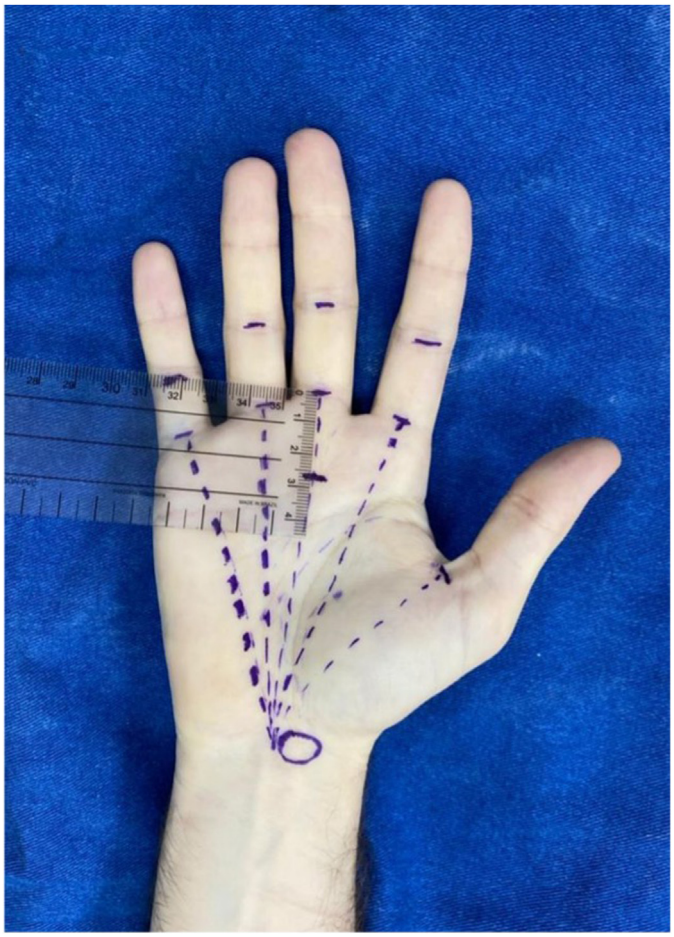

Figure 4. Marking of the proximal and distal boundaries of the pulley.

