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Original Research

A Cadaveric Study Examining the Accuracy of Wireless Hand-Held Guided Ultrasound Injections Versus Blind Injections in the Flexor Tendon Sheath

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A R T I C L E I N F O

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Purpose: Hand-held ultrasound (HHUS) is gaining popularity among clinicians. Although its use for procedural guidance could have several advantages in hand surgery, other surgeons may wonder about its added benefits. This cadaveric study aimed to examine the hypothesis of increased accuracy of wireless HHUS-guided injections versus that of blind injections into the flexor sheath.
Methods: Our series included 20 fresh cadaveric hands with 80 fingers randomly assigned to 2 groups. In group A, 10 hands were randomly assigned to receive a landmark injection and then received a blinded injection to the flexor tendon sheath (FTS). In group B, 10 hands were blinded in the same manner and received an ultrasound-guided injection with HHUS. Methylene blue was injected, and anatomic dissection was performed to evaluate the injection accuracy based on the dye's filling pattern in the FTS as stage I (no filling), stage II (<50% filling), and stage III (>50% filling). Statistical analysis was performed, and P <.05 indicated a significant difference.
Results: One finger was excluded because of severe Dupuytren contracture. In group A, 39 blind injections of the FTS were performed, with 82% (32/39) fingers achieving stage III filling. In group B, 40 ultrasound-guided FTS injections were performed, with 90% (36/40) of fingers achieving stage III filing. Our study did not reveal any superiority in accuracy when ultrasound guidance was used (P = .35).
Conclusions: Hand-held ultrasound–guided FTS injections were not more accurate than blind injections performed by an experienced hand surgeon. These findings suggest that blind injections can be used as routine practice when performed by experienced operators to treat trigger finger. However, the use of HHUS may offer other advantages in hand surgery practice.
Clinical relevance: Ultimately, choosing to perform HHUS-guided injection versus blind injection to treat trigger finger depends on the surgeon's experience and preference for a particular technique.

Trigger finger is a frequent cause of hand disability, affecting up to 2% of the general population.[1,2] The use of static and dynamic ultrasonography to determine severity has increased in practice.[3,4] Classical sonographic signs include nodular or global hypoechoic thickening of the A1 pulley and hyperemia on Doppler.[2] The management of trigger finger includes splinting, corticosteroid or nonsteroidal anti-inflammatory drug injections, and percutaneous or open release of the first annular pulley.[1] Corticosteroid injections have well-documented efficacy and can be administered under ultrasound guidance.[5]

Hand-held ultrasound (HHUS) is gaining popularity among clinicians for bedside routine use owing to its size, ease of use, low cost, and portability.[6,7] Point-of-care ultrasound is usually

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performed using a conventional cart-based ultrasound device with more probes and higher-quality imaging; nevertheless, cost can be an issue in resource-limited facilities.[8]

Although the use of HHUS has been assessed for other medical applications, its use in routine hand surgery practice has not been fully assessed.[9–11] However, HHUS has found a place in diagnosis in medical care facilities where nonspecialist radiologists can access it and low-resource settings.[12–14] It has also proven to be useful and cost effective for screening.[12] Price is another interesting feature, ranging between $2,000 and $7,000.[6] Our department's conventional ultrasound (LOGIQ E R71, General Electric) costs approximately 35,000 euros. In contrast, HHUS Vscan Air CL (GE Healthcare) is priced at 4,000 euros.

Some studies have compared the accuracy of conventional cart-based ultrasound versus that of blind injection and found that sonographically guided injections are more accurate and safer than blind injections.[15] In this cadaveric study, we aimed to compare the added benefit of using wireless HHUS guidance versus that of blind injection in the flexor tendon sheath (FTS) in terms of accuracy. Our hypothesis was that HHUS-guided injections would achieve greater accuracy than blind injections in the FTS. The null hypothesis posits that there is no significant difference between the two groups.

Materials and Methods

Twenty fresh upper extremities from adult cadavers of Caucasian origin were obtained from the voluntary body donation program of the Research Institute against Digestive Cancer pursuant to the legal procedures and ethical framework governing body donation programs in France. All specimens were fresh and frozen. The patients' medical history was unknown. The anonymity of the body donation program did not provide information regarding the age and sex of the specimens.

A total of 20 hands were included, labeled from 1 to 20, and randomly assigned to 2 groups using a number randomization website.[16] Ten hands each were assigned to group A (blind injection technique for FTS) and group B (HHUS-guided injection technique for FTS). Approximately 2 mL of methylene blue dye was injected through a 22-gauge in-needle in both the groups.

