Review Article

Novel Use of the Wide-Awake Local Anesthesia No Tourniquet Technique for Release of Spastic Upper Limbs

Anubrat Kumar, MS, * Pak-Cheong Ho, MBBS *

* Department of Orthopaedics and Traumatology, Prince of Wales Hospital, Hong Kong, Special Administrative Region

A R T I C L E   I N F O

Article history:
Received for publication February 4, 2022
Accepted in revised form May 20, 2022
Available online July 7, 2022

Key words:
Local anesthesia
Release
Spastic
WALANT

Copyright © 2022, THE AUTHORS. Published by Elsevier Inc. on behalf of The American Society for Surgery of the Hand. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Surgeries for spastic upper limbs have traditionally been performed under general anesthesia (GA). The 3 major surgical procedures in spastic upper limbs are lengthening of a tight musculotendinous unit, augmenting a weaker muscle by tendon transfer, and arthrodesis. Fractional lengthening involves 1 or several transverse sections of the tendon within the musculotendinous junction area (Fig. 1), with each cut being followed by passive extension of the in-line joints. The residual, intact muscle fibers maintain the integrity of the muscle-tendon unit. This simple technique, however, may have unsatisfactory results if there is insufficient lengthening, overlengthening, or a disruption of the muscle-tendon unit. Lengthening inevitably reduces the muscle power but, during surgery, the degree of power loss cannot be calibrated to the length gained. The functional results of lengthening performed under GA are revealed only after surgery. In the absence of a quantifiable intraoperative guide, the release surgeries can be unnerving, especially for the less experienced surgeon.

Unlike GA, wide-awake local anesthesia no tourniquet (WALANT) procedures allow the patient to remain conscious and cooperative during surgery, allowing intraoperative assessments of hand function. This is useful in spastic hand surgeries, allowing an instant assessment of the muscle releases and residual power, thus guiding an optimal balance with the best possible functional outcomes. We describe the novel use of wide-awake, local anesthesia, no tourniquet surgery in spastic upper-limb surgery in forearm flexor-pronator release, thumb-in-palm and intrinsic-plus deformity correction, and elbow flexor release.

Indications and Contraindications

The procedure is indicated for residual spasticity impairing the upper-limb function, after exhausting all avenues of Botox injections and hand therapy sessions. The patients consented to surgery under WALANT. The patients should be communicable, have normal intelligence, and be able to follow a physician’s verbal order during the surgery.

Contraindications include patients with severe cognitive impairments, anxiety disorder, sedation or GA requests, compliance or communication issues, documented hypersensitivity to lignocaine, uncontrolled hypertension, compromised peripheral circulation, or...
infections at operating sites. Relative contraindications include an athetoid type of spasticity and a high-risk profile for ischemic cardiac events.

**Surgical Technique**

Before the surgery, the patient should be assessed adequately under relaxed conditions to identify the status of the spasticity and the muscle groups causing functional impairment needing release. The patient is placed supine, with the affected hand and upper limb supported on a hand table. An arm tourniquet is applied as a precautionary measure. A local anesthesia solution consisting of 1% lignocaine with 1:100,000 adrenaline is injected into the subcutaneous layer in the intended areas of release under aseptic precautions (Fig. 2A). We avoid injecting into the proximal forearm muscle area to maintain the responsiveness of the muscle groups. We use a 27-gauge, ophthalmic, long needle, and follow Dr Lalonde’s WALANT technique. The anesthesia solution infiltration is divided among the release sites, adhering to a maximum dose limit of 7 mg/kg of lignocaine with epinephrine. We dilute it to 0.5% in cases where a larger area of field block is required. When pain control in a deeper tissue level is suboptimal, an additional, top-up injection to the specific, painful site might be warranted. Painting and draping are then performed, which generally allows sufficient time for the local anesthesia to become effective.

