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Combination of ultrasound-guided percutaneous A1 pulley release and intra-tendon sheath injection improves the therapeutic outcomes in adult trigger finger patients

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Abstract

Aim: This study aimed to use high-frequency ultrasound guidance to compare the efficacy of percutaneous release combined with intra-tendon sheath injection (PR-ITSI) and percutaneous release only (PR-ONLY) in the treatment of adult trigger finger (TF) patients. **Materials and methods**: A total of 48 patients were randomly divided into PR-ITSI group and PR-ONLY group. The thickness of the A1 pulley was measured prior to surgery and 1-year after surgery. Visual Analogue Scale (VAS) score and Patient Global Impression of Improvement (PGI-I) scale score of affected fingers were evaluated at 1 day, 1 month, and 1 year after surgery. **Results**: The overall difference of VAS score between the two groups after treatment was statistically significant ($p<0.001$), while the VAS scores gradually decreased in both groups at different time-points after treatment. The VAS scores in the PR-ITSI group at 1 day and 1 month after surgery were 1.475 and 0.904 ($p<0.001$), respectively, which were lower than those in the PR-ONLY group. Different treatment methods had no effect on the VAS score at 1 year after surgery ($p=0.055$). The thickness of the A1 pulley at 1 year after surgery was lower than that before surgery ($p<0.001$), whereas there was no significant difference in A1 pulley thickness between the two groups ($p=0.095$). The rate of PGI-I scale improvement by one grade at 1 day, 1 month, and 1 year after surgery in the PR-ITSI group was 15.322 times (95%CI: 4.466-52.573, $p<0.001$), 14.807 times (95%CI: 2.931-74.799, $p=0.001$), and 15.557 times (95%CI: 1.119-216.307, $p=0.041$), respectively, than that in the PR-ONLY group. **Conclusion:** Ultrasound-guided PR-ITSI is superior to PR-ONLY in the VAS score and PGI-I scale for adult TF patients.

Keywords: trigger finger; ultrasonography; injections

Introduction

Trigger finger (TF), also known as snap finger or stenosing tenosynovitis of A1 pulleys, is a common cause of hand pain and dysfunction in adults [1], and its incidence among healthy individuals was reported to be 2.6% [2]. The thickening and contracture of A1 pulleys cause the flexor tendons to bounce by blocking, which may cause pain, popping, or snapping.

Although TF has been reported to be associated with diabetes, rheumatoid arthritis, or metacarpal aponeurotic contracture [3], repetitive microtrauma due to chronic mechanical overuse was considered as a major risk factor [2].

Treatments for TF include corticosteroid injection, percutaneous release, or open surgery [4,5]. The European multidisciplinary consensus guideline for managing TF [6] indicated that short-term injection of corticosteroid is effective, while medium- or long-term injection is not efficacious. Percutaneous release has shown several advantages over open surgery, such as shorter operation

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time, faster functional recovery [7], and lower cost [8]. Blinded percutaneous A1 pulley release performed with simple clinical markers could achieve an efficacy similar to open surgery [8,9]. However, due to the lack of the operator's experience or changes in patients' anatomical structure, blinded percutaneous A1 pulley release may result in injuries to the flexor tendon or adjacent nerves and vessels [10]. High-frequency ultrasound (HFUS)-guided percutaneous A1 pulley release can identify fine anatomical structures to prevent damage [11]. However, patients undergoing percutaneous release only (PR-ONLY) obviously experience short-term pain. The longest time of administering an oral pain reliever can be up to 17 days [12]. Maneerit et al [13] found that for TF patients, percutaneous release combined with intra-tendon sheath injection (PR-ITSI) had a higher success rate (97% vs. 47%) than injection therapy alone. Wu et al [14] opinion is that ultrasound-guided needle release of the A1 pulley combined with corticosteroid injection had better treatment benefits than single ultrasound-guided corticosteroids injection in improving finger tendon and joint function. Jegal et al [15] reported that PR-ITSI is more effective than PR-ONLY in reducing pain and improving early postprocedural subjective outcomes; however, their study was conducted as a blind percutaneous release rather than US guided. Up to now, there has been no report on the comparison between HFUS-guided PR-ITSI and PR-ONLY. As ultrasound guidance can improve the effects of percutaneous release therapy [8,10,11], the present study aimed to use HFUS guidance to compare the efficacy of PR-ITSI and PR-ONLY in the treatment of adult TF patients.

