Reconstruction of Posterior Interosseous Nerve Injury Following Biceps Tendon Repair: Case Report and Cadaveric Study

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Abstract Surgical repair of distal biceps tendon rupture is a technically challenging procedure that has the potential for devastating and permanently disabling complications. We report two cases of posterior interosseous nerve (PIN) injury following successful biceps tendon repair utilizing both the single-incision and two-incision approaches. We also describe our technique of posterior interosseous nerve repair using a medial antebrachial cutaneous nerve graft (MABC) and a new approach to the terminal branches of the posterior interosseous nerve that makes this reconstruction possible. Finally, we advocate consideration for identification of the posterior interosseous nerve prior to reattachment of the biceps tendon to the radial tuberosity.

Keywords Posterior interosseous nerve ·
Biceps tendon repair · Nerve graft ·
Nerve reconstruction · Radial nerve

Introduction

Surgical repair of distal biceps tendon rupture is a technically challenging procedure that has the potential for

devastating and disabling neurological complications. The anatomy of the proximal forearm is complex, containing the radial nerve and its bifurcation into the posterior interosseous nerve and its superficial sensory branch. Exposure of the radial tuberosity places all of these nerves in danger. Radial nerve palsies are conventionally treated with tendon transfers to restore wrist, finger, and thumb extension [7]. We report two cases of posterior interosseous nerve injury following biceps tendon repair and their subsequent reconstruction utilizing a medial antebrachial cutaneous nerve graft.

The reconstruction of a nerve injury requires the availability of both the proximal and distal stumps of the nerve. The proximal stump is the source of regenerating axons that remain viable and in continuity with the proximal cell body. The distal nerve stump will undergo Wallerian degeneration but will provide the structural framework to guide the regenerating axons to their target end organs. Nerve injuries that are very proximal (e.g., brachial plexus root avulsion) or very distal near the target motor endplates may not be reconstructable because the proximal or distal nerve stump may not be available or accessible. The site of injury to the PIN in the following case reports was at the proximal border of the supinator muscle just after the PIN entered the muscle and was no longer visible. The standard approach to the PIN through the interval between the brachioradialis and the extensor carpi radialis longus (ECRL) provides access to the PIN proximal to the supinator muscle but is inadequate to expose the nerve as it passes through the inferior half of the supinator muscle or further distally [8]. Critical terminal branches distal to the supinator include the extensor pollicis longus (EPL), abductor pollicis longus (APL), extensor digitorum communis (EDC), extensor carpi ulnaris (ECU),

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and extensor digiti quinti (EDQ). A standard approach for access to these branches has not been previously described and is proposed here to enable the reconstruction and reinnervation of these muscles.

Case no. 1

The patient is a 41-year-old right-hand-dominant male who was referred to our office 5.5 months after repair of biceps tendon rupture for evaluation of a posterior interosseous nerve palsy. The patient had ruptured his biceps tendon in a bungee jumping accident and then subsequently underwent repair using a two-incision approach. The biceps tendon was reattached to the radial tuberosity. Postoperatively, he complained of an inability to extend his fingers and thumb. These deficits persisted for several weeks, prompting his orthopedic surgeon to order electromyographic and nerve conduction studies at 11 weeks postoperatively. These studies confirmed posterior interosseous nerve injury. On physical examination, the patient lacked thumb and finger extension. Wrist extension was intact; however, there was marked radial deviation. Full active and passive range of motion was maintained. Pinch and grip strength measured 30 and 90 lbs on the right versus 25 and 65 lbs on the left. A repeat electromyogram (EMG) demonstrated 4+ denervation of the EDC, extensor indicis proprius (EIP), EPL, and ECU. Motor unit potentials in these muscle groups were absent. There was milder denervation of the ECR muscles. Sensory NCS of the radial sensory nerve was normal. The patient was informed of these findings, and the possibility of nerve reconstruction with nerve grafts taken from either the medial antebrachial cutaneous nerve in the ipsilateral arm versus the sural nerve. He was also informed of the possibility of tendon transfers but chose radial nerve exploration and grafting of the posterior interosseous nerve.

Cadaveric Studies

Six forearms from three cadaver specimens were dissected to study the anatomy and determine landmarks for the exposure of the PIN distal to the supinator muscle. A “retrograde” approach was used to identify the terminal EDQ and ECU branches of the PIN, and then dissection continued proximally to expose the distal PIN prior to its terminal muscular branches. The terminal branch to the EDQ and ECU was easily found as it penetrated into the fifth extensor compartment after mobilizing the EDQ muscle from its bed. The exposure was through a longitudinal incision approximately 3–4 cm in length, centered about 8 cm (8 ± 1 cm, mean $\pm$ SD) distal to the

lateral epicondyle and 1 cm dorsal to the palpable border of the ulnar shaft. The fascia was incised over the fifth extensor compartment, and the EDQ mobilized to visualize its neurovascular pedicle entering the deep radial aspect of the muscle. The nerve branch was dissected several centimeters proximally to reach the distal PIN. The branch to the ECU is commonly seen as an adjacent branch from the PIN, and the branches to the EDC, EPL, EIP, abductor pollicis longus (APL), and extensor pollicis brevis (EPB) muscles were all visualized “fanning” from the radial aspect of the PIN (Fig. 1). The distance from the entrance of the EDQ branch into the fifth extensor compartment and the PIN just proximal to its terminal branches was approximately 2.5–3 cm. The distal border of the supinator muscle was encountered and incised to provide more length to the PIN trunk.