**Forearm flexor-pronator release**

A curvilinear incision is made at the middistal forearm, radial to the flexor carpi radialis (FCR; Fig. 2B). The skin is undermined to reach both the radial and ulnar borders of the forearm. The flexor fascia is split next. The radial artery and median nerve are identified and safeguarded. The spastic flexors, including the FCR, flexor carpi ulnaris (FCU), palmaris longus (PL), flexor digitorum superficialis (FDS), flexor digitorum profundus (FDP), and flexor pollicis longus (FPL) muscles and their musculotendinous junctions, are subsequently identified, and cotton tapes are looped around them.

The pronator teres (PT) tendon (Fig. 2C) is exposed between the brachioradialis and the wrist extensors, and divided from its bony insertion. For patients with a milder degree of pronation spasticity, fractional lengthening over the musculotendinous junction of the PT muscle can also be performed. The forearm is passively supinated to the full range to stretch the muscle and other secondary constraints. Then, the patient is instructed to perform active forearm rotation. Subsequently, fractional lengthening of the flexor tendons is performed.

Our strategy is to release the tight flexor muscles of the wrist before those of the fingers and thumb. We perform the release sequentially from the FCR, PL, and then the FCU (Fig. 2D). A first cut to the aponeurotic part of the musculotendinous junction with a 15T surgical blade is carefully performed, preserving the muscle bulk, followed by a passive stretch to the muscle (Fig. 1B–E). We then instruct the patient to demonstrate active wrist extension after sequential release of the wrist flexors (Fig. 1F). Further cuts can be made until active wrist motion control is satisfactory. Each cut on the aponeurosis of the same musculotendinous junction should be separated by about 2 cm, and without violating the integrity of the muscle or tendon substances (Fig. 2G). Usually, an optimal cut should not be at more than 3 sites to avoid the disastrous, iatrogenic rupture of tendon or muscle during or after
surgery. Finger or thumb flexors are released next in the same manner, in the sequence of FDS, FDP, and then FPL muscles (Fig. 2E).

Figure 2. Case 2 displayed forearm flexor-pronator release and thumb-in-palm and intrinsic-plus deformity correction. A One percent lignocaine with 1:100,000 adrenaline was injected into the subcutaneous layer in the intended areas of release (dotted areas) under aseptic precautions. B A curvilinear incision was planned for the forearm flexor-pronator release, extending between the middle to distal forearm and radial to flexor carpi radialis; for the thumb-in-palm and intrinsic-plus deformity correction, an incision was planned over the palm, along the thenar crease. C The PT tendon (arrow) was exposed between brachioradialis and wrist extensors, and local anesthesia (typically about 5 ml) is added to the bony insertion of the PT before division from its bony insertion. D Wrist flexors are released sequentially from the FCR, PL, and then the FCU, and the patient’s wrist ROM is checked. E The FDS, flexor digitorum longus, and FPL (black arrow) are released next. F Active extension in neutral wrist extension was performed by the patient at end of the finger flexor releases. G The adductor pollicis muscle was detached from the bony origin at the third metacarpal bone with a periosteal elevator, and the thumb was stretched to slide the muscle. H Wound closure with 5-0 nylon and subcuticular sutures with 4-0 Monocryl.

After each cut, the patient demonstrates active finger extension and flexion (Fig. 2F). Further cuts are made until optimal functional ROM is obtained. We define optimal functional ROM as adequate power and control for functional wrist extension, hand opening, opposition, and gripping objects.

Thumb-in-palm and intrinsic-plus deformity correction

An incision is made over the palm along the thenar crease (Fig. 2B). The palmar aponeurosis is split. Thereafter, flexors of the index and middle fingers and the associated neurovascular bundles are retracted, exposing the adductor pollicis muscle origin at the third metacarpal bone. The muscle is then detached from the bony origin with a periosteal elevator, and the thumb is stretched to slide the muscle (Fig. 2G). If there is notable intrinsic muscle tightness over the fingers after the fractional lengthening at the musculotendinous junction, the interosseous muscles could also be released from the metacarpal origin in the same fashion.

