30 Minimally Invasive Treatment of Elbow Neuropathies

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Ulnar Nerve

The incidence of ulnar neuropathy has been reported to be 25 cases per 100,000 people in the USA or about 75,000 new cases of cubital tunnel syndrome per year. In fact, ulnar nerve entrapment at the elbow is second only to carpal tunnel syndrome in frequency. Symptoms classically include paresthesias, dysesthesias, hypesthesias, tenderness, atrophy, or muscle weakness in the affected elbow, forearm, or hand [2].

Causes are also diverse; occupational factors are common and may result from increased tension on the nerve, increased intraneural pressure, and decreased volume through the cubital tunnel during elbow flexion [3]. Any anatomic structure like an osteophyte, cyst, or loose body that infringes upon the cubital tunnel can have a significant effect on the ulnar nerve. Anatomic structures, going from proximal to distal, most often cited as locations for compression are the arcade of Struthers, the intermuscular septum, the medial epicondyle, the anconeus muscle, Osbourne's ligament at the cubital tunnel, and the fascia and fibrous bands of the flexor carpi ulnaris as the nerve decussates [1, 4]. A robust or subluxing medial triceps can contribute to compression or impingement on a nerve that is well fixed in the groove, or these structures can contribute to painful subluxaton of the nerve over the medial epicondyle [1]. Advocates of extensile approaches cite this varied and extensive list of possible sites of compression as the reason to avoid limited exposure, as most

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structures are confined to 8 cm proximal and 5 cm distal to the medial epicondyle.

Common treatments for primary ulnar neuropathy include ulnar nerve decompression in situ, ulnar nerve transposition, with or without medial epicondylectomy, and submuscular transposition. The same arguments in favor of limited incision surgery can be made regarding simple decompression instead of ulnar nerve transposition, as simple decompression has reduced rates of postoperative wound infection, hematoma formation, hypertrophic scarring, and shorter recovery time [5]. Moreover, the Cochrane Collaboration found similar outcomes when comparing ulnar nerve decompression in situ with ulnar nerve transposition [6]. Several endoscopic techniques have been described and share many of the same hallmarks of minimal incision decompressions without any decrease in complication or reoperation rate; postoperative hematoma is the most commonly reported complication with the endoscopic techniques [1–12].

Furthermore, with an increased usage of arthroscopic capsular release in the last 20 years, there may be an expanded role for concomitant less invasive treatment of the ulnar nerve [13]. Williams et al. reported an 8 % incidence of new onset of ulnar nerve symptoms in patients that did not have a prophylactic ulnar nerve release; at closer inspection, the rate was 15.2 % in patients whose preoperative flexion was <100°, compared to 3.7 % in patients whose flexion was greater than 100°. Blonna and O'Driscoll have reported on the phenomenon of "delayed onset ulnar neuritis" (DOUN) after elbow contracture release in 26 of 235 cases (11 %) who did not have a prophylactic procedure; upon surgical exploration they found compression of the nerve in 94 % of the cases. Of note, though, these authors also observed a 3 % incidence in a cohort of patients who did undergo a prophylactic decompression, albeit with less impairment [14, 15]. The authors did find a five times increased risk of failure of prophylactic decompression when the release was less than 6 cm [14, 15].

Anatomic structures that contributed to the compression included the cubital tunnel retinaculum, the posterior bundle of the medial collateral ligament, osteophytes on the medial olecranon and trochlea, and the medial portion of the triceps [15]. The ulnar nerve can be subjected to a 5 mm increase in length, a 50 % narrowing of the cubital tunnel, and a 45 % increase in intraneural pressure at the elbow during flexion. For these reasons, prophylactic release of the ulnar nerve at the elbow is recommended in patients with these preoperative findings: less than 100° of elbow flexion, ulnar nerve symptoms, a positive Tinel's, or electrodiagnostic findings of ulnar compression preoperatively, or heterotopic ossification [13–15].