Materials and methods

TF patients admitted to our hospital from November 2017 to December 2018 were prospectively recruited. Due to the 12-month follow-up period for the study, the actual data collection deadline is December 2019.

Inclusion criteria were patient's age >18 years old with TF grade II-IV [16] and duration of TF symptoms ≥3 months in which no treatment was given. Exclusion criteria were: patients with diabetes, rheumatoid arthritis, and other systemic diseases; patients with other pathological conditions of the wrist, such as metacarpal aponeurosis contracture and carpal tunnel syndrome; patients with local infection; patients with coagulation disorders.

Based on the above-mentioned inclusion and exclusion criteria, 48 patients with 55 TFs (5 patients with 2 or 3 TFs) were included. Patients were randomly divided into the experimental group (PR-ITSI) – 28 TFs and control group (PR-ONLY) – 27 TFs. In case of one patient

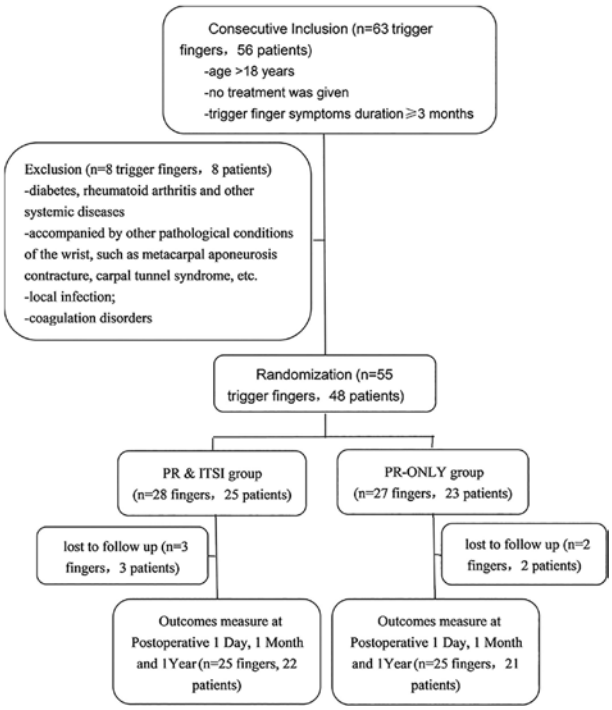

Fig 1. Flowchart of involvement of 55 trigger fingers (48 patients) in the PR-ITSI group or PR-ONLY group.

with multiple TFs, each finger was evaluated separately in the same group. During postprocedural follow-up, 3 patients (3 TFs) in PR-ITSI group and 2 patients (2 TFs) in PR-ONLY group were excluded due to loss to follow-up. Finally, 25 TFs were included in each group (fig 1).

TFs were graded using the system developed by Quinnell and modified by Green [17] The relief of pain in TF patients was scored by the Visual Analogue Scale (VAS): 0 represents no pain and 10 represents severe pain (mild pain: 1~3, no influence on sleep, moderate pain: 4~6, mild influence on sleep, severe pain: 7~10, patients are unable to fall asleep or wake up from sleep). Patients' overall improvement was evaluated by the modified Patient Global Impression of Improvement (PGI-I) scale [15]: level I – no change or worse; level II – slightly better; level III – significantly better; level IV – perfect. The study was approved by the Ethics Committee of our hospital, and all patients signed informed consent forms.

Diagnostic criteria

TF grading system [17] : Grade I (pre-triggering) – pain, history of catching, while not being demonstrable on physical examination, tenderness over the A1 pulley; Grade II (active) – demonstrable catching, while a patient can actively extend the digit; Grade III (passive) – demonstrable catching, requiring a passive extension (Grade IIIA) or inability to actively flex (Grade IIIB); Grade IV (contracture) – demonstrable catching with a

fixed flexion contracture of the proximal interphalangeal (PIP) joint.

