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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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].

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 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
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 re-
sult in injuries to the flexor tendon or adjacent nerves and
vessels [10]. High-frequency ultrasound (HFUS)-guided
percutaneous A1 pulley release can identify fine anatom-
ical structures to prevent damage [11]. However, patients
undergoing percutaneous release only (PR-ONLY) ob-
viously 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, percu-
taneous release combined with intra-tendon sheath injec-
tion (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 com-
bined 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 patholog-
ical conditions of the wrist, such as metacarpal aponeuro-
sis contracture and carpal tunnel syndrome; patients with
local infection; patients with coagulation disorders.
Based on the above-mentioned inclusion and exclu-
sion 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 con-
trol group (PR-ONLY) – 27 TFs. In case of one patient
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 Pa-
tient 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 pul-
ley; 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
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 L15-7i0 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 dippionate + 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.

**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
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.

**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).

**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**

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

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.

**Fig 4. Repeated measures ANOVA of VAS pain score**
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.

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

<table>
<thead>
<tr>
<th>Dependent variable: VAS score after surgery</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>-1.475</td>
<td>0.354</td>
<td>-4.17</td>
</tr>
<tr>
<td>1 month</td>
<td>-0.904</td>
<td>0.189</td>
<td>-4.79</td>
</tr>
<tr>
<td>1 year</td>
<td>-0.308</td>
<td>0.161</td>
<td>-1.92</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Dependent variable: PGI-I scale score after surgery</th>
<th>B</th>
<th>SE</th>
<th>Z</th>
<th>p</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day</td>
<td>2.729</td>
<td>0.629</td>
<td>4.34</td>
<td>&lt;0.001</td>
<td>15.322</td>
<td>4.466 52.573</td>
</tr>
<tr>
<td>1 month</td>
<td>2.695</td>
<td>0.826</td>
<td>3.26</td>
<td>0.001</td>
<td>14.807</td>
<td>2.931 74.799</td>
</tr>
<tr>
<td>1 year</td>
<td>2.745</td>
<td>1.343</td>
<td>2.04</td>
<td>0.041</td>
<td>15.557</td>
<td>1.119 216.307</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Factor</th>
<th>B</th>
<th>SE</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.260</td>
<td>0.125</td>
<td>10.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PR-ONLY group PR-ITSI group</td>
<td>0.093</td>
<td>0.056</td>
<td>1.67</td>
<td>0.095</td>
</tr>
<tr>
<td>Age</td>
<td>0.003</td>
<td>0.003</td>
<td>1.23</td>
<td>0.218</td>
</tr>
<tr>
<td>Quinnell (control: IV) II</td>
<td>-0.837</td>
<td>0.073</td>
<td>-11.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>III</td>
<td>-0.481</td>
<td>0.087</td>
<td>-5.5</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

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 layer is 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

Acknowledgments: This study was financially supported by the National Key R&D Program of China (Grant No. 2017YFC0114300, C.H. HU) and the National Natural Science Foundation of China (Grant No. 81271629, X.M. Fang).

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