A detailed knowledge of the anatomy can allow the surgeon to provide an appropriate decompression while minimizing the risk of complications. The medial antebrachial cutaneous nerve (MABC), arising from the medial cord, provides sensation overlying the medial epicondyle, arm, and forearm; it is most at risk from direct surgical exposure of the ulnar nerve. The standard incision for ulnar nerve decompression or transposition puts the posterior branch of the MABC at greatest risk [4].

Borrowing from Blonna and O'Driscoll, a standard ulnar decompression can be defined as a decompression of at least 8 cm (usually 12–14 cm) as measured from the midpoint of Osborne's ligament, exposing the nerve at least 4 cm in either direction. A limited decompression provides for 6–8 cm of nerve release, and a mini decompression provides for only 4–6 cm of release [14]. Advocates of the endoscopic techniques strive for 8–10 cm of decompression in either direction through a 2–3 cm incision [1–12].

Comparison of minimally invasive open techniques to endoscopic techniques has yielded equivalent results, often with shorter operative times and lower cost for the minimally invasive techniques [2]. This chapter will focus on a limited incision approach (2–3 cm) that provides for equivalent decompression as a standard open technique (>12 cm) and utilizes common surgical instrumentation. Furthermore, the skin incision can be readily extended as needed, can allow for any variation of transposition, and lends itself to a gradual reduction in size as surgeon experience improves.

Technique

The patients are placed supine on the operative table with the arm extended on an arm board. General anesthesia is preferred, but the surgery can be performed with a regional block. The patient's arm must be mobile to allow for easy shoulder abduction and external rotation and elbow flexion and extension. The surgeon sits in the axilla facing the medial epicondyle. If an endoscopic technique is to be utilized, the endoscopy tower should be at the head of the patient to allow for easy visualization (Fig. 1) [9]. A nonsterile tourniquet is applied prior to prepping and draping. Once the surgical landmarks and skin incision have been identified, 5–10 cc of local anesthetic is applied, the limb is exsanguinated with an Esmarch band, and the tourniquet is inflated to 250 mmHg. A small bump of towels placed under the olecranon can assist with visualization. Standard surgical instruments are used; headlight or operating loupes are at the discretion of the surgeon (Fig. 2).

In general, the operative techniques involve a 2–3 cm incision at the retrocondylar groove about midway between the medical epicondyle and the olecranon (Fig. 3). Dissection should proceed directly to the roof of the cubital tunnel (Osborne's ligament) and the ulnar nerve by means of blunt tipped tenotomy scissors, avoiding tunneling (Fig. 4) [2]. Once the nerve and fascia have been identified, a Freer elevator or similar device can be used to protect the nerve while the overlying fascia is incised with scissors or beaver blade scalpel (Fig. 5); the cubital tunnel proper, Osborne's ligaments, averages 2.5 cm; therefore, the most consistent site of compression can be addressed in the floor of the skin incision (Fig. 6) [8].

Fig. 1 Preferred operating room set up for ulnar nerve surgery. The patient's right arm is extended on an armboard. An arthroscopy tower is placed where the surgeon has an unobstructed view

Fig. 2 Standard instruments used for ulnar and radial nerve surgery

Fig. 3 Standard 2–3 cm curvilinear incision used for ulnar nerve surgery, centered between the medial epicondyle (*M.E.*) and the olecranon

A double-ended retractor can be used to elevate the skin, providing 5–10 cm of visualization in either direction of the skin incision depending on body habitus (Fig. 7a–c). Elbow flexion can assist with the visualization proximally, and elbow extension assists with the distal view. It may be necessary to resect a portion of the medial intermuscular septum or triceps fascia as proximal as 8 cm or distal fibrous bands at a similar distance [11]. As a final check, an intelligent probe, i.e., the surgeon's finger, can palpate the wound and confirm adequate release (Fig. 8). Layered closure is performed, and a soft compressive elastic bandage is applied. The tourniquet is deflated after bandage application. Activity restrictions include ADL's only for 1 week, nonstrenuous activity between

Fig. 4 The incision is located directly above Osbourne's ligament, providing for release of the most common area of ulnar compression

Fig. 5 A Freer elevation can be used to bluntly dissect along the nerve, protecting it during the release

weeks 1 and 2, and full activity to tolerance after week 2.