In group A, an experienced senior hand surgeon (A.M.) performed blind injections into the FTS. In group B, experienced senior hand surgeons (S.F.) with a background in musculoskeletal sonography administered HHUS-guided injections. The Vscan Air CL ultrasound system (GE Healthcare) equipped with a linear probe (3–12 MHz) was paired with a tablet computer (Ipad, Apple) and an interface gel (Uni'gel US1, Asept InmedTM).

Ethical approval by the institutional review board was not required for this cadaveric study.

Injection technique in FTS

Eighty fingers were included (excluding thumbs).

In group A, the injection was administered proximal to the first annular pulley after palpating the metacarpal head and the FTS. The needle was inserted through the FTS and tendons until it reached the bone. Subsequently, the needle was then gradually withdrawn, and the dye was administered.

In group B, the long sagittal axis was first used to identify the A1 annular pulley; then, the transducer was rotated along the short axis. The needle was introduced, on short-axis view, into the FTS between the space of the A1 pulley and the flexor digitorum superficialis tendon (Figs. 1, 2).

Figure 1. Sonographically guided injection into the right middle finger of a cadaver.

Anatomic dissection

Dissection was performed, after injection, by a different examiner (C.H.) to assess the location and diffuse pattern of injection. Another examiner, independent of our department and not involved in our study, assessed each dissection and its results. To assess the FTS, a Brunner surgical incision was made from the proximal palmar crease to the distal interphalangeal joint crease. Subcutaneous tissues and the inside of the flexor tendon were inspected.

Evaluation of accuracy

An injection was considered nonaccurate (stage I) when the dye was not delivered into the sheath (filling = 0%); moderately accurate injection (stage II) was defined as the dye being located only around the metacarpal joint and filling less than 50% of the sheath. An injection was considered accurate (stage III) when the dye was distributed along the FTS and filled more than 50% of the sheath, extending beyond the proximal phalangeal joint (Fig. 3). The presence of a dye inside the flexor tendon was not an evaluation criterion.

Statistical analysis

Categorical variables were described using counts and proportions. The injection accuracy (stage I, II, and III) of the fingers was compared between the two groups (blind and ultrasound injections) using a generalized estimating equation model for correlated ordinal responses to account for repeated measurements for the same subject (injections on all four fingers of the same subject). We used an adjacent-category logic model for marginal probabilities. Statistical significance was set at $P < .05$. Analyses were performed using the R software, version 4.1.1. (R Core Team; 2021; R: Language and environment for statistical computing, R Foundation for Statistical Computing).[17]

Results

In total, 79 fingers were used for this study, 1 of which was excluded because of Dupuytren disease with flexion contracture of the metacarpal joint at 60°. In total, 39 fingers were included in group A and 40 in group B.