Elbow flexor release

A curvilinear, S-shaped incision is made over the cubital fossa. The cephalic vein is protected. The lacerates fibrosis and biceps brachii tendons are identified, and the former is divided. Z-lengthening of the biceps brachii tendon is performed next. The aim is to allow maximum elbow extension while preserving adequate elbow flexion. The WALANT technique enables the patient to actively flex and extend the elbow after the z-tenotomy. The surgeon can then gauge and adjust the appropriate z-length required for a functional balance between flexion and extension. The z-lims are then sutured with 2-0 nylon. In cases where the z-lims are not apposable at the desired extension limit and the brachialis power is adequate, the z-lims can be left unanchored, equating to a biceps tenotomy, while the brachialis maintains the functional elbow flexion.

Postoperative Management

A long-arm Plaster Of Paris slab is applied for a period of 1 week with the forearm in full supination, wrist in 30° extension, and the...
fingers and thumb in full extension. By week 2, the slab is replaced by a resting, long-arm orthosis (Fig. 3), which maintains the forearm in supination and the wrist, fingers, and thumb in extension while allowing active and passive mobilization of the forearm, wrist, and fingers and thumb intermittently. Range of motion exercises are started from week 2. The orthosis is maintained throughout for 4 weeks and at night for the next 2 months. In elbow flexion release patients, we immobilize for 4 weeks with the elbow in 20° extension in an orthosis, followed by mobilization (Table).

Pearls and Pitfalls

In our experience, a good preoperative rapport with the patients is vital in selecting suitable cases for spastic hand releases. It allows an opportunity for preoperative patient education, and builds preparedness by familiarizing patients with the intraoperative instructions. Diluting the lignocaine solution to 0.5% allows for a larger volume of WALANT infiltration when a larger area of field block is required, without compromising the need for tourniquet usage. Alkalinization of the lignocaine solution may improve pain in diluted solutions. We also allow draping to be adjustable to enable patients to have a direct view of the operated limb. This helps to get live feedback after sequential releases and demonstrates improved ROM to the patients.

Case 1

We treated a 24-year-old, right-handed, sedentary worker with left upper-limb hemiparesis due to an infantile head injury and failed conservative management (Video, available on the Journal's website at www.jhsgo.org; Fig. 1). His major issue was social embarrassment by the involuntary hand fisting. On examination, he could open his hand voluntarily only with his wrist in maximum flexion, was unable to open his fist when in a neutral wrist position, had thumb-in-palm deformity, and could not supinate his forearm beyond neutral. His flexor muscle strength was good. Release surgery was performed under WALANT using 30 ml of a solution of 1% lignocaine. During surgery, 4.5 ml lignocaine was added. We performed PT release first, followed by fractional lengthening of the FCU and FCR, then passive stretching, and sequential second cuts to have adequate release. Next, fractional lengthening of the FDS (2 cuts), FDP (2 cuts), and FPL (4 cuts) muscles was performed using the same principles, based on the patient's on-table response. The resultant lengthening of each muscle ranged from 13 to 34 mm. Post-release, finger extension was possible with the wrist in a neutral position, active supination increased to 45°, and wrist extension improved. The operative time was 152 minutes, without using a tourniquet. At 5 years after surgery, he had active wrist extension of 30° and simultaneous opening of the fingers and thumb with his wrist in a neutral position (Fig. 4). He had active supination of 50°, pronation of 60°, and passive supination to 70°. He could manage activities of daily living and work well, and was able to drive with special car adjustments.

Case 2

A 27-year-old man who suffered a cerebrovascular accident presented with a residual right hemiplegia with spasticity of the right upper limb in the wrist, fingers, and pronators. His body weight was 72 kg. He had failed Botox injections, and hand therapy for several years with an inadequate outcome. He could extend his fingers only at 50° of wrist flexion, and was unable to open his fist at neutral wrist extension. He could actively extend his wrist to 20°, and supinate up to 60°. All flexor muscles were spastic. Forearm and palmar releases were performed (Fig. 2A–H). A diluted solution of 0.5% lignocaine with 1:100,000 adrenaline was used, with 40 ml injected to the forearm and 20 ml to the palm. During surgery, 11 ml of lignocaine was added. Fractional lengthening was performed on PT (1 cut), FCU (1 cut), FCR (2 cuts), FDSs (1 cut) and FDP to index finger (1 cut), FDP to ulnar 3 fingers (2 cuts), FPL (2 cuts). The PL was tenotomized. The resultant lengthening of each muscle ranged from 10 to 45 mm. An adductor slide was performed for the thumb as described above. The operative time was 170 minutes, without using a tourniquet. After release, finger extension was possible in a neutral wrist position and the wrist extension range improved, with smoother motion. At 3 months after the surgery (Fig. 5), he maintained simultaneous full finger and wrist extension, his wrist active ROM was 80° of flexion to 70° of extension, and forearm supination and pronation were full.

