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Options for Restoring Finger Extension in Mangled Forearm Injuries

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Restoration of finger extension in mutilating hand injuries is crucial for restoring prehension and independent use of the hand. Patients often express desire to restore finger extension once finger flexion is achieved. However, the extensive forearm injury precludes use of any of conventional donors like the wrist or finger flexors for transfer to restore finger extension. Two patients with sequelae of mangled forearm injuries, underwent biceps and long head of triceps transfer to the finger extensors to improve opening up of the fingers. We discuss the treatment considerations while planning these transfers and provide the technical details, rehabilitation and outcome of these patients. Both the patients expressed dramatic improvement of their hand function and were satisfied with the outcome. Biceps and long head of triceps could serve as an effective second-line donor for restoration of finger extension when the conventional donors are not available.

Level of Evidence: Level V (Therapeutic)

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INTRODUCTION

In severe crush injuries of the forearm, like most other complex upper limb problems, the initial emphasis is on achieving finger flexion; however, for effective prehension, finger extension is also essential. Severe crush injury to the muscles locally precludes the use of any of the conventional donors[1] (wrist or finger flexors) for finger extension. In such situations, we have used the biceps and triceps brachii extended with fascia lata graft to restore finger extension in two patients. Both patients attained useful finger extension and were able to use their hand independently and as a superior support to the uninjured hand. Herein, we present the considerations while planning the surgery, technical details and outcome of these tendon transfer options for restoring finger extension.

CASE REPORTS

Two patients with mangled proximal forearm injuries with loss of entire extensor muscle mass and severe crushing of the flexor muscle mass are presented; both underwent debridement, skeletal stabilisation, en-mass repair of the flexors, revascularisation of the hand and later abdominal flap cover of the raw areas. Total loss of extensor muscles precluded extensor tendon repair. Both underwent multiple staged reconstructive procedures with last of them being restoration of finger extension as detailed below. Both lacked all the conventional donors for finger extension like the wrist and finger flexors (Fig. 1). However, the elbow flexion and extension power were MRC grade greater than or equal to 4 providing us the option of reconstruction.

Case 1 – Biceps Brachii to Extensor Digitorum Transfer: At 6-months post injury, this 45 years, right-hand dominant gentleman had reasonably good finger flexion and was happy with the outcome. However, he desired finger extension as he was unable to open-up the fingers for grasping any object. The options considered for finger extension transfer included pedicled latissimus dorsi, biceps/brachialis extended with fascia lata graft and free functioning muscle transfer. With the experience of the outcomes achieved by transfer of biceps to finger flexors in cases of brachial plexus injuries, the authors chose to transfer the biceps to the finger extensors.

An S-shaped incision was made across the elbow and the biceps tendon was divided closer to its insertion. It was extended with fascia lata graft measuring 20 cm. The graft was tunnelled under the flap over the dorsum of forearm, crossing the elbow on the volar aspect and then weaved with Pulvertaft sutures into the finger extensors with the elbow fully extended, wrist extended to 30°, metacarpophalangeal (MCP) joints in full extension and interphalangeal (IP) joints in complete flexion. The transfer was tensioned in such a way that with elbow extension, the fingers attained extension at the MCP joint and with elbow flexion they fell into flexion, with full passive flexion of fingers possible when the elbow was flexed.