Operative Procedure

An incision was made over the region of the PIN, in the region of the arcade of Frohse. Dissection was carried down through the soft tissue with care to protect the posterior cutaneous nerve of the forearm. The interval between the

Figure 1 **a** Schematic of the surface anatomy of the distal posterior interosseous nerve approach. **b** Schematic demonstrating the interval between the extensor digiti quinti and the extensor digitorum communis, with the terminal branches of the PIN deep to the muscle bellies. The terminal branches of the PIN are dissected proximally to the main trunk of the PIN distal to the supinator.

brachioradialis and extensor carpi radialis longus was entered, exposing the posterior interosseous nerve. As dissection of the posterior interosseous nerve was carried through the supinator muscle distally, increasing amounts of scar tissue were encountered. Finally, a large Ethibond suture that had encircled and essentially divided the PIN was discovered, causing large neuroma. Through a second incision centered around a point 8–9 centimeters distal to the lateral epicondyle and 1 cm dorsal to the edge of the ulna, the EDC, EDQ, and ECU muscles were exposed. After entering the interval between EDQ and EDC, the EDQ muscle was mobilized from its bed, and its neurovascular pedicle was easily identified. The nerve to the EDQ was then dissected further proximally beneath the EDC until the individual terminal posterior interosseous nerve branches were identified. Dissection was continued proximally to the main trunk of the posterior interosseous nerve. Intraoperative stimulation confirmed no function in the PIN distal to the neuroma. We then identified the MABC nerves in the arm and harvested the anterior medial portion as nerve graft material.

The area of scarred PIN was excised proximally and distally until a good fascicular pattern was identified. Four cables of MABC graft, each 6 cm in length, were used to reconstruct the nerve injury using standard microsurgical technique and 9-0 Nylon suture.

The patient began to show signs of muscle reinnervation 8 months after surgery. Specifically, both thumb and finger extension began to return at this time. At 11 months of follow-up, the patient had regained excellent function of both thumb and finger extension, although they were still weak. In addition, his wrist still radially deviated with extension. Eighteen months after surgery, the patient had obtained 4/5 strength in his EDC, 4+/5 strength in thumb extension and abduction. At 23 months of follow-up, pinch and grip strength measured 30 and 105 lbs on the right versus 26 and 90 lbs on the left. He was very pleased with his recovery and was subsequently discharged from our care.

Case no. 2

This 38-year-old right-hand-dominant male ruptured his left biceps tendon 5 months earlier after incurring a stretching force to his elbow while trying to tag the ear of a calf. He underwent operative repair 2 weeks after his injury through a single incision approach. Postoperatively, the patient complained of weakness in the left hand with an inability to extend his fingers and thumb. After 3.5 months without clinical improvement, electromyographic and nerve conduction studies were obtained, and these were consistent with posterior interosseous nerve palsy. On our examina-

tion, the patient was noted to have no finger or thumb extension. There was no stiffness with full active and passive range of motion. His wrist extension was very weak compared to the right side. Pinch and grip strength were 21 and 118 lbs on the right versus 12 and 39 lbs on the left. Repeat electromyographic and nerve conduction studies at 5 months postoperatively demonstrated acute denervation of the EIP, EDC, and ECU without any motor unit potentials, all consistent with severe posterior interosseous nerve injury.

Operative Procedure

The patient's original incision was opened. Dissection proceeded in a manner as described previously. Again, located within a bed of heavy scar tissue formation, a large Ethibond suture that was used to reattach the biceps tendon was identified (Fig. 2). The nerve was severely contused proximally as it passed into the scar tissue, forming a large neuroma. A second incision, as described earlier, was used to dissect the distal portion of the posterior interosseous nerve and its terminal branches (Fig. 3). Both the proximal and distal ends of the nerve were dissected back to a normal fascicular pattern. A red rubber catheter was used to measure the distance between the nerve stumps prior to dividing the nerve. We then harvested the MABC through a third incision in the medial upper arm. A second red rubber catheter was used to tunnel the nerve graft deep to the skin bridge between the two incisions after the proximal coaptation was performed using standard microsurgical techniques (Fig. 4). The distal nerve coaptation was then performed, and the incisions were closed. The patient was admitted for 23-h observation and then discharged.

Figure 2 PIN neuroma. Note the large Ethibond stitch embedded in the neuroma.