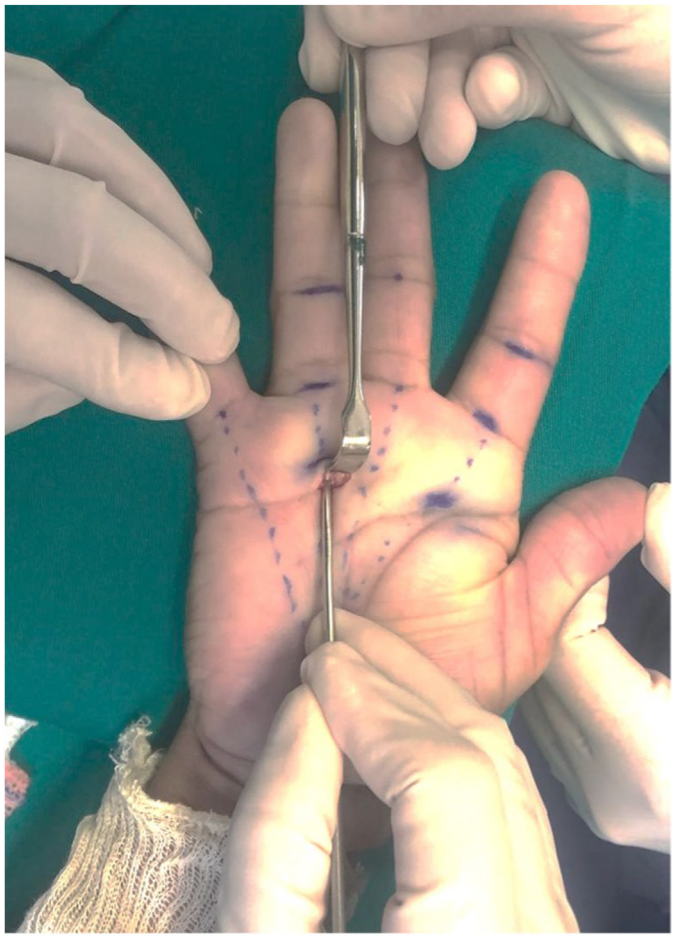

Figure 5. Introduction of the spacer into the osteofibrous tunnel at the proximal edge of the A1 pulley.

5. We inserted the spacer to confirm the limits of the A1 pulley; this action was carried out to facilitate the use of the new device (Figs. 5–7).
6. The new device was inserted longitudinally following the path of the previously marked osteofibrous tunnel (Figs. 8–11).
7. We slowly advanced the device longitudinally until the resistance was encountered, previously verified with the spacer (Figs. 9–11).

Technique for group 2: ultrasonographic parameters

1. Steps 1–4 were similar to those of group 1.
2. Ultrasound gel was applied to the A1 pulley region.
3. The transducer was placed longitudinally on the volar side of the affected finger, identifying the flexor tendons throughout the length of the ultrasound image to ensure proper alignment. The metacarpophalangeal joint should be seen at the distal end of the image.
4. We inserted the pulley spacer until the end of the A1 pulley, confirmed with the assistance of ultrasonography.
5. The new device was inserted longitudinally following the path of the previously marked osteofibrous tunnel.
6. We slowly advanced the device longitudinally until complete release of the pulley was observed through ultrasonography.
7. After opening, we confirmed the success of complete A1 pulley release using transverse ultrasound images.

Percutaneous technique using a needle

1. Steps 1 and 2 were similar to those of group 1. The technique used was described by Sato et al.[3]
2. The 40 mm × 12 mm needle was inserted perpendicularly through the A1 pulley and flexor tendon at a point equidistant from the marked edges.
3. The needle position was verified by passively flexing the finger.
4. The needle was then slightly retracted, and using the bevel, the pulley was incised longitudinally in line with the tendon until complete sectioning of the A1 pulley.

For outcome evaluation, the evaluator was blinded. A T-shaped incision, performed by a hand surgeon not affiliated with the study, was made over the A1 pulley of all operated fingers, and the following outcomes were assessed through macroscopic examination and photographic documentation:

1. Complete or partial section of the A1 pulley.
2. Integrity of the A2 pulley.
3. Integrity of the flexor tendons.
4. Integrity of neurovascular bundles.

Descriptive statistical analysis was performed, and categorical variables were expressed in terms of frequencies and percentages. Fisher exact test was used to compare the three groups in categorical variables. The significance level was set at .05. Two-tailed hypotheses were considered with a 95% confidence interval.

