Minimally invasive thread trigger digit release: a preliminary report on 34 digits of the adult hands

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Abstract
The trigger finger release was performed in 34 digits (11 thumbs and 23 fingers) of 24 patients through the thread transecting technique with the tip-to-tip approach, in which a 22-gauge needle inserts into a 18-gauge needle when both needles are inside the hand, guiding the 22-gauge needle to exit the hand at the same access point of 18-gauge needle. We prospectively evaluated the effectiveness and functional recovery of these patients. In all 34 digits, triggering and locking were resolved, and complete extension and flexion occurred immediately following the release. There were no complications, such as incomplete release, neurovascular or flexor tendon or A2 pulley injury, infection, or tendon bow-stringing. Patients did not require prescription pain medications. Most patients used their hands to meet their basic living needs the same day of the procedure. The hand function evaluated with the Quick Disabilities of the Arm, Shoulder and Hand questionnaire, and scored 4 within 3 months.

Level of evidence: II

Keywords
Trigger finger release, percutaneous procedure, ultrasound guided procedure, minimally invasive procedure

Introduction
Surgical trigger finger release is suggested if steroid injection or other non-operative treatments have failed. The widely used surgical methods are open, endoscopic and percutaneous release. Open trigger finger release remains the definitive method. In addition to open and endoscopic trigger finger release, sonographic percutaneous trigger finger release is an alternative, which has both advantages and disadvantages (Amirfeyz et al., 2017; Kim et al., 2016; Jou and Chern, 2006; Nikolaou et al., 2017; Rojo-Manaute et al., 2012). It can be performed with ease, results in decreased pain and allows for a faster recovery without a painful palmar scar. It also reduces costs with the flexibility of performing this procedure in the office (Calleja et al., 2010; Eastwood et al., 1992). Even with ultrasound guidance, percutaneous release has disadvantages that uncommonly result in digital nerve injury, incomplete division of the pulley and superficial flexor tendon injuries (Amirfeyz et al., 2017; Chern et al., 2005; Guler et al., 2013; Nikolaou et al., 2017; Paulius and Maguina, 2009; Rojo-Manaute et al., 2010, 2012; Werner et al., 2016). Imprecise cutting results in postoperative complications and is due, in part, to difficulty controlling the needle tip or hook knife. We believe the improvement can be made by pursuing a new method for cutting using the thread trigger finger release.

A cadaveric study of the thread trigger finger release demonstrated was performed initially (Guo et al., 2018). We report our results of a prospective study of use of this method in 34 digits of the hands in 24 patients. We hypothesized that the...
thread trigger finger release is both safe and clinically effective.

Methods
This study was approved by our institutional review board. Informed consent was obtained from all patients for being included in the study. All procedures in the study were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration.

Patient
Eleven thumbs and 23 fingers in 24 patients were released with the improved thread trigger finger release. The average age was 58 years (range 36–82). There were six men and 18 women, and all except one were right handed.

One patient had four digits released at separate sessions, two patients had three digits released at separate sessions and two patients had two digits released at one time. Six patients were diabetic, and one patient had rheumatoid arthritis without noteworthy joint deformity. Five patients took narcotics for chronic pain. Some patients had secondary limitations of digital motion because of the severe tenosynovitis of the A1 pulley. None of the digits had undergone a prior procedure for trigger finger release. All patients had a trigger digit of grade 2 to 4 on the Green classification (Green et al., 2005) and had either failed the non-operative management, including steroid injection, or requested a surgical release. The pre-procedure sonographic evaluation showed those patients were eligible for the procedure if there was no variant anatomy that interfered with the path of the needle or thread. The diagnosis was based on the standard history and physical examination as well as sonographic studies.

Equipment
The ultrasound system used was a GE Logiqe ultrasound machine (General Electric Company, Fairfield, CT, USA) fitted with a GE L8-18i-D 18 MHz compact linear transducer (hockey stick probe). Other materials included an 18-gauge 2.5-in (63 mm) spinal needle, a 22-gauge 2.5-in (63 mm) needle, a 27-gauge 1-in (25 mm) needle, a 30-gauge 1-in (25 mm) needle, a piece of commercial surgical dissecting thread (Loop&Shear™, Ridge & Crest Company, Monterey Park, CA, USA), and a 10 mL syringe filled with 0.5% lidocaine for local anaesthesia and hydro-dissection.

Location of A1 pulley and ultrasound detection
The location of the division of the A1 pulley is selected in the same way as previously described (Guo et al., 2018). The division was along the mid-line of the A1 pulley over the metacarpophalangeal (MP) joint. The proximal limit is determined by the sonographic bony landmark at the head–neck junction on the volar surface of the metacarpal, and the distal limit was determined at the phalangeal base-shaft junction (Figure 1).