Contraindications for this technique include: body habitus as the adipose layer of an obese patient may limit visibility, failed previous ulnar nerve intervention, or inability to position the arm for adequate visualization (such as a patient with limited shoulder or elbow mobility). Indications for transposition include instability of the nerve at the medial epicondyle, aberrant anatomy, or prominent hardware [1]. Lequint et al. reported excellent outcomes in 30 patients with transposition through this limited approach demonstrating the feasibility and reliability of a limited incision transposition (Fig. 9) [16].

Special mention must be made about the feasibility of arthroscopic ulnar nerve release. With many capsular releases and osteocapsular arthroplasties, it becomes necessary to release a portion of the medial collateral ligament and resect medial osteophytes. During this portion of the arthroscopy, the nerve is adjacent to the tissues that are being released. Furthermore, the nerve can be inadvertently exposed during extensive work on the medial aspect of the joint. With careful

Fig. 6 The ulnar nerve is exposed in the floor of the wound after complete release

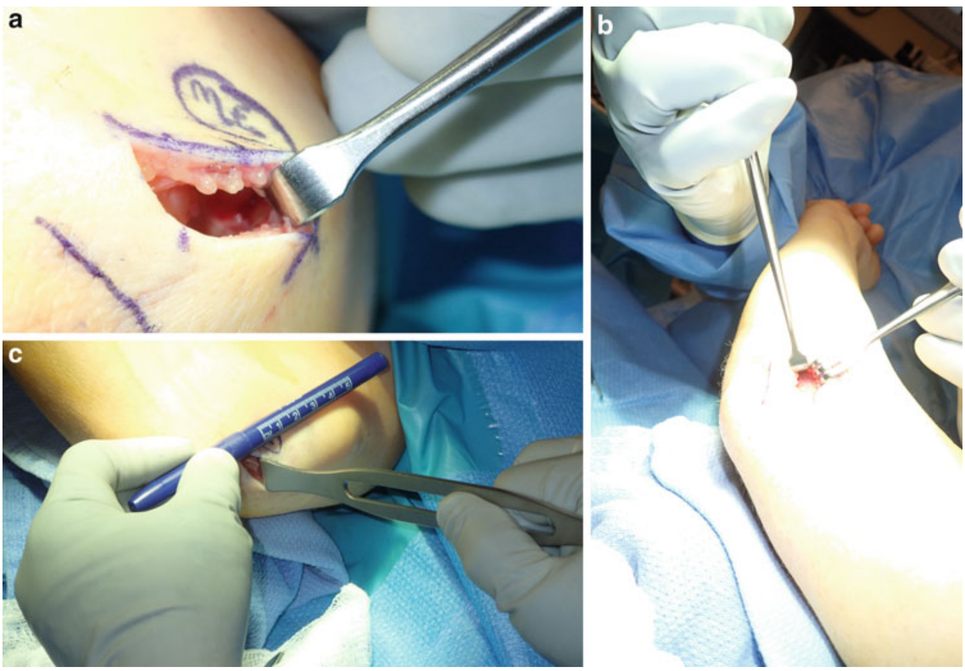

Fig. 7 Elbow flexion and retraction with a bent retractor allows for proximal visualization (**a**) and (**b**), while extension allows for distal inspection of the nerve and its branches (**b**); the retractor, itself, can confirm nearly 5 cm of release (**c**)

dissection, it is possible to introduce a retractor through a specific "nerve" portal; the nerve can be transilluminated, the portal localized with a spinal needle, and then a "nick and spread" technique can be used to introduce a retractor to protect the nerve during medial work. Moreover, this technique can be utilized to protect the nerve as the medial structures that surround the nerve are removed with a basket cutter or shaver. After the release, it becomes possible to visualize the nerve from the triceps tendon to the motor branches as the nerve decussates (Fig. 10).