US examination

A Philips iU 22 ultrasound machine (Philips Medical Systems, Bothell, WA, USA) was used with a L15-7io hockey linear probe, and the musculoskeletal (MSK) preset was chosen.

HFUS was performed preoperatively and 1 year after operation by two senior sonographers expert in MSK field, blinded to the patients' grouping. The thickness of the A1 pulley of the affected finger was thrice measured in the long axis of flexor tendons, and the mean value was used for further analysis. Disagreements related to the thickest point of A1 were solved by consensus. The echogenicity of A1 pulley, thickness, changes of the flexor tendons, and the passage of flexor digitorum tendon at A1 pulley level were also assessed.

The following US diagnostic criteria for TF [2,16] were used: significant hypoechoic thickening (>0.62 mm) of the A1 pulley with simultaneously observation of the blockage or snapping syndrome at A1 pulley of the flexor digitorum tendons through blocked during dynamic observations.

US-guided treatment

First, the surgical area was disinfected routinely. Then, a sterile coupling agent and a sterile surgical sleeve were coated onto the probe in sequence. The affected finger was overextended, the probe was in line with the finger and the injection was performed in-plane. The puncture spots of the trigger thumb were localized about 10 mm distal to the probe marker, and the A1 pulley was released from distal to proximal (fig 2a). The puncture spots of the rest of the affected fingers were localized at palm horizontal stripes and the A1 pulley was released from proximal to distal (fig 2b).

Local anesthesia (1 ml of 1% lidocaine) was performed. In the PR-ONLY group (fig 3), A1 pulley was released with 23G puncture needle from shallow to deep layers by repeated puncture, with the tip of the needle parallel to flexor tendons. In the PR-ITSI group, after releasing A1 using the techniques previous described, the flexor tendons sheath was injected with 0.5 ml compound betamethasone suspension (2.5 mg betamethasone dipropionate + 1 mg betamethasone sodium phosphate; Shanghai Schering Plough Pharmaceutical Co., Ltd., Hangzhou, China), 0.5 ml (10 mg) lidocaine hydrochloride (Shiyao Silver Lake Pharmaceutical Co., Ltd., Yuncheng, China), and 0.5 ml normal saline. The movements of the affected finger were evaluated immediately after treatment. The procedure was considered to be successful if the TF snap or contracture symptoms disappeared. All injections and releases were performed by a 10-year experienced MSK sonographer in the interventional surgery room of the ultrasound department. VAS score and PGI-I scale were evaluated during follow-up (1 day, 1 month, and 1 year after surgery). Phone follow up was conducted 1 day and 1 month after the surgery, and field assessment was carried out 1 year after the surgery. Oral painkillers were not given after the surgery. Patients were asked to stop the repetitive activities that might cause TF formation for 1 month, so that the affected finger could get sufficient rest.

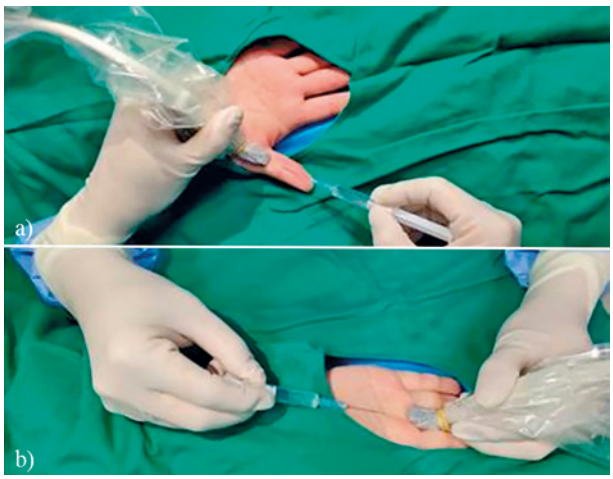

Fig 2. a) Representation of right trigger thumb needle insertion, releasing A1 pulley from distal to proximal; b) Representation of the third right finger trigger finger needle insertion. The needle was inserted at the palm horizontal stripes, releasing A1 pulley from proximal to distal.