Operative technique
The surgery was performed in an office-based procedure room. Using ultrasound, the landmarks were marked on the skin at the mid-line of the A1 pulley and proximal and distal ends of the pulley.

The process was guided with real-time ultrasound visualization and accompanied with the hydro-dissection. The needle access points were approximately 2 cm proximal to proximal border and 2 cm distal to the distal border. A 30-gauge 1-in needle was used for anaesthetizing at the access points with 1 mL of 1% lidocaine.
lidocaine. The superficial and deep surfaces of the A1 pulley were dissected by injecting 5 mL of 0.5% lidocaine using a 27-gauge 1-in needle. An 18-gauge 2.5-in spinal needle was bent at the distal shaft to a 15° angle with the bevel side facing this concavity and was connected with a 10 mL syringe filled with 0.5% lidocaine.

The technique for routing the thread loop, called the tip-to-tip approach, inserted the tip of 22-gauge needle into the tip of an 18-gauge needle when both needles were inside the hand (Figure 2), guiding the 22 gauge to exit the hand at the access point of the 18 gauge. The concrete routing process for forming a thread loop is illustrated in two parts: routing under the A1 pulley and routing over the A1 pulley. After sonographic confirmation of the position of neurovascular bundles (Figure 3), the A1 pulley was manually dissected by a reciprocating motion of the thread until the thread pulled out of the finger (Figure 4). Usually the procedure takes 10 minutes, which was done in office with the patients awake (Lalonde, 2017).

All the procedures were performed by a pain and rehabilitation specialist, who had experience in ultrasound musculoskeleton for 6 years and had been an orthopaedic surgeon for 10 years (level of expertise of level III) (Tang, 2009; Tang and Giddins, 2016).

Figure 2. Left – Methods of routing the thread under the A1 pulley: (a) The 18-gauge needle was inserted into the subcutaneous tissue at the proximal access point and advanced distally in the subcutaneous tissue, then inserted into the tendon sheath at the proximal end of the A1 pulley, advanced between the A1 pulley and flexor tendon to the distal end of the pulley. (b) The 22-gauge needle was inserted at the distal access point and advanced in the subcutaneous level to insert into the 18-gauge needle. (c) The transecting thread was fed through the 22-gauge needle and exited through the 18-gauge needle. (d) The needles were withdrawn from each side, leaving the thread in the sheath deep to the pulley. Right – The method of routing the thread over the A1 pulley: (a) The same 18-gauge needle was inserted into the proximal access point and advanced subcutaneously over the surface of the A1 pulley. (b) The 22-gauge needle was inserted at the distal access point and advanced into the subcutaneous level to insert into the 18-gauge needle. (c) The 18-gauge needle was withdrawn to leave the 22-gauge needle tip exiting through the first access point. The proximal end of the thread was fed through the 22-gauge needle. (d) The 22-gauge needle was withdrawn from the access point, leaving the thread looped around the A1 pulley.
Follow-up
The patients had a pre-procedure Quick Disability of the Arm, Shoulder, and Hand (DASH) evaluation (Beaton et al., 2005) and had a 24-hour postoperative call, a 3–7 day postoperative clinical evaluation in person and a series of follow-up phone calls at 1 month, 3 months, 6 months and 1 year. Patients filled in the QuickDASH at each clinical visit or phone follow-up.

Results
Surgical complication
There were no instance of incomplete release. There was no surgical complications, such as neurovascular injury, flexor tendon or A2 pulley injury, infection or tendon bowstringing.

Effectiveness, immediate recovery and pain
Triggering and locking were resolved and complete extension and flexion were recovered immediately following the release in all 34 digits.
Postoperatively the patients required no pain medications, or if requested, patients were advised to take 1–2 tablets of over-the-counter acetaminophen (paracetamol) or ibuprofen. Two patients had multiple spinal surgeries and chronic pain before and took opioid medications routinely and did not require additional opioid medication. Most patients, although the exact data were not available, returned to light daily activities with caution advised right after the procedure.

Figure 3. (a) Ultrasound longitudinal view of the thread loop. (b) Ultrasound sectional view of the thread loop. Arrow: location of the cutting thread; MC: metacarpal bone; PH: phalanx (proximal); na: nerve and artery.

Figure 4. (a) 22-gauge needle inserted into 18-gauge needle under the A1 pulley. (b) 18-gauge needle inserted and advanced over the A1 pulley. (c) After confirming the correct routing.
A patient with rheumatoid arthritis reported increased pain 2 weeks after the procedure. An ultrasound identified an intra-articular hypoechoic effusion, and the patient's pain was resolved following a steroid injection.