Fig. 8 The surgeon can easily palpate the wound to confirm adequate release, identifying any remaining fascial bands

Fig. 9 Healed incision following subcutaneous transposition of the ulnar nerve

Fig. 10 Arthroscopic view of the ulnar after following arthroscopic release

It is this "inside-out" technique that the author employed for a series of 16 patients [17]. Similarly, Kovachevich and Steinmann reported a series of 15 elbows with an arthroscopic ulnar nerve decompression [3]. In both series there was a 20 % revision rate for ulnar recurrent neuropathy [3, 17]. For the patients that underwent subsequent surgery, the most troubling aspect was a consistent finding of extensive scarring at the later surgery. With this in mind, and with the ease of a concomitant small open decompression at the time of an elbow arthroscopy, an arthroscopic ulnar nerve release with this technique may not be a recommended procedure. Because this particular technique is a transarticular approach, a selective approach within the nerve sheath, as is found with traditional endoscopic techniques, may minimize the risk of scarring to the joint. However, at this stage, the author performs the described mini-open in situ

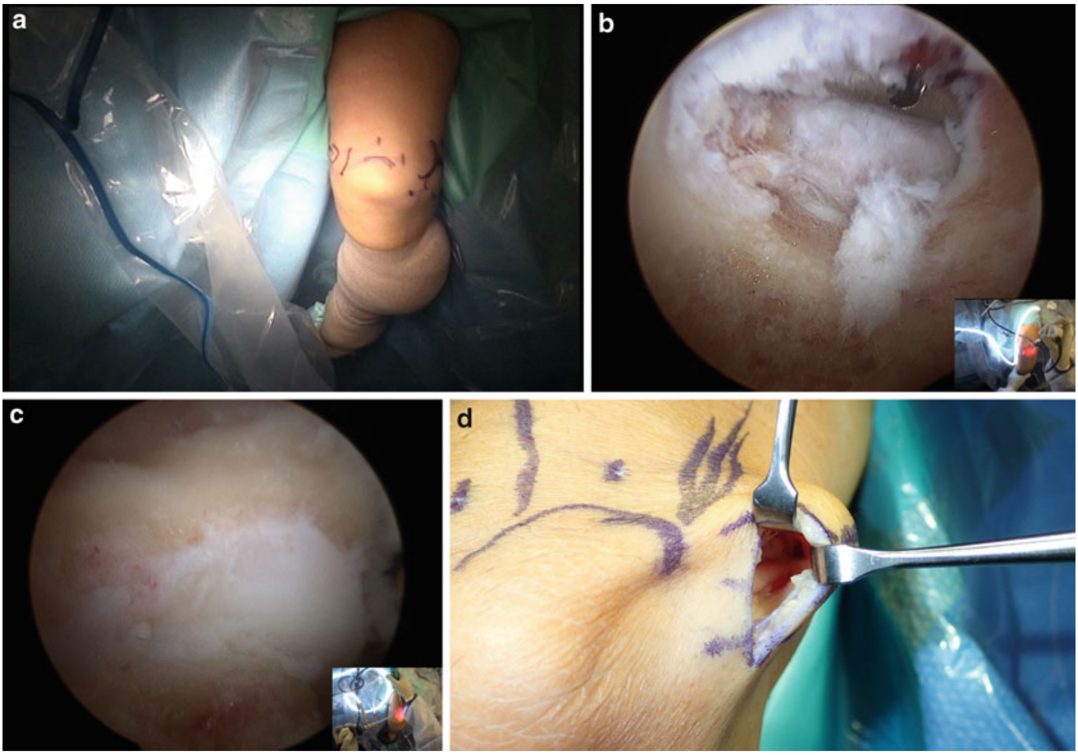

Fig. 11 Surgeon's view of a right elbow prior to ulnar nerve decompression and arthroscopy (**a**); intraarticular view of the elbow joint with the ulnar nerve transilluminated in the ulnar incision (**b**); the ulnar nerve incision can serve as an accessory arthroscopic portal (**c**); Ulnar nerve exposure of a left arm prior to arthroscopy (**d**)

decompressions at the beginning of any case that may require a concomitant elbow arthroscopy and ulnar nerve release. Furthermore, the skin incision can serve as a medial portal for instrumentation of the medial aspect of the joint after the nerve has been released and controlled with a vessel loop. For patients that undergo arthroscopy of the elbow in a lateral position, elbow extension aids the proximal visualization, while flexion enhances the distal (Fig. 11a–c).