Statistical analysis

SAS 9.4 software (SAS Institute, Cary, NC, USA) was used to perform the statistical analysis, and R 4.10 software (R Foundation for Statistical Computing, Vienna, Austria) was utilized for plotting. The measured

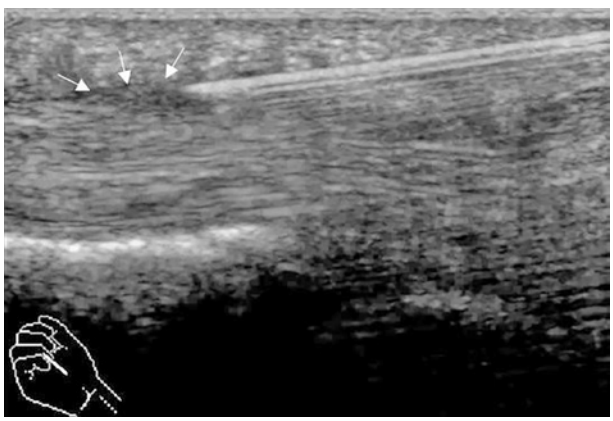

Fig 3. Trigger finger of the third right finger in a 50-year-old woman. Illustration of percutaneous release of A1 pulley under ultrasound guidance (the arrow shows thickened A1 pulley).

data were expressed by mean ± standard deviation (SD), and age was compared between the two groups using the independent samples t-test. The enumeration data were presented as percentage [n (%)], and the Chi-square test was used for comparing enumeration data between the two groups. The nonparametric Mann-Whitney U test was used for comparison of grade-based data. VAS score and A1 pulley thickness were compared using the repeated measures analysis of variance (ANOVA). When the interaction between time and groups was statistically significant, the simple effect was analyzed. The influential factors of VAS score and A1 pulley thickness were analyzed by using the correlation function of generalized estimating equations (GEE). The influential factors of PGI-I grade were analyzed by the correlation function of GEE analysis with cumulative logit. In the GEE analysis, the single-factor GEE analysis was carried out first, and the meaningful variables in the single-factor analysis were included in the multi-factor GEE analysis. $p < 0.05$ was considered statistically significant.

Results

The general characteristics of the patients are presented in Table I. There was no significant difference in the general characteristics (age, gender, affected finger, affected side, preoperative Quinnell grading of TF, etc.) between the two groups ($p > 0.05$). During the reexamination at 1 year after the surgery, all symptoms of TF disappeared, the thickness of A1 pulley and the echo were returned to normal (close to the echo of tendon), the thickness of flexor tendons was uniform, and no reduction of localized echo was found. Dynamic observations showed that flexor tendons could pass through A1 pulley smoothly in both groups.

Table I. Demographic characteristics of patients in PR-ITSI group and PR-ONLY group

	PR-ITSI (n=25)	PR-ONLY (n=25)	p
Age (years)	53.4±11.4	53.3±9.1	0.978
Gender, male	7 (28)	8 (32)	0.758
Affected finger			
Thumb	16 (64)	15 (60)	0.771
Other fingers	9 (36)	10 (40)	
Affected side			
left side	10 (40)	9 (36)	0.771
Preoperative Quinnell grading			
II	12 (48)	13 (52)	0.941
III	8 (32)	6 (24)	
IV	5 (20)	6 (24)	

The results are expressed as number±SD or number (percent). PR-ITSI – percutaneous release combined with intra-tendon sheath injection; PR-ONLY – percutaneous release only

Comparison of therapeutic effects of PR-ITSI and PR-ONLY

The results of the multivariate GEE analysis showed that VAS score at 1 day and 1 month after surgery was lower in the PR-ITSI 1.475 ($p < 0.001$) and 0.904 ($p < 0.001$), respectively. However, different treatment methods had similar on VAS score at 1 year after surgery ($p = 0.055$) (Table II). Different treatment methods had influences on the PGI-I scale score at 1 day, 1 month, and 1 year after surgery, and the rate of PGI-I scale improvement by one grade at 1 day, 1 month, and 1 year after surgery in the PR-ITSI group was higher than that in the PR-ONLY group, respectively (Table III). Both treatment methods had similar effect on A1 pulley thickness at 1 year after surgery ($p = 0.095$) (Table IV).