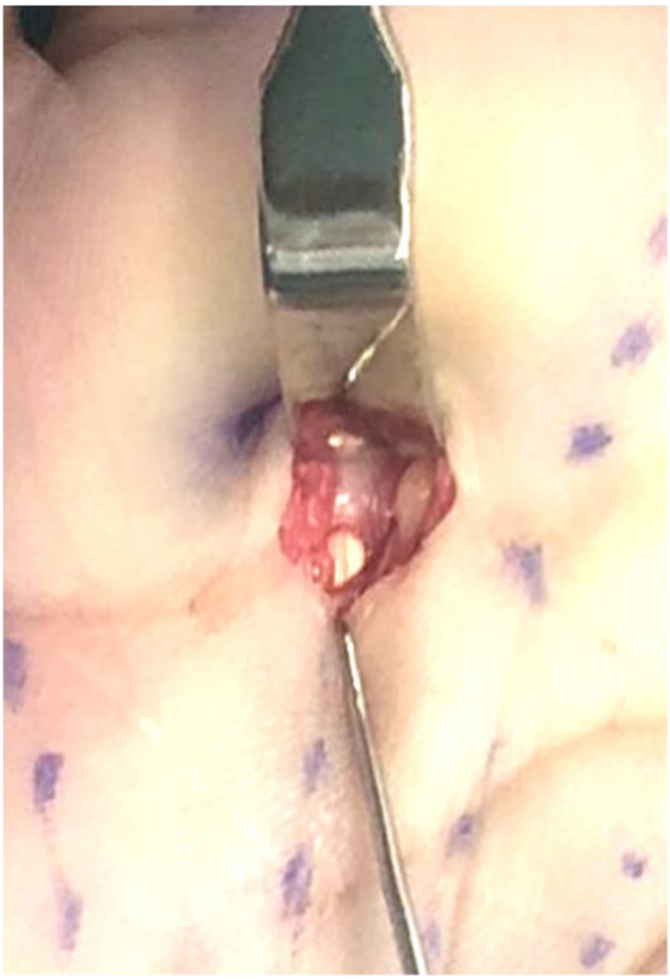

Figure 6. Detail of the dissection and proximal edge of the A1 pulley.

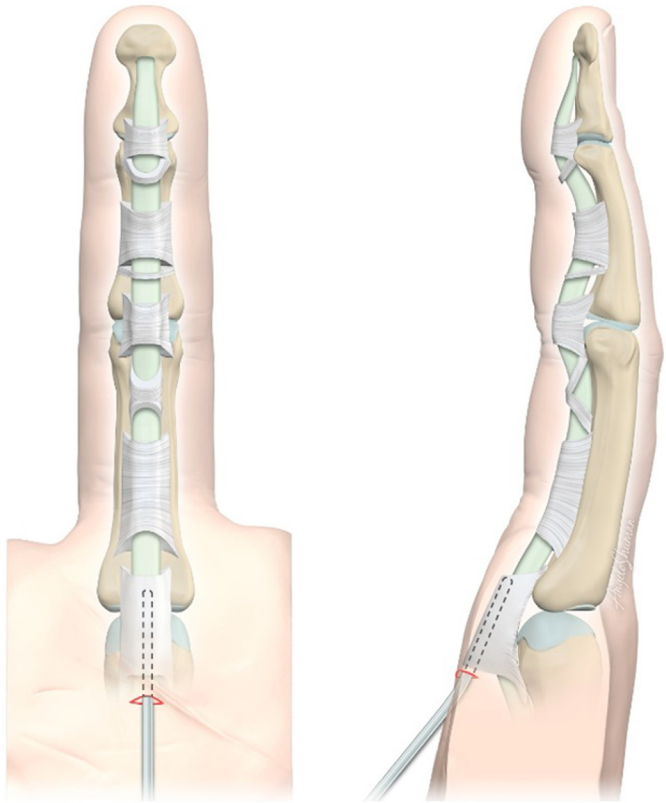

Figure 7. Schematic illustration in anteroposterior and profile views showing the correct introduction of the spacer into the osteofibrous tunnel proximal to the A1 pulley.

Results

Complete A1 pulley release

In group 1, complete A1 pulley release was achieved in 14 of 14 fingers (100%); in group 2, there was complete release in all 13 of 13 fingers (100%); in group 3, 5 of 13 fingers (38.5%) were completely released. There was a statistically significant difference favoring groups 1 and 2 compared with group 3 in terms of complete A1 pulley release ($P < .001$). There was no difference between groups 1 and 2 (Tables 1, 2).

Integrity of A2 pulley

No instances of A2 pulley injury occurred in any of the groups.

Neurovascular bundles

There was one neurovascular bundle injury in group 3, where during thumb release, there was a partial laceration of the ulnar digital nerve. There was no statistical difference between the groups regarding neurovascular injuries.