Radial Nerve

Radial nerve entrapment at the elbow, radial tunnel syndrome or posterior interosseous nerve syndrome (PIN), is compression of the radial nerve or its terminal branches (esp. the deep branch) after it passes from the posterior aspect of the arm to the anterior aspect of the arm and forearm [18–22]. Classically, radial tunnel syndrome is described as a sensory malady and PIN syndrome a motor deficit; compression in the proximal forearm may affect these structures simultaneously, though [18, 21, 22]. Because the symptoms may mimic or coexist with lateral epicondylitis or radiocapitellar plica syndrome, or may result from effects of a mass lesion, it is often a diagnosis of exclusion [23]. Furthermore, electrodiagnostic testing is rarely positive due to the depth of the course of the nerve, and significant compression may occur only with activity as the offending structures become engorged with blood; if positive, the EMG typically demonstrates changes in the muscles supplied by the PIN. Pain will commonly be at the lateral aspect of the elbow and can radiate to the first webspace of the hand; weakness with wrist or finger extension or increased pain with these motions may occur.

The radial tunnel, as it is classically described, extends for approximately 4 cm from the lateral epicondyle to the distal portion of the supinator muscle; the walls are defined laterally by the brachioradialis and extensor carpi radialis longis (ECRL) and medially by the brachialis muscle and biceps brachialis tendon [18, 21, 22]. The floor of the space is comprised of the radiocapitellar joint capsule and deep portion of the supinator muscle, distally. The superficial portion of the supinator muscle and the medial portion of the extensor carpi radialis brevis (ECRB) as well as fibromuscular attachments between the structures create the roof [18, 19]. The proximal edge of the supinator muscle commonly forms a fibrous arch know as the “arcade of Froshe”; it is this structure that is most often implicated in radial tunnel syndrome.

Because both the ECRB and supinator muscles are often tendinous as they cross the deep branch of the radial nerve, they are most often responsible for the pathologic compression; moreover, as the muscle bellies become engorged with blood, they will increase the compression during physical activity, especially resisted supination. Anatomic studies describe the bifurcation (and in some cases, trifurcation) of the radial nerve over a region of 6 cm when centered over the joint interepicondylar line or about 4.8 cm above the radiocapitellar joint line to 1.2 cm below it [18–22]. The arcade of Froshe typically sits 2.5 cm distal to the superior aspect of the radiocapitellar joint [19, 20]. Clavert’s study demonstrated that the nerve typically bifurcates 4 cm proximal to the arcade of Froshe [18].

Technique

The patient is placed supine on the operative table with the arm internally rotated and the elbow semiextended on an arm board. General anesthesia is preferred, but the surgery can be performed with a regional block. A nonsterile tourniquet is applied prior to prepping and draping. The surgeon sits to the ulnar, lateral aspect of the forearm facing the lateral epicondyle (Fig. 12). Once the surgical landmarks and skin incision have been identified, 5–10 cc of local anesthetic is applied, the limb is exsanguinated with an Esmarch band, and the tourniquet is inflated to 250 mmHg. Standard surgical instruments are used for the procedure; headlight or operating loupes are at the discretion of the surgeon.