Figure 3 **a** Intraoperative markings of the distal PIN approach. The “X” marks the lateral epicondyle. The incision is centered over a point 8–9 cm distal to the lateral epicondyle along the edge of the ulna. **b** The interval between the EDQ and the EDC muscle bellies. The main trunk of the PIN distal to the supinator is isolated by the vessel loop.

The patient returned to our clinic most recently, 8 months postoperatively for follow-up. Pinch and grip strength in the left hand was 29 and 90 lbs, compared to 30 and 120 lbs on the right. The patient demonstrated 4+/5 strength in wrist extension and 4/5 strength in finger extension, thumb extension, and thumb abduction. There was no radial deviation with wrist extension. He was very pleased with his result and has been instructed only to follow-up with our clinic as needed (Fig. 5).

Discussion

Rupture of the distal biceps tendon is rare, accounting for only 3% of biceps tendon ruptures [6]. Reattachment to the radial tuberosity can be a hazardous undertaking, however, because of the complexity of the anatomy. Early reports of biceps tendon repair through the anterolateral approach of Henry reported a high incidence of injury to the radial nerve, posterior interosseus nerve, and lateral antebrachial cutaneous nerve [4]. Because of this risk of radial nerve injury in the dissection around the radial

tuberosity, some authors have suggested reattaching the biceps tendon to alternate sites, including the brachialis tendon [4, 15]. The disadvantage of this operation is that the supination function of the biceps is not restored.

Figure 4 **a** One red rubber catheter is used to measure the distance between the proximal and distal PIN stumps. The other catheter is used to tunnel the nerve graft. **b** Proximal PIN to nerve graft coaptation. **c** Distal nerve graft to PIN coaptation.

Figure 5 **a** Postoperative photograph, 8-month follow-up. The patient has full range of motion in thumb extension with 4/5 strength. **b** The patient has 4/5 strength in finger extension. He has a persistent extensor lag in his index finger.

Others have recommended nonoperative management, arguing that elbow flexion still occurs with adequate strength through the brachialis muscle and that shoulder adduction along with internal rotation augments supination [3, 18]. Modern series suggest, however, that repair should be undertaken in active and healthy patients to achieve the optimum functional results [1, 5, 12, 14, 17]. In 1961, an alternate two-incision approach was described by Boyd and Anderson that avoids the PIN altogether and thus theoretically eliminates the risk of injury [2]. There have since been case reports of PIN palsy, however, utilizing this technique [10, 11, 16, 19]. In addition, there are other complications such as heterotopic ossification and radioulnar synostosis that may be associated with this approach [9, 11].

The patient with intraoperative radial nerve injury usually presents during their first postoperative visit with complaints of inability to extend the wrist, thumb, or

fingers, or weakened wrist extension with radial deviation. A waiting period of at least 6 weeks is indicated to allow for spontaneous recovery. If there is no improvement after this time period, electromyographic and nerve conduction studies should be obtained.

In both of our cases, the PIN was injured a few centimeters proximal to its arborization into the extrinsic extensor branches. Grossly, the zone of injury spanned at least 3 to 4 cm, and there was heavy scar tissue formation in the surrounding area. We present a new surgical approach to the distal PIN and its terminal motor branches that enables nerve graft reconstruction that would not otherwise be feasible. The anatomy has been studied in cadaveric dissections, and landmarks are described. We chose the medial antebrachial cutaneous nerve as our graft because of its excellent size match and location within the same extremity. It was easily harvested from an incision in the medial upper arm in the intermuscular groove, just anterior to the basilic vein.

The results of both of our cases are comparable to the functional results from tendon transfer operations. Wrist, finger, and thumb extension and thumb abduction were all restored with at least 4/5 MRC grade strength. Potential benefits of nerve graft reconstruction versus tendon transfers include an anatomic reconstruction and recovery of spontaneous function without the need for motor reeducation and cortical remapping. There is also no functional donor morbidity, and no additional incisions and scars are required distally on the hand and wrist with the potential for stiffness and altered biomechanics. If functional recovery is suboptimal, then tendon transfers can always be performed selectively to improve function where needed.

Despite early reports of PIN palsy after the single-incision anterolateral approach of Henry, larger and more recent series of biceps tendon repairs have much lower incidences of injury. In a series of 53 patients, McKee et al. reported only one PIN palsy that resolved in 6 weeks [14]. Most importantly, there were no cases of permanent nerve injury. Another series of 13 patients by Louis, et al. reported no cases of PIN injury [13]. While we cannot advocate one operative approach to biceps tendon repair versus another, we do agree with the assessment of both authors that identification of the radial nerve and its branches is most important in protecting it from injury. At the very least, if the radial nerve and its PIN branch are identified intraoperatively, the incidence of injury to these important structures can theoretically be minimized. In heavily scarred forearms where dissection proves to be too difficult, consideration should be given to biceps tendon reattachment to the brachialis [4, 15]. Although the functional result may be suboptimal with regard to supination, elbow flexion strength will improve and disabling PIN injury can be avoided.

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