Repeated measures ANOVA showed that the overall difference in VAS score after treatment between the PR-ITSI and PR-ONLY groups was statistically significant ($F = 14.953$, $p < 0.001$). Furthermore, the simple-effects analysis showed that the VAS score in the PR-ITSI group ($F = 106.160$, $p < 0.001$) and PR-ONLY group ($F = 128.603$, $p = 0.001$) gradually decreased at different time points after treatment. Before treatment, there was no statistical significance in VAS score between the two groups ($p = 0.848$). The VAS score in the PR-ITSI group was significantly lower than that in the PR-ONLY group (all $p < 0.05$) at different post-treatment time points (fig 4). Repeated measures ANOVA showed that at 1 year after surgery, the A1 pulley thickness in the two groups was significantly lower than that before surgery ($F = 259.155$, $p < 0.001$) (fig 5), while there was no significant difference in pulley thickness between the two groups ($F = 0.232$, $p = 0.632$) (fig 6).

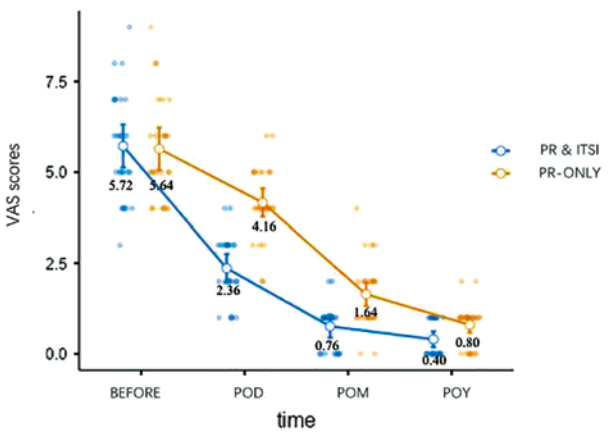

Fig 4. Repeated measures ANOVA of VAS pain score

Table II. Multi-factor generalized estimating equations analysis of Visual Analogue Scale (VAS) score at different time points of treatment.

Dependent variable: VAS score after surgery	***B***	***SE***	***Z***	**P**
1 day	-1.475	0.354	-4.17	<0.001
1 month	-0.904	0.189	-4.79	<0.001
1 year	-0.308	0.161	-1.92	0.055

Independent variable is treatment methods and PR-ONLY is the control group.

Table III. Multifactor generalized estimating equations analysis of PGI-I scale score at different time points of treatment.

Dependent variable: PGI-I scale score after surgery	***B***	***SE***	***Z***	**p**	**OR**	**95%** *CI*	
						Lower	**Upper**
1 day	2.729	0.629	4.34	<0.001	15.322	4.466	52.573
1 month	2.695	0.826	3.26	0.001	14.807	2.931	74.799
1 year	2.745	1.343	2.04	0.041	15.557	1.119	216.307

Independent variable is treatment methods and PR-ONLY is the control group. PGI-I-Patient Global Impression of Improvement

Table IV. Multivariate generalized estimating equations analysis of difference in A1 pulley thickness at 1 year after surgery

Factor		***B***	***SE***	***Z***	**p**
Intercept		1.260	0.125	10.05	<0.001
PR-ONLY group	PR-ITSI group	0.093	0.056	1.67	0.095
Age		0.003	0.003	1.23	0.218
Quinnell (control: IV)	II	-0.837	0.073	-11.47	<0.001
	III	-0.481	0.087	-5.5	<0.001

PR-ONLY – percutaneous release only group; PR-ITSI – percutaneous release combined with intra-tendon sheath injection group.