Function of the hand during follow-up

The average score of QuickDASH was 50 (SD 15, 34 digits) before treatment, 39 (SD 15, 34 digits) at 24 h postoperative, 30 (SD 13, 34 digits) at 3–7 days, 13 (SD 18, 30 digits) at 1 month, 4 (SD 9, 27 digits) at 3 months, 3 (SD 7, 23 digits) at 6 months and 4 (SD 9, 17 digits) at 1 year.

For those six employed patients, one patient returned the office work at full duty the following day after both procedures. One returned to office typing the day following procedure. Three part-time workers returned to work in 3–6 days and an assembly line worker returned to full duty in 5 days.

Discussion

Recently, an ultrasound-guided minimally invasive procedure, the thread transecting technique, has been applied to carpal tunnel release by transecting the transverse carpal ligament with thread percutaneously looped around the structure under ultrasound guidance (Burnham et al., 2017; Guo et al., 2015, 2016, 2017; Ray et al., 2017). The technique ensures that only structures inside the loop of thread are divided. The thread can be easily routed in the hand through a spinal needle using two punctures as entry and exit points. Applying the thread transecting technique to trigger finger release is an extension of this method. The study in cadaveric hands tested the feasibility of this technique (Guo et al., 2017).

In our clinical case of the thread trigger finger release, we found that manipulating a needle in a patient’s hand was more difficult than what we experienced in a cadaver, especially in controlling the routing needle to the desired exit point. Usually a chronically disordered A1 pulley becomes very stiff and thick, and some patients have additionally complicated anatomy due to osteoarthropathy of the MP joints. It was difficult to extend the MP joint of the involved digit to coordinate the needle clinically, while a supple cadaveric hand is flexible and easily extended at the MP joint.

Due to these difficulties, the routing process of the thread trigger finger release must be modified with the needle tip-to-tip inserting approach, in which a fine needle (22 gauge) inserts into the other needle (18 gauge) in the subcutaneous layer of a digit, and exits the skin at the exactly desired point under guidance of the 18-gauge needle, without needing to extend the MP joint.

Izadpaneh et al. (2013) found ultrasound-guided percutaneous release had the highest success rate (98%), followed by open surgical release (94%), percutaneous release (92%) and steroid injection (70%). However, in a meta-analysis by Wang et al. (2013) that reviewed the results in 676 patients, there were no differences in the incidence of failure and complications between those undergoing percutaneous release and open surgery. Gilberts et al. (2001) showed the symptoms were relieved for 100% of patients treated percutaneously for 54 patients and for 98% with an open surgery for 46 patients, with no complications.

A limitation for previously reported percutaneous techniques is that the method does not ensure complete release of the A1 pulley, regardless of using a needle or a knife as a cutting tool. Smith et al. (2010) found complete release of this pulleys in 88% of cadaveric fingers using a knife and 32% using a needle. Rojo-Manaute et al. (2010) reported 96% complete release with an intra-sheath technique using a hook knife. Chern et al. (2005) reported 96% complete release with an extra-sheath technique using a hook knife. Some of the cadaveric studies showed that there were scratches on the flexor tendon and minor injuries to the proximal edge of the A2 pulley (Chern et al., 2005; Rojo-Manaute et al., 2010). For those techniques, there is no controllable boundary for cutting, and the cutting process is difficult to control with the necessary accuracy while manipulating a needle or knife.

A systematic review and meta-analysis by Izadpaneh et al. (2013) showed the percutaneous procedure without ultrasound had an average 92% success incidence, while the incidence with ultrasound guidance was 98%. Without ultrasound, the surgeon does not have a view of the pulley during cutting, which may raise the risk of complications.

In our patients, ultrasound guidance aided the release procedure. Before the final transecting step, the position of the loop of dividing thread can be verified relative to the A1 pulley and other anatomical structures sonographically. If an incorrect thread path is determined, the thread can be removed and re-routed using the same procedure. The routing process is reversible, and the whole procedure adopts a confirm-then-act approach. This method distinguishes this technique from other percutaneous, endoscopic or open techniques in which the repeated cuttings are following multiple searches and checks.

The control and accuracy was improved from our cadaveric study by utilizing the tip-to-tip inserting
approach for thread routing. The actual accuracy of the routing technique is between 0.15–0.2 mm based on the screen measurement of ultrasound device, which is precise enough to avoid iatrogenic injuries. Our patients had no any postoperative complications.

Our present study was limited in that 34 cases were included with limited clinic visit or follow-up and that it lacked case-controls. However, the study demonstrates that the improved thread trigger finger release is clinically feasible and effective.

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Ethical approval This study was approved by our institutional review board or quality committee. All procedures in the study were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Informed consent Informed consent was obtained from all patients for being included in the study.

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