Integrity of flexor tendons

None of the flexor tendons were injured in group 2. In group 1, there was a partial flexor tendon injury in 1 of 14 fingers (7%), constituting a 20% diameter laceration of the tendon in one thumb, without statistical significance (Table 3). In group 3, flexor tendon injury occurred in 10 of 13 fingers (77%), all being partial and longitudinal lacerations. There was a statistically significant difference in the incidence of flexor tendon injury favoring groups 1 and 2 compared with group 3 ($P = .001$). There was no difference between groups 1 and 2 (Table 3).

Discussion

Classic open release of the A1 pulley can lead to a 6% to 30% incidence of painful conditions or limited active finger mobility, primarily due to scar-related complications.[3] Hence, percutaneous techniques aim to prevent surgical incision over the osteofibrous tunnel, minimizing these potential complications and enabling an earlier return to patients' routine activities.[3,9]

In this experimental study conducted on cadavers, we evaluated a new surgical instrument (PulleyCut) specifically designed for percutaneous A1 pulley release, tested across all digits.

Our study demonstrated complete A1 pulley release in all digits without any injury to anatomical structures upon macroscopic examination of cadaver fingers (100% success rate). Dunn and Pess[6] conducted a study using a retinaculotome for percutaneous release on 78 fresh cadaver digits, achieving complete A1 pulley section in 51 of 52 digits (98%). However, the group using the percutaneous needle technique achieved complete A1 pulley release in only 10 of 26 digits (38%).

Our findings indicate the limited efficacy of the needle percutaneous technique in achieving complete A1 pulley section in fresh cadaver digits, with only 38.5% of operated digits showing complete

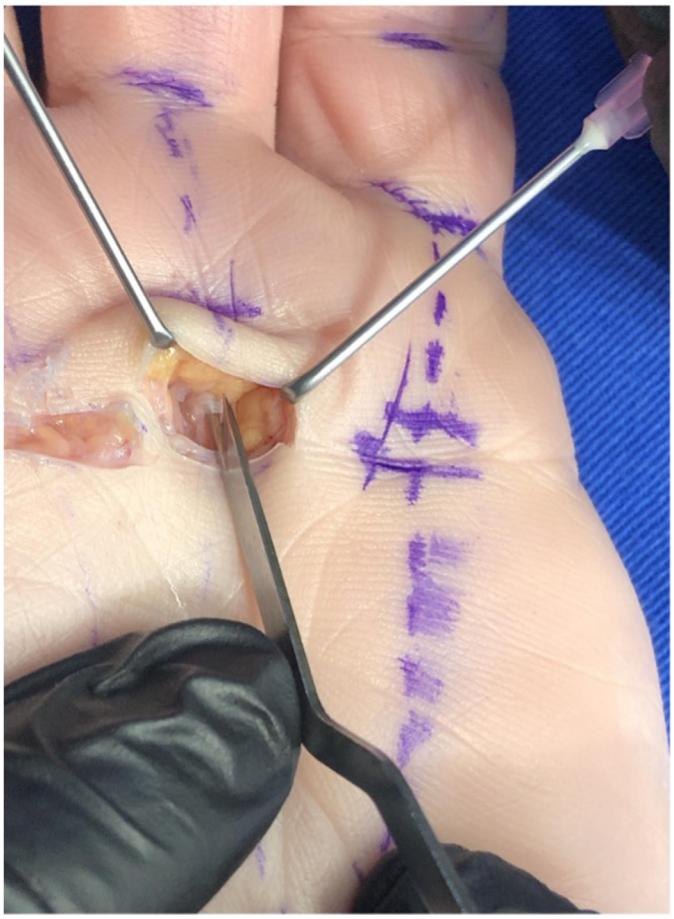

Figure 8. Insertion of the PulleyCut, positioning it at the A1 pulley.