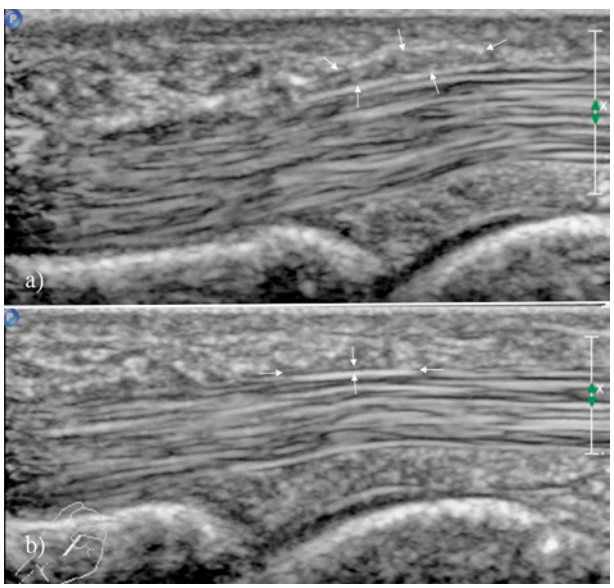

Fig 5. Trigger finger in a 39-year-old woman in the PR-ITSI group: a) A1 pulley was significantly thickened before surgery, up to 1.2 mm at the thickest point; b) A1 pulley became significantly thinner at one year after surgery, with the thickest part of about 0.3 mm.

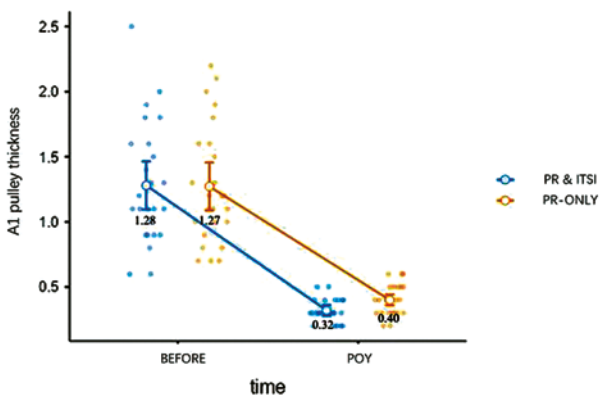

Fig 6. Repeated measures ANOVA of A1 pulley thickness

Postprocedural complications

There were 2 cases (8%) of finger swelling, 1 case (4%) of finger numbness in the PR-ITSI group, as well as 4 cases (16%) of finger swelling and 1 case (4%) of finger numbness in the PR-ONLY group. All the complications occurred at 1 day after the interventional therapy and disappeared at 1 month or 1 year of follow-up. There was no TF recurrence at 1-year follow-up.

Discussion

We found that the PR-ITSI group could significantly improve patients' pain symptoms. VAS scores 1 day and 1 month after surgery, PGI-I scale at different time points after surgery were significantly better than those of the PR-ONLY group, and A1 pulley thickness was significantly reduced 1 year after surgery.

Similar to a study conducted by Rojo-Manaute et al [13], the postprocedural pain was more obvious in the PR-ONLY group in the present study and the VAS score was 4.2±1.0, higher comparing with the pain in PR-ITSI group was (2.4±0.9). Additionally, in Rojo-Manaute et al study the patients in the PR-ONLY group spent an average of 1.9 days taking painkillers orally due to the feeling of an obvious pain [12]. After percutaneous trigger finger release, overreaction of local repair inflammation can easily lead to tendon adhesion and scar formation in some patients [15]. The injection of corticosteroids can provide relief from local aseptic inflammation and alleviate pain. Corticosteroids may influence softening of the pulley [18]. However, the difference over time between the two groups gradually decreased, which is similar to previously reported findings [15]. The results indicated that the short-term improvement of VAS score and PGI-I scale score in the PR-ITSI group was more noticeable. Jegal et al study [15] was not conducted under the US guidance and some patients had recurrence or worse of the symptoms at the three-month follow-up. However, in our study, no patients showed recurrence or worse of symptoms at the follow-up of 1 month and 1 year after surgery, which may be related to ultrasound-guided precise release. Liu et al study [19] was also not conducted under US guidance, and vertical needle insertion was adopted for release, which resulted in a high incidence of postprocedural extensor lag, while no such complication was found in our study.