A 4–5 cm longitudinal incision is made on the anterior aspect of the forearm centered over the proximal radius; the incision begins at the same level as radiocapitellar joint and can follow the raphe between the brachioradialis and ECRL

Fig. 12 Radial nerve incision following the path of the nerve and brachioradialis. Palpation of the forearm aids in identification of the raphe along the border of the muscle

Fig. 13 Palpation of the radiocapitellar joint serves as a reference for centering the incision in the most likely zone of radial nerve compression

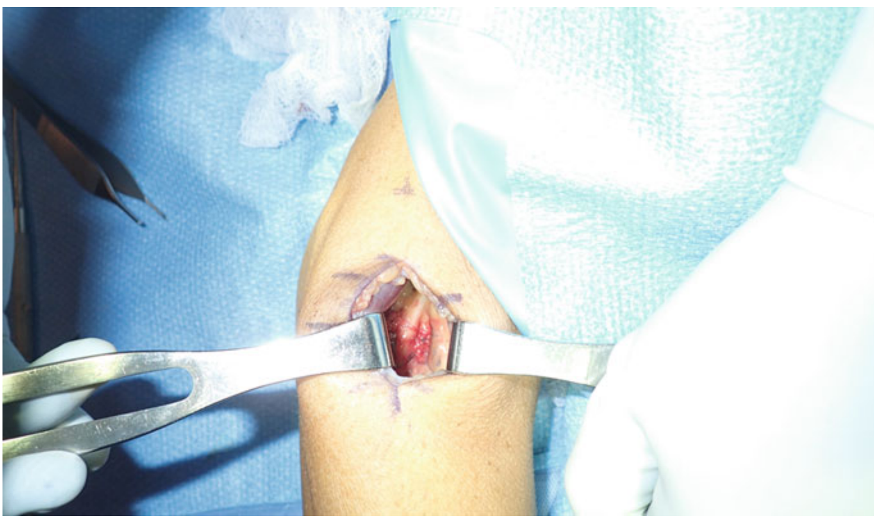

Fig. 14 Blunt dissection should begin proximally under the brachioradialis to observe the radial nerve entering the anterior aspect of the arm

(Fig. 13). The skin is elevated and the muscle fascia is incised with blunt tipped tenotomy scissors. Next double-ended retractors are used to bluntly dissect down to the ECRB fascia and the supinator fascia by retracting the brachioradialis laterally (Fig. 14); elbow flexion and wrist extension can help to elevate the origins of the ECRB and ECRL. The radial nerve can then be identified and traced proximally to its appearance in the anterior arm and distally to its submergence into the supinator. At this time, the surgeon can identify the braches and possible

Fig. 15 The branches of the radial nerve can be seen in the floor of the wound

Fig. 16 The PIN courses in an ulnar direction to enter the supinator, as seen in this right arm; the Freer elevator is under the supinator tendon of a right forearm; the hand is to the left

sites of compression. The radial sensory nerve will be encountered first with the nerve to the ECRB running parallel to it (Fig. 15). The PIN will be seen coursing obliquely towards the ulnar side of the forearm to enter the supinator (Fig. 16). The ECRB fascia should be divided, and below it will be the supinator and the arcade of Froshe (Fig. 17). To ensure adequate release divide any of the fibrous structures that cross the pathway of the nerve. Elbow extension will assist in visualization of the distal structures. Closure is performed at the skin only.

Conclusions

Minimally invasive approaches (Fig. 18a, b) can still safely provide maximal surgical release, and in some cases transfer of the radial and ulnar nerves at the elbow. Complications can be