Case 3

Thirty-nine years female presented 2 years post-stroke with right spastic hemiplegia that failed repeated Botox treatment. At presentation, her elbow was held in 90° flexion with 20° of extension, her forearm was in supination, her wrist and fingers were in flexion as a tight fist with thumb-in-palm deformity, and she was only able to extend her fingers with her wrist in maximum flexion. A biceps tenotomy; fractional lengthening of the FCR (2 cuts), FCU (2 cuts), FPL (1 cut), FDS (3 cuts), and FDP (2 cuts) muscles; and PL division were performed under WALANT with 20 ml of a solution of 1% lignocaine. After the biceps tenotomy, she had active ROM at her elbow of 10° to 120°, and full, passive extension of her fingers at a neutral wrist position was possible but she lacked active finger extension control. She had a recurrence of thumb-in-palm deformity at 6 months, and agreed to undergo a second WALANT procedure for z-lengthening of the FPL and an extensor carpi radialis longus to extensor digitorum communis transfer 7

Figure 3. In case 2, postoperative orthosis fabrication for forearm flexor-pronator release and thumb-in-palm and intrinsic-plus deformity correction with a long-arm orthosis maintains the forearm in supination and the wrist, fingers, and thumb in extension, and is worn full time for 4 weeks and at night for the next 2 months (A volar aspect; B dorsal aspect).
months after her first surgery. At 3 years after surgery, her elbow ROM continued to be smooth, with ROM of 0° to 120°, a wrist passive flexion or extension arc of 60°, and a neutral resting position.

Discussion

Traditionally, spastic muscle lengthening under GA has been a nonquantifiable technique with unpredictable results. Surgeons can only speculate on the functional outcome based on personal experience that relies on a subjective, passive extension. Complications of under- and overlengthening are well known. Up to 19% of patients did not see improvement or felt deterioration in their hand function after release surgeries. Surgeons may feel underconfident at intraoperative decision-making. With WALANT, the surgeon has a live, objective assessment tool in the form of the patient response. This allows us to customize each stroke of fractional lengthening and the degree of lengthening to the maximum functional ROM achievable, in real time. There were no complications of overdone releases in our series.

The WALANT technique effectively overcomes the downside of absent intraoperative patient communication at GA surgeries. The patients can view the surgical results during surgery, which can enhance satisfaction, confidence, and compliance to rehabilitation, and can maintain the intraoperative outcome. Intraoperative patient education can be provided effectively. In other WALANT-based surgeries, such communications have translated to better postoperative rehabilitation.

Regarding pain experienced with WALANT, all 3 patients documented satisfaction with the pain control during surgery with minor top-ups. The patient in case 3 chose a repeat surgery under WALANT, indicative of her positive patient satisfaction during her first surgery.

Factors that may limit WALANT use in cases of spastic hand include multiple-level, long surgeries, but a dilution to 0.5% can, in principle, allow infiltration of a maximum of 98 ml of the anesthesia in a 70-kg man, like in our case 2. Patient tolerance was good in our series, and the surgeries could last from 1 hour and 30 minutes to 2 hours and 50 minutes without the need for conversion to GA.