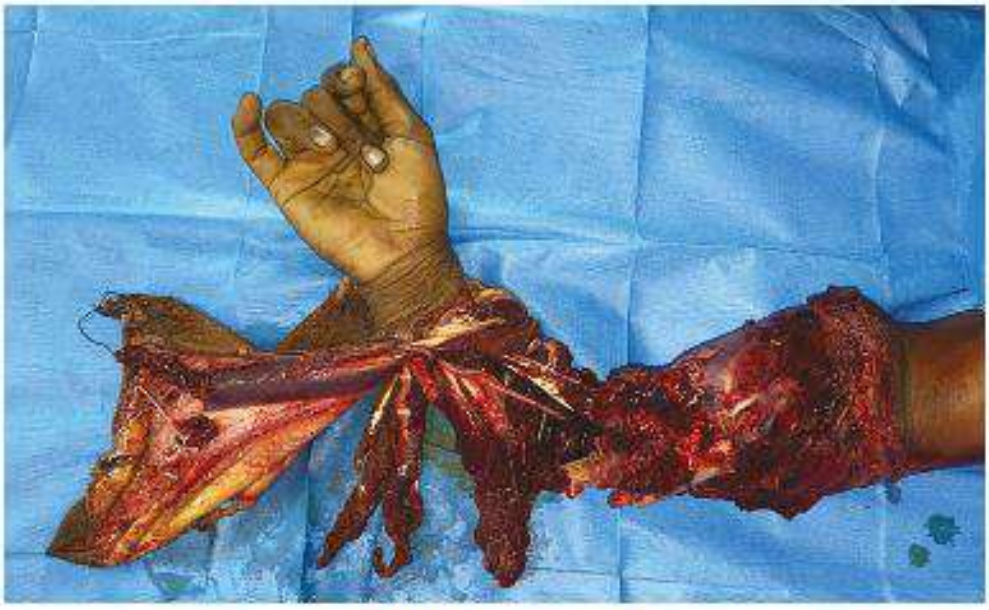

Fig. 1. Severe crush injury of the forearm muscles required their removal in the primary surgery and did not spare any potential donor for future reconstruction.

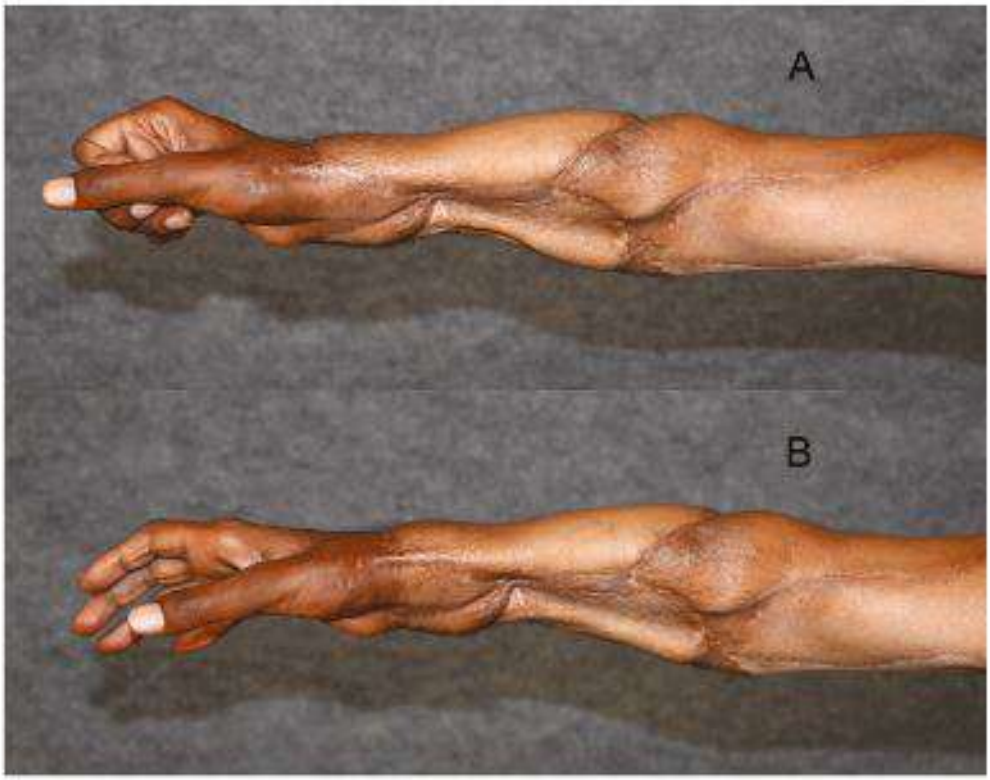

Fig. 2. Outcome of the biceps to finger extensor transfer at 8 months (A&B).

Strong repairs were performed to allow early active mobilisation (Fig. 2).

Case 2 – Triceps Brachii to Extensor Digitorum Transfer: At 9-months post injury, this 18-year-old, right-handed male, had satisfactory finger flexion but totally lacked finger extension which precluded any opening up of the hand for independent use. The skin graft over the volar aspect of the distal arm and elbow precluded the use of biceps brachii as a donor. Triceps brachii was the stand-alone regional muscle that was available for transfer with MRC grade 5. Hence, it was decided to use the long head of triceps for transfer while leaving the lateral and medial head in place to continue to act as elbow extensor.