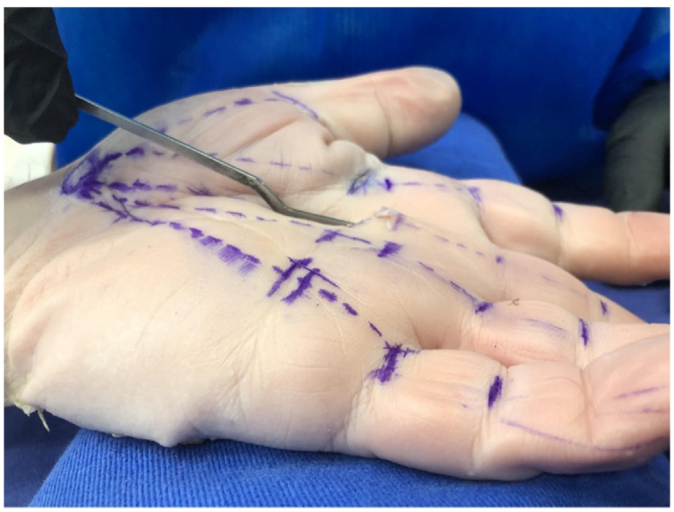

Figure 9. Proper positioning of the PulleyCut against the hand for cutting the pulley.

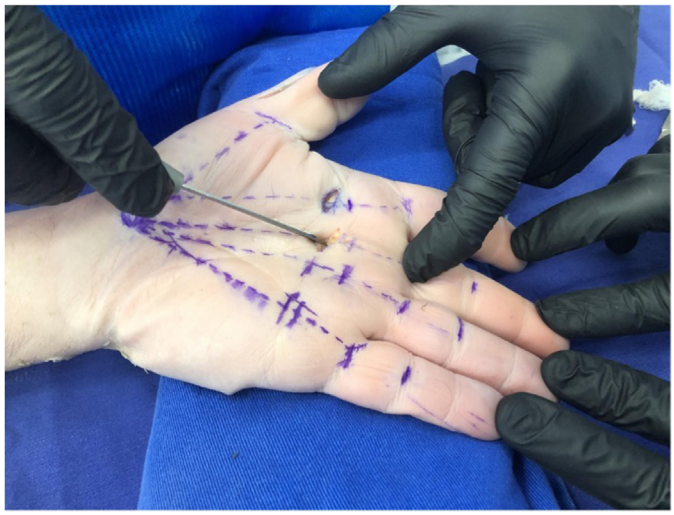

Figure 10. Advancement of the PulleyCut with the surgeon's free finger at the metacarpophalangeal line, preventing excessive advancement of the PulleyCut.

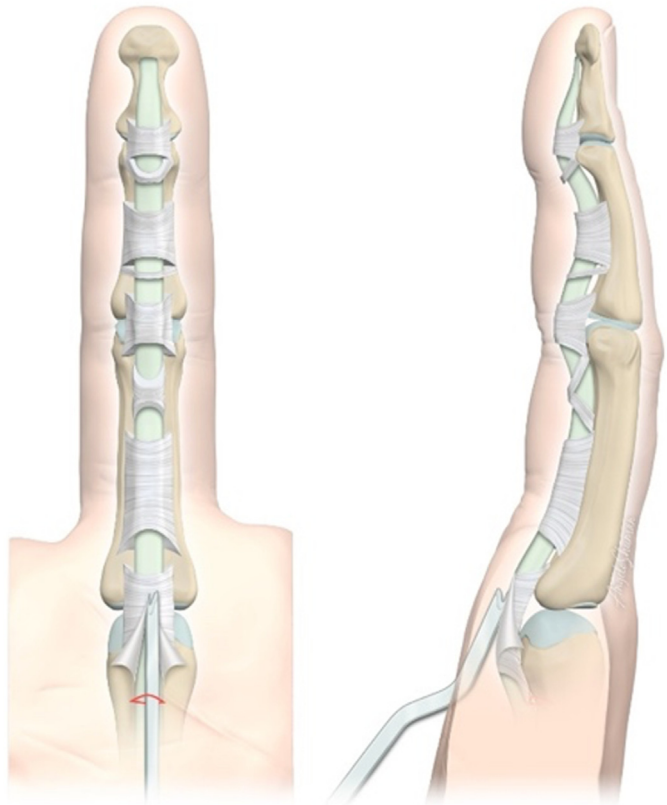

Figure 11. Schematic illustration in anteroposterior and profile views of the correct release with the PulleyCut of the A1 pulley.