Fractional lengthening, tendon transfer, z-lengthening, tenotomy, and slide procedures could all be performed under WALANT but, unlike in the lengthening procedures, calibration of slide and tenotomy procedures to the on-table patient functions is not exact or modifiable because of the “all or none” nature of these releases. Bezuhly et al. found that WALANT improved tensioning during tendon transfer surgery in nonspastic hands. We did perform FPL z-lengthening and an extensor carpi radialis

| Case | Wrist Flexion | Wrist Extension | Supination | Pronation | Finger Extension | Elbow |
|------|---------------|----------------|------------|-----------|------------------|-------|
| Case 1 | 30°           | 30°            | 50°        | 60°       | Full, with wrist in neutral | NA    |
| Case 2 | 80°           | 70°            | 90°        | 90°       | Full, with wrist in extension | NA    |
| Case 3 | 30°           | 30°            | 90°        | 90°       | Full, with wrist in neutral | 0–120 |

NA, not applicable.

* All ROM values were tested at the most current follow-ups.
  1 Case 1 values are from 5 years after surgery.
  2 Case 2 values are from 3 months after surgery.
  3 Case 3 values are from 3 years after surgery.

Figure 4. Case 1 outcome. A Before surgery, the patient could open his hand voluntarily only with the wrist in maximum flexion, and was unable to open his fist in a neutral wrist position. B At 5 years after surgery, the patient had wrist extension of 30° and simultaneous opening of fingers and thumb with the wrist in a neutral position.
longus to extensor digitorum communis transfer in case 3.

Z-lengthening and tendon transfers under WALANT share the same advantages of real-time quantification of optimal tension and excursion of the involved muscles, and more precise calibration of lengthening.

Lastly, our cases of spastic hand surgery under WALANT expand WALANT’s usage under resource constraints. Case 2 was performed during the COVID-19 pandemic with reduced GA sections at our center. The WALANT technique additionally lowers the risk of viral dissemination, as it avoids ventilation, requires simpler operating room set-ups, and lowers the number of professionals required. Objective data on preoperative and postoperative Disabilities of the Arm, Shoulder, and Hand scores and grip strengths were not collected in all 3 index cases, but should be considered to validate WALANT use in spastic upper-limb release in future studies.

Conclusion

The WALANT technique was observed to be advantageous in spastic upper-limb surgery, by permitting an on-table, real-life assessment of muscle releases and of residual muscle power during release, thus, in turn, allowing the surgeon to instantly corroborate release to the patient’s hand function while allowing guided adjustments for the best achievable, functional ROM and control.

Acknowledgments

The authors acknowledge Dr Michael Chu-Kay Mak (clinical and surgical advice), Dr Wing-Lim Tse (clinical and surgical advice), Mr Wai-Wang Chau (clerical support), and Ms Wai-Ping Fiona Yu (ethical approval preparation and submission) for their enormous contributions.

References

1. Keenan MA, Abrams RA, Garland DE, Waters RL. Results of fractional lengthening of the finger flexors in adults with upper extremity spasticity. J Hand Surg Am. 1987;12(4):575–581.
2. Lalonde DH. Latest advances in wide awake hand surgery. Hand Clin. 2019;35(1):1–6.
3. Lalonde D. Minimally invasive anesthesia in wide awake hand surgery. Hand Clin. 2014;30(1):1–6.
4. Bezuhly M, Sparks GL, Higgins A, Neumeister MW, Lalonde DH. Immediate thumb extension following extensor indicis proprius-to-extensor pollicis longus tendon transfer using the wide-awake approach. Plast Reconstr Surg. 2007;119(5):1507–1512.
5. Mohammed AK, Lalonde DH. Wide awake tendon transfers in leprosy patients in India. Hand Clin. 2019;35(1):67–84.
6. Woo SH, Yoo MJ, Ahn HC. Lessons learned in the authors’ first years of wide-awake hand surgery at the W hospital in Korea. Hand Clin. 2019;35(1):59–66.
7. Wright J, MacNeill AI, Mayich DJ. A prospective comparison of wide-awake local anesthesia and general anesthesia for forefoot surgery. Foot Ankle Surg. 2019;25(2):211–214.
8. Tang JB, Xing SC, Ayhan E, Hediger S, Huang S. Impact of wide-awake local anesthesia no tourniquet on departmental settings, cost, patient and surgeon satisfaction, and beyond. Hand Clin. 2019;35(1):29–34.