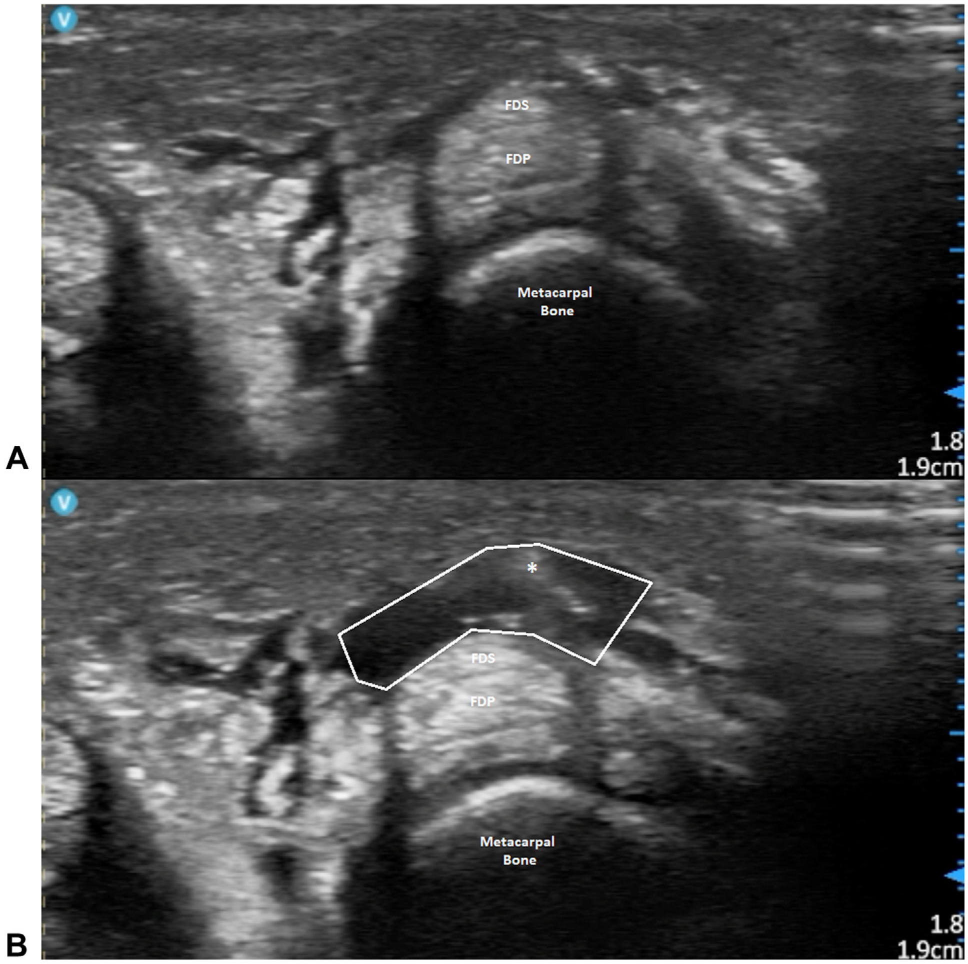

Figure 2. Axial views of the FTS before and after injection. **A** Preinjection view. **B** Intrasheath injection view showing the diffusion pattern within the FTS indicated by the white polygon. The tip of the needle is represented by the white asterisk. FDS, flexor digitorum superficialis; FDP, flexor digitorum profundus.

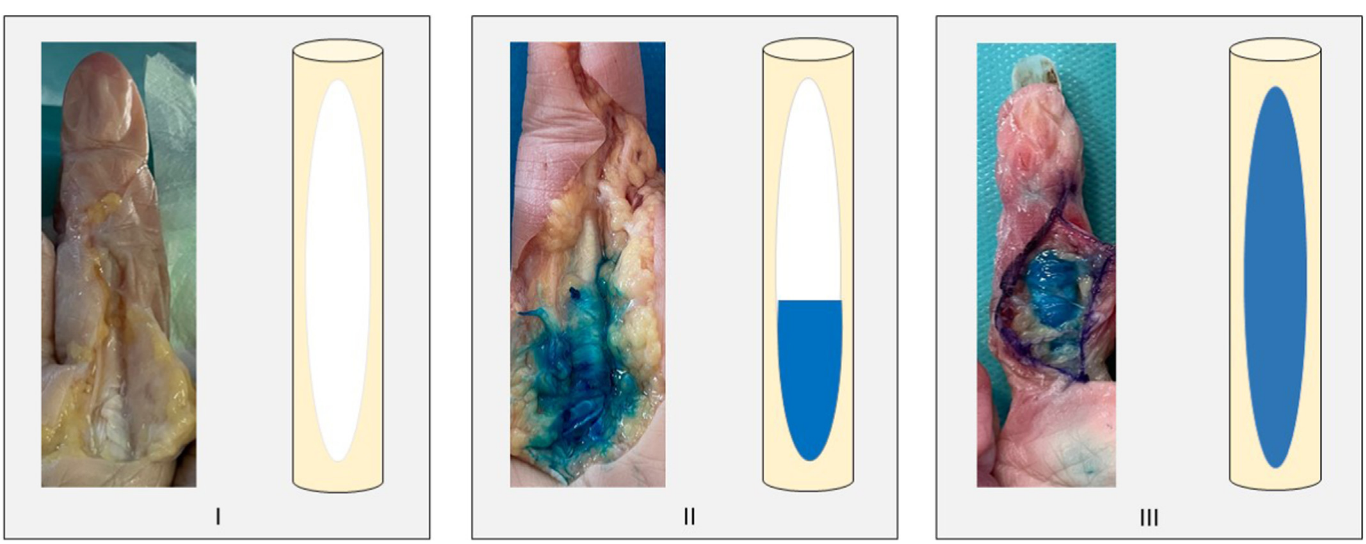

Figure 3. Injection accuracy based on the dye's filling pattern of FTS classified as stage I (no filling), stage II (<50% filling), and stage III (>50% filling).

The results are shown in the Table.

In group A, only 5% (2/39) were classified as stage I, 13% (5/39) as stage II, and 82% (32/39) as stage III. In group B, only 5% (2/40) were classified as stage I, 5% (2/40) as stage II, and 90% (36/40) as stage III. However, the difference in accuracy between the two groups was not statistically significant ($P = .35$).

