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Early total reconstruction for a Gustilo type IIIB open forearm fracture associated with avulsion injury of multiple extensor tendons: A case report

Shuya Nohmi [a,*], Masahiro Suzuki [b], Yukiko Sakamoto [b], Ryo Nakano [b], Hikaru Kamada [c]

[a] Department of Orthopaedic Surgery, Misawa City Hospital, 164-65 Horiguchi, Misawa, Misawa-shi, Aomori 033-0022, Japan
[b] Department of Orthopaedic Surgery, Towada City Central Hospital, 14-8 Nishi12-bancho, Towada-shi, Aomori 034-0093, Japan
[c] Department of Orthopaedic Surgery, Hachinohe City Hospital, 3-1-1 Tamukai, Hachinohe-shi, Aomori 031-8555, Japan

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ABSTRACT

Gustilo type IIIB open forearm fractures associated with avulsion injuries of multiple extensor tendons are difficult to reconstruct. Not only are bones, nerves, blood vessels, and soft tissues injured, but also tendons directly related to hand function.

A 74-year-old man sustained an injury to his dominant right hand after being hit by a heavy pulley. The patient was diagnosed with a Gustilo type IIIB open forearm fracture, and multiple extensor tendons were avulsed from the musculotendinous junction. On the day of injury, the radius was fixed using a volar locking plate, and the ulnar head was fixed to the radius. On the fourth day, the avulsed extensor tendons were reconstructed using tendon transfer, and the exposed tendons and soft tissue defects were covered using a free anterolateral thigh flap on the seventh day. Three years after the injury, the patient had no difficulty in performing activities of daily living.

Single-stage reconstruction allows for early rehabilitation. We believe that the more complex and severe the injury is, the more we should aim to repair the injured tissue as early as possible, that is, early total reconstruction.

Introduction

The treatment of Gustilo type IIIB [1] open forearm fractures differs from that of open fractures in other parts because not only are bones, nerves, blood vessels, and soft tissues injured, but often also tendons directly related to hand function. There is little problem if the injured tendons can be sutured end-to-end and covered with healthy soft tissue. However, if the stump of the tendons is crushed or avulsed from the musculotendinous junction and exposed, end-to-end direct repair is not possible, and the exposed tendons must be covered with healthy soft tissue. In such cases, other methods to restore tendon function and reconstruct the soft tissue must be applied. However, the method of restoring tendon function (tendon transfer or tendon grafting), optimal timing of tendon reconstructive surgery (primary or secondary), soft tissue reconstruction (skin grafting or flap), and flap selection (pedicled or free) are controversial.

Herein, we present a case of a Gustilo type IIIB open forearm fracture associated with avulsion injury of multiple extensor tendons

* Corresponding author.
E-mail address: gsybm634@ybb.ne.jp (S. Nohmi).

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treated with early total reconstruction, wherein bony fixation, tendon transfer, and free flap coverage were performed almost simultaneously.

Case presentation

A 74-year-old man with hypertension and diabetes mellitus was admitted to the emergency department. He injured his dominant right hand after being hit by a 40 kg pulley while working on a ship. On admission, the patient complained of severe pain in his right distal forearm, and an open wound extending three-quarters around the distal forearm was confirmed (Fig. 1A). Capillary refilling of the fingers of the injured limb was normal, and the patient was able to flex his fingers actively but could not extend them. Injured extensor muscles and ruptured blood vessels were exposed through an open wound. Preoperative radiographs and three-dimensional computed tomography images of the right forearm revealed radial and ulnar fractures in the distal forearm and disruption of the ulnar artery (Fig. 1B).

Emergency surgery was performed on the day of injury. Debridement and identification of injured tissues were performed first. At the volar side of the forearm, the tendons of the flexor digitorum superficialis 3 and 4 and flexor carpi ulnaris (FCU) were ruptured along with the ulnar artery (Fig. 2A). On the dorsal side, the tendons, except for the extensor carpi ulnaris (ECU), were avulsed from the musculotendinous junction, and the cephalic vein was ruptured (Fig. 2B). Continuity of the ulnar nerve and superficial branch of the radial nerve was confirmed. After debridement, the radius was fixed using a volar locking plate, and the Sauvé-Kapandji procedure [2] was performed in which the proximal stump of the distal ulnar fragment was resected and the ulnar head was fixed to the radius using a headless screw and a stainless-steel wire (Fig. 2C). The FCU tendon was then repaired end-to-end, and the ulnar artery and cephalic vein were anastomosed end-to-end. The avulsed extensor tendons were left untreated at the initial surgery, and the debrided open wound was covered using a negative-pressure wound therapy (NPWT) device. Postoperatively, the patient could not actively dorsiflex his right wrist joint, and we decided to reconstruct not only finger extension but also dorsiflexion of his wrist joint. Tendon transfer was performed on the fourth postoperative day. The pronator teres was transferred to the extensor carpi radialis brevis, the palmaris longus to the extensor pollicis longus, and the flexor carpi radialis to the extensor digitorum communis [3]. On the seventh day, free anterolateral thigh flap (ALT) reconstruction was performed (Fig. 3A–C). The descending branch of the lateral circumflex femoral artery (LCFA) was anastomosed end-to-side to the radial artery, and one of the two concomitant veins of the LCFA was anastomosed end-to-end to the concomitant vein of the radial artery and the other end-to-side to the repaired cephalic vein.

Postoperatively, the flap was successfully engrafted, and a planned exercise program was initiated four weeks after immobilization for tendon transfer surgery. At the 3-year follow-up, the Disabilities of the Arm, Shoulder and Hand score [4] was 10.8. The patient retired from his original job but had no complaints regarding activities of daily living (Fig. 4A and B).