pulley release. Furthermore, this technique caused partial injuries with longitudinal lacerations in 77% of the flexor tendons, aligning with similar experimental studies on cadavers.[6,7,12]

Comparative studies, such as the one by Bain et al,[12] reported a 68% success rate with needle percutaneous techniques, accompanied by 88% tendon flexor injuries. Similar studies by Hoang et al[13] and Habbu et al[14] showed varying degrees of success with needle percutaneous techniques, highlighting the challenges in achieving consistent and safe outcomes using this approach.

In our study, we observed no A2 pulley injuries upon macroscopic examination of the operated cadaver fingers. Brown et al[5] utilized a retrograde endoscopic technique on 16 cadaver digits, resulting in 100% complete A1 pulley release without

Table 1
PulleyCut (Group 1) Versus Needle: Evaluated Outcomes

Outcomes	Category	PulleyCut (G1)	Needle (G3)	*P* Value	Test
Complete A1 pulley release		14 (100%)	5 (38.5%)	.001	Fisher exact test
Injury to the A2 pulley		0 (0%)	0 (0%)		
Flexor tendon injury	Longitudinal—partial	0 (0%)	10 (77%)	<.001	Fisher exact test
	Transverse—partial	1 (7%)	0 (0%)		
Neurovascular injury	Partial	0 (0%)	1 (7.5%)	.481	Fisher exact test

G, group.

Table 2
Descriptive Analysis: PulleyCut With USG Versus Needle

Outcomes	Category	PulleyCut Without USG (G2)	Needle (G3)	*P* Value	Test
Complete A1 pulley release		13 (100%)	5 (38.5%)	.002	Fisher exact test
Injury to the A2 pulley		0 (0%)	0 (0%)		
Flexor tendon injury	Longitudinal	0 (0%)	10 (77%)	<.001	Fisher exact test
Neurovascular injury	Partial	0 (0%)	1 (7.5%)	1.000	Fisher exact test

G, group; USG, ultrasonographic assistance.

Table 3
Descriptive Analysis: PulleyCut With USG Versus PulleyCut Without USG

Outcomes	PulleyCut Without USG (G2)	PulleyCut With USG (G1)	*P* Value	Test
Complete A1 pulley release	14 (100%)	13 (100%)		
Injury to the A2 pulley	0 (0%)	0 (0%)		
Flexor tendon injury	1 (7%)	0 (0%)	1.000	Fisher exact test
Neurovascular injury	0 (0%)	0 (0%)		

G, group; USG, ultrasonographic assistance.

injuries to flexor tendons or neurovascular structures. However, partial injuries to the A2 pulley were reported, although statistically insignificant, possibly because of the retrograde nature of the endoscopic instrument entry between the A1 and A2 pulleys.

Regarding the comparison between the PulleyCut technique with and without ultrasound guidance, no statistically significant differences were observed, suggesting that the technique without ultrasound guidance maintains the same safety and efficacy as the technique with ultrasound guidance.

The use of ultrasound did contribute to verifying complete release of flexor tendons at the A1 pulley level. This finding aligns with a study by Pan et al,[15] where they compared A1 pulley release using the “Hanzhang” needle knife with and without ultrasound guidance, showing no statistically significant difference in success rates between the groups. However, the ultrasound-guided group did have a longer surgical duration.