A midline incision was made along the posterior aspect of the arm. The long head of the triceps muscle was dissected out proximally and separated from the medial and lateral heads. Distally, its tendon continuation was harvested as a central slit (2 cm wide) from the broad combined triceps tendon to the insertion site. The tendon tissue on the either side of the harvested central slit was then approximated to close the gap and repaired with 3-0 prolene. Triceps long head was extended by weaving fascia lata graft of 20 cm. The graft was then tunnelled to bring it anterior to elbow joint while passing it along the lateral aspect of the distal humerus in the subcutaneous fat plane. It was then passed under the mobile wad muscles to the dorsum of the forearm. The mobile wad muscles maintained the transfer anterior to the elbow joint axis (Fig. 3). The distal end of the fascia lata graft was then weaved into the digital extensor tendons while keeping the elbow in full extension; MCP joints in full extension and IP joints in full flexion. The adequate tension was confirmed by observing that the fingers extending well at the MCP joint with elbow in full extension and falling into flexion with elbow flexion with full passive flexion of the fingers possible when the elbow is flexed to 90° **(Video 1)**. Strong repairs were performed to allow early active mobilisation of the transfer.

Rehabilitation: After surgery, patients were given an above elbow plaster with elbow flexed to 90°, with wrist in 20° extension, MCP joints flexed 45° and IP joints in full extension. Both the patients were changed to a dynamic elbow brace to allow early mobilisation on the second postoperative day to prevent adhesion of the facia lata.

The first patient was advised to do two exercises. First, he was asked to do active elbow extension from 90° to 30° of flexion. This induced a tenodesis effect and produced finger extension as the transfer crossed the elbow on the volar side. The second exercise was done by keeping the

Fig. 3. The route used for transfer of triceps to finger extensor with the fascia lata autograft.

elbow flexed to 45° and asking the patient to actively contract the biceps without flexing the elbow and produce finger extension.

The second patient was instructed to actively extend the elbow by contracting the triceps and observe the resulting finger extension. Since the transfer traversed volar to the elbow joint axis, extension of the elbow also produced a passive tenodesis, supplementing the active finger extension produced by the triceps transfer itself.

Active and assisted active movements were done to encourage to reach full finger extension. At 4 weeks, the splints were removed, and the patients were asked to continue the exercises without any splints. They were encouraged to use their hands for picking up objects of various sizes and shapes by actively opening the fingers, and by 4 months post surgery, they were able to do this comfortably.

Both the transfers were able to fully extend the MCP joints in these patients with grade 3 power of finger extension. Although it took approximately 4 months for both patients to comfortably extend their fingers, they were both able to use the reconstructed hand for their daily routines and expressed immense satisfaction with the achieved results, considering the nature of their respective injuries. Both patients learnt to dissociate the elbow and the finger motion enabling them to extend the fingers irrespective of the position of the elbow. There was no reduction in the power of elbow flexion and extension in either of patient.

DISCUSSION

Restoring finger extension is crucial for restoring prehension and independent hand use. Given the unavailability of conventional donors in the forearm, our exploration extended proximally to the arm and above. The considered options included free functioning gracilis,[2] latissimus dorsi extended with fascia lata graft,[3] brachialis[4] and triceps long head. While feasibility of the transfer of the biceps brachii to the finger extensors was studied only in a cadaver,[5] the transfer of triceps brachii had a cadaveric study and was used in one patient.[6] Those authors had to use a separate incision on the anterior aspect of the elbow to isolate the lacertus fibrosus to be used a pulley when the graft was tunnelled from the posterior to the anterior aspect. In our case, the previous injury precluded the use of such pulleys. Moreover, we feel that the mobile wad provides a sturdier and more spacious pulley than the lacertus fibrosus. The primary goal is to allow the transfer to pass through the anterior aspect of the elbow so that the tenodesis effect of elbow movement can support the transfer, i.e. with elbow extension, the fingers would extend. This makes the training easy as the patients are trained to do an active elbow extension to power the

transfer and with the same movement the tenodesis effect also produces finger extension. Adding the tenodesis also increases the excursion of the transfer. From our experience with these two transfers, we found that the triceps long head transfer was much easier to rehabilitate.

Biceps and long head of triceps could serve as an effective second-line donor for restoration of finger extension when the conventional donors are not available because of the severe injury to the forearm. Restoring finger extension must be part of the overall plan for staged reconstruction in such complex injuries as it dramatically improves the ability to use the hand independently and improves prehension.

DECLARATIONS

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Supplementary File: The supplementary files for this manuscript (listed as follows) are online only and can be accessed at http://www.worldscientific.com/doi/suppl/10.1142/S2424835524710012

Video 1: Appropriate tensioning of the triceps to finger extensors transfer – the fingers remain flexed when the elbow is flexed and open-up with elbow extension with the long-term outcome.