Histologically, the A1 pulley is composed of three layers, and the innermost and middle layers are mainly composed of chondroid cells and collagen fibers [20]. Due to the metaplasia of the innermost fibrous cartilage in TF patients, the flexor tendons do not match with the A1 pulley [8,21]. Therefore, the first choice is to inject corticosteroids between the innermost and middle layers of the tendon sheath [22,23]. Under US guidance, corticosteroids can be injected into the tendon sheath accurately without being injected into the tendon, accompanying by a higher safety [24].

Previous studies on US-guided percutaneous release therapy showed that the needle entry points were either from distal to proximal [8,13,25-26] or from proximal to distal [27-28] uniformly. As the radial collateral nerve of the thumb crosses the flexor pollicis longus tendons at the proximal or at the level of the A1 pulley [2], the safe area of the thumb is smaller than that of other fingers [25], and there is a high risk of nerve injury. Open surgery has reported [28] to play a role in permanent loss of thumb sensation resulted from damage to the radial collateral nerve. Nerve injury of finger has become a major complication of percutaneous trigger finger release [23]. Therefore, in the present study, the needle was inserted from distal for the trigger thumb to avoid nerve injury. However, there was 1 trigger thumb case and distal finger numbness appeared in each group, which could be related to postprocedural finger swelling that compressed the nerve. Such damage is not irreversible, and it can be eliminated in the long-term follow-up [12].

Studies on cadavers showed that the release of A1 pulley with 21G needle under US guidance was partial. However, partial release can achieve the same clinical effect as open surgery [8]. In the present study, the therapeutic effect of a 23G needle was similar to previous studies [8,29], while the needle was thinner. A finer needle puncture has less damage to the surrounding soft tissue, smaller volume of bleeding, and is more acceptable to patients.

Corticosteroids, short-acting methylprednisolone acetate (pharmacological action for about 3 days) [30] or water-insoluble triamcinolone acetonide [16,31,32] used in previous studies have proven that triamcinolone acetonide tends to gather around the tendon and form crystals, thereby affecting the tendon movement. The corticosteroid used in the present study was a water-soluble betamethasone compound, which rarely leads to form crystals, and it can provide sustained pharmacological action lasting for about 4 weeks. There is no need to re-insert the needle into the tendon sheath after US-guided percutaneous release. Regarding the low cost of compound betamethasone injection, combined injection therapy does not increase the financial burden on patients.

The longest follow-up period in the current study was 1 year, which was longer than that in previous studies (3 [15] or 6 months [8]). A longer follow-up time was found beneficial for evaluating the long-term recovery of ultrasound-guided release of trigger finger.

There are also some shortcomings in the present study. First, the sample size was small，which made a challenge in performing subgroup analysis based on affected finger and US guidance. Second, a surgeon's experience may influence the treatment outcomes. Finally, the effects of different Quinnell grades and A1 pulley thicknesses on the treatment outcomes should be further explored on expanded samples. Patients' working conditions after treatment (high intensity finger activity, low

intensity finger activity, rest, etc.) may affect patients' recovery. Climate, environment, and patients' mood may also affect postprocedural evaluation, but researchers cannot control these effects.

In **conclusion**, HFUS-guided percutaneous 23G puncture needle release of A1 pulley combined with ITSI could eliminate popping symptoms of TF intraoperatively, significantly elevate short-term VAS scores of TF patients, reduce complications caused by blind procedures, and significantly increase PGI-I scale score compared with percutaneous release only. The postprocedural complications were limited and mild, and gradually disappeared over time. US-guided percutaneous release combined with injection therapy is an effective method for the treatment of adult TF patients.

Conflict of interest: none

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