Minimally invasive technique is contraindicated for early-stage trigger finger diseases associated with collagen disorders (such as rheumatoid arthritis and Dupuytren disease) and preexisting bone deformity, being one of the inclusion criteria for future clinical studies.

The results from our experimental study could provide a rationale for future clinical studies evaluating the actual clinical effectiveness of this surgical instrument for percutaneous trigger finger release. In conclusion, percutaneous A1 pulley release using the PulleyCut instrument proved to be more effective and safer than the needle technique, with no A2 pulley or neurovascular injuries observed in any digit. The needle percutaneous technique resulted in a higher incidence of tendon injuries and, in one digit, neurovascular bundle injury, although the latter was not statistically significant. No superiority was observed in any outcome when ultrasound was used as an aid for A1 pulley release with the retinaculotome.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

References

1. Belloti JC, Sato ES, Faloppa F. Trigger finger treatment. *Rev Bras Ortop (Sao Paulo)*. 2020;57(6):911–916.
2. Fiorini HJ, Tamaoki MJ, Lenza M, et al. Surgery for trigger finger. *Cochrane Database Syst Rev*. 2018;2(2):CD009860.
3. Sato ES, Gomes Dos Santos JB, Belloti JC, Albertoni WM, Faloppa F. Treatment of trigger finger: randomized clinical trial comparing the methods of corticosteroid injection, percutaneous release and open surgery. *Rheumatology (Oxford)*. 2012;51(1):93–99.
4. Lorthioir J Jr. Surgical treatment of trigger—finger by a subcutaneous method. *J Bone Joint Surg Am*. 1958;40-A(4):793–795.
5. Brown AM, DellaMaggiora RJ, Tsai EY, Kulber DA. Endoscopic retrograde approach for trigger finger release: a cadaver study. *Plast Reconstr Surg Glob Open*. 2020;8(12):e3294.
6. Dunn MJ, Pess GM. Percutaneous trigger finger release: a comparison of a new push knife and a 19-gauge needle in a cadaveric model. *J Hand Surg Am*. 1999;24(4):860–865.
7. Pope DF, Wolfe SW. Safety and efficacy of percutaneous trigger finger release. *J Hand Surg Am*. 1995;20(2):280–283.
8. Eastwood DM, Gupta KJ, Johnson DP. Percutaneous release of the trigger finger: an office procedure. *J Hand Surg Am*. 1992;17(1):114–117.
9. da Silva PHJ, de Moraes VY, Segre NG, Sato ES, Faloppa F, Belloti JC. Diagnóstico e tratamento do dedo de gatilho no Brasil—estudo transversal. *Rev Bras Ortop*. 2021;56(2):181–191.
10. Bezerra PM, de Neiva Borba M, Guerriero ICZ, Dallari SG. Ethical and legal analysis of scientific research on corpses in Brazil. *Rev Bioét*. 2020;28(3):554–564.
11. Fiorini HJ, Santos JBG, Hirakawa CK, Sato ES, Faloppa F, Albertoni WM. Anatomical study of the A1 pulley: length and location by means of cutaneous landmarks on the palmar surface. *J Hand Surg Am*. 2011;36(3):464–468.
12. Bain GI, Turnbull J, Charles MN, Roth JH, Richards RS. Percutaneous A1 pulley release: a cadaveric study. *J Hand Surg Am*. 1995;20(5):781–784.
13. Hoang D, Lin AC, Essilfie A, et al. Evaluation of percutaneous first annular pulley release: efficacy and complications in a perfused cadaveric study. *J Hand Surg Am*. 2016;41(7):e165–e173.
14. Habbu R, Putnam MD, Adams JE. Percutaneous release of the A1 pulley: a cadaver study. *J Hand Surg Am*. 2012;37(11):2273–2277.
15. Pan M, Sheng S, Fan Z, et al. Ultrasound-guided percutaneous release of A1 pulley by using a needle knife: a prospective study of 41 cases. *Front Pharmacol*. 2019;10:267.