Discussion

We report the case of a 74-year-old man who was successfully treated using early total reconstruction, wherein bony fixation, tendon transfer, and free flap reconstruction were performed almost simultaneously, for a severe open fracture of the forearm associated with avulsion injuries of multiple extensor tendons.

Forearm injuries are often associated with tendon injuries that are directly related to hand function. In cases of avulsion injury at the musculotendinous junction, direct repair is often difficult. Collins et al. [5] proposed treatment algorithms for avulsion injuries of the tendons at the musculotendinous junction. The authors recommended tendon transfer or side-to-side repair. However, in our case, side-to-side repair could not be performed because multiple extensor tendons, except for the ECU tendon, were avulsed, and the ECU tendon, which showed no avulsion injury on visual inspection, was also not functional. Izawa et al. [6] reported a pull-in suture for tendon avulsion injuries at the musculotendinous junction that showed good functional results. However, in our case, large exposure was required to identify and pull the extensor tendons into the proximal muscle bellies. Therefore, we performed tendon transfer

Fig. 1. Preoperative images of the right forearm on the day of injury. (A) A photograph showing an open wound extending three-quarters around the distal forearm. (B) Preoperative radiographs and three-dimensional computed tomography images of the right forearm showing radial and ulnar fractures in the distal forearm and a disruption of the ulnar artery.

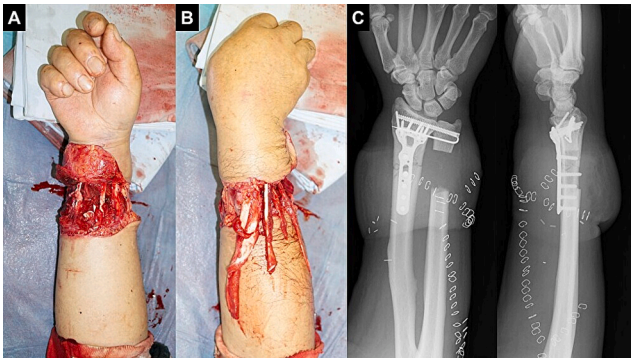

Fig. 2. Intra- and postoperative images during the initial surgery. (A) At the volar side of the right forearm, the tendons of the flexor digitorum superficialis 3 and 4 and flexor carpi ulnaris are ruptured along with the ulnar artery. (B) On the dorsal side, the tendons, except for the extensor carpi ulnaris, are avulsed from the musculotendinous junction, and the cephalic vein is ruptured. (C) Postoperative radiographs after bony fixation.

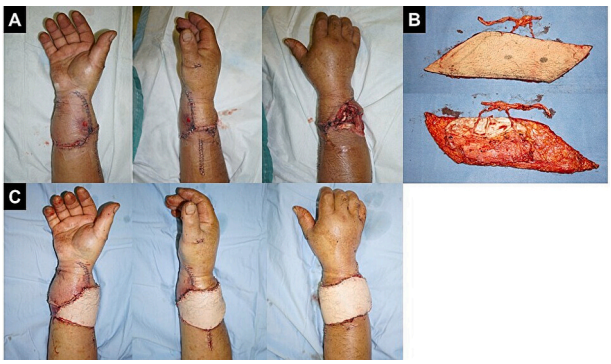

Fig. 3. Images obtained during flap surgery. (A) The transferred tendons are exposed through an open wound. (B) A free anterolateral thigh (ALT) flap is elevated. (C). The exposed tendons and defect are covered with a free ALT flap.

Fig. 4. Follow-up clinical images at three years postoperatively. Range of motion of (A) the wrist joint and forearm, and (B) right hand.

instead.

Regarding the optimal timing of reconstructive surgery, immediate reconstruction reportedly allows for a faster recovery to the range of motion, fewer operations, and a greater chance of returning to work [7]. The obvious advantages of a single-stage technique include the ability to initiate rehabilitation earlier. We believe that the more complex and severe the injury is, the more we should aim to repair the injured tissue as early as possible, that is, early total reconstruction.

To restore hand function, soft tissue reconstruction that allows for early rehabilitation and tendon gliding as well as tendon surgery is essential. In our case, skin grafting was inappropriate because the transferred tendons were exposed, and when the skin graft was applied, tendon gliding was inhibited due to adhesion to the grafted skin. It must be noted that we used an NPWT device after initial debridement to prevent nosocomial infections [8] rather than to increase granulation tissue for skin grafting. Pedicled or distant flaps

are also not indicated because of the size and location of the defect, and these flaps are disadvantageous for early range of motion exercises not only for the hand but also for the elbow and shoulder joints. In the present case, we selected a free ALT flap to cover the exposed tendon and defect because of its low bulkiness and large size. Postoperatively, the patient was unable to return to his original job but had no difficulty in performing activities of daily living with relatively good hand function.

Conclusion

A Gustilo type IIIB open forearm fracture associated with avulsion injury of multiple extensor tendons was treated with early total reconstruction, wherein bony fixation, tendon transfer, and free flap coverage were performed almost simultaneously. The more complex and severe the injury is, the more we should aim to repair the injured tissue as early as possible.

Consent

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images. A copy of the written consent form is available for review by the Editor-in-chief of this journal upon request.

Source funding

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Ethical approval

The Ethics Committee of the Misawa City Hospital, to which the author belongs, does not require ethics review for case reports of medical procedures performed within the normal scope of care if written consent is obtained from the individual patient.

Guarantor

The guarantor for the present case report is Shuya Nohmi.

CRediT authorship contribution statement

Shuya Nohmi: Conceptualization, Writing – original draft. **Masahiro Suzuki:** Writing – review & editing. **Yukiko Sakamoto:** Writing – review & editing. **Ryo Nakano:** Investigation. **Hikaru Kamada:** Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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