Case Report

Outcomes of Tendon Transfer Surgery for Correction of Ulnar Claw Hand: A Case Series

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This case series presents detailed postoperative physiotherapeutic rehabilitation and functional outcomes of 3 patients following tendon transfer surgery for the correction of claw hand due to traumatic nerve injury. Three patients with different etiologies of claw hand and sociodemographic characteristics presented to the hand therapy center after claw correction surgery. Two patients underwent flexor digitorum superficialis 4-tail tendon transfer, and 1 patient underwent the Zancolli lasso procedure. Hand therapy began after 4 weeks of appropriate postoperative immobilization. It began with the activation and strengthening of the new muscle-tendon unit and its integration into functional activities. All patients returned to work 12 weeks after surgery, followed by an assessment of outcomes at 16 weeks. Satisfactory improvements in the functional outcomes based on the Brand criteria, the Patient-Rated Wrist and Hand Evaluation, and the Patient-Specific Functional Scale were observed in all patients at 16 weeks.

Clawing of fingers occurs because of ulnar nerve palsy. The biomechanics of making a fist is altered because of force imbalance, as shown in Figure 1.1 Surgical correction aims to restore the balance between overactive extrinsic muscles and weak