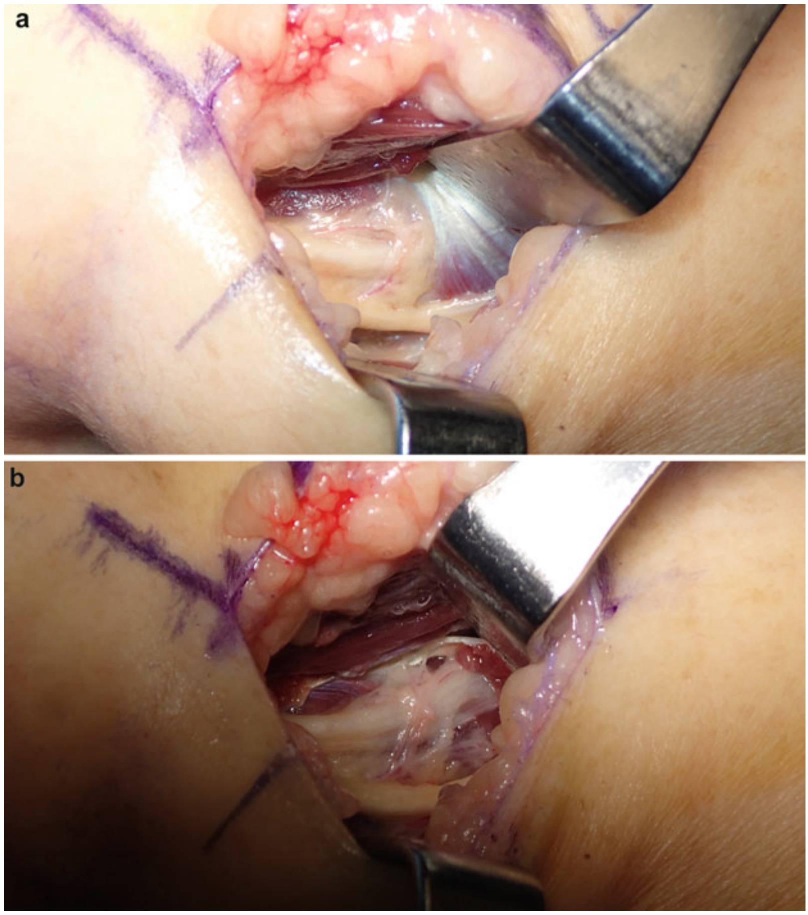

Fig. 17 The supinator tendon (Arcade of Froshe) and proximal muscle belly are visualized in this left forearm; the hand is to the right (**a**). The supinator tendon has been divided, and the nerve branches are visible at the distal extent of the wound **(b)**

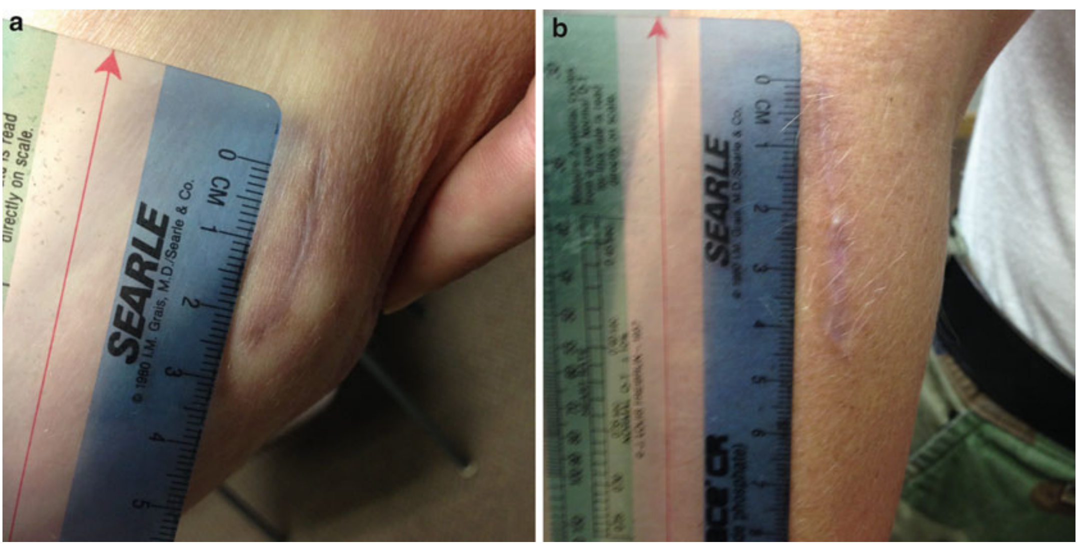

Fig. 18 Ulnar nerve incision (**a**) and radial nerve incision (**b**) 6 months after releases

minimized with accurate understanding of the anatomy and appropriate patient selection; high satisfaction rates with early return of function are hallmarks of these techniques.

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