Table
Comparison of Injection Accuracy Between Blind Injections (Group A) and Ultrasound-Guided Injections (Group B) Based on the Intrasheath Dye's Filling Pattern of the FTS

Group A			Group B		
Cadaveric Hands (n)	Finger (F2–5)	Accuracy of Injection (Stage I–III)	Cadaveric Hands (n)	Finger (F2–5)	Accuracy of Injection (Stage I–III)
1	F2	III	1	F2	III
	F3	III		F3	III
	F4	II		F4	III
	F5	III		F5	III
2	F2	III	2	F2	III
	F3	III		F3	III
	F4	III		F4	III
	F5	III		F5	III
3	F2	III	3	F2	III
	F3	III		F3	III
	F4	Excluded		F4	III
	F5	III		F5	III
4	F2	III	4	F2	III
	F3	III		F3	III
	F4	III		F4	III
	F5	III		F5	III
5	F2	I	5	F2	III
	F3	III		F3	III
	F4	III		F4	III
	F5	III		F5	III
6	F2	II	6	F2	III
	F3	III		F3	I
	F4	III		F4	III
	F5	II		F5	III
7	F2	II	7	F2	III
	F3	III		F3	III
	F4	III		F4	III
	F5	III		F5	III
8	F2	II	8	F2	III
	F3	III		F3	III
	F4	III		F4	III
	F5	III		F5	II
9	F2	III	9	F2	III
	F3	III		F3	III
	F4	III		F4	III
	F5	I		F5	III
10	F2	III	10	F2	III
	F3	III		F3	I
	F4	III		F4	III
	F5	III		F5	II

The power analysis revealed correlation coefficients between 89% and 99% for the interfinger correlation coefficients of the same hand, ranging from 0.6 to 0.1.

Discussion

Recently, ultrasound guidance has become the gold standard for steroid injections; however, there is limited evidence to support its use.[18] Most of the studies were uncontrolled prospective studies or were conducted using cadaveric models.[18] The current opinion is that US guidance offers advantages over blind or fluoroscopy-guided injections. It increases accuracy by allowing visualization of the targeted anatomic structure directly, reducing the risk of nerve or vascular puncture and tendon damage.[19] It is also less harmful to patients because there is no exposure to ionizing radiation or the need for an iodine-based contrast medium.[19] Moreover, ultrasound imaging is effective in evaluating the musculoskeletal system, especially in the hands, because most anatomic structures are superficial. Conventional cart-based methods are commonly used in this setting because they produce high-resolution images. Nonetheless, price can be a limiting factor for some facilities and clinicians.

In recent years, HHUS has been developed; its size is significantly smaller, it can be carried in physicians' laboratory coat, and it has a significantly lower price, which creates opportunities. Many devices are available for surgeons willing to incorporate point-of-care ultrasound into hand surgery practice. Each device has different features: some are connected to a smartphone or screen unit, and others are connected wirelessly. The use of ultrasound by hand surgeons as part of routine practice can influence the overall management of patients in 21% of cases.[20]

The hypothesis of our study that injections under HHUS guidance would be more accurate than blind injections in the FTS was not confirmed. We demonstrated that an experienced hand surgeon was as accurate as an ultrasound-guided injection according to our criteria of accuracy. However, a similar cadaveric study found contradictory results when using sonographically guided injections using a cart-based device.[15]

Although we only explored the accuracy of FTS injection in this study, other procedural guidance applications could be tested with HHUS. Evidence-based reports have shown the utility of ultrasound-guided injection in carpal tunnel syndrome, the trapezometacarpal joint, de Quervain tenosynovitis, the metacarpal phalangeal joint, and the proximal interphalangeal joint.[18] Nevertheless, the feasibility and reliability of HHUS injections have not been assessed in these settings.

With regard to the strengths of our study, we used a power analysis, and the distribution of fingers was almost identical in the two groups. With regard to the weak points of this study, because our study was cadaveric, the clinical outcome could not be measured; therefore, additional clinical studies are needed.

In conclusion, the use of HHUS has increased in recent years, with many medical and surgical applications. It is an attractive tool for hand surgeons, and its incorporation into clinical practice could improve the accuracy of the diagnosis of certain pathologies. Nevertheless, regarding procedural guidance, our study failed to demonstrate the superiority of HHUS-guided injections over blind injections in the FTS. However, the use of HHUS by hand surgery fellows for procedural guidance during the learning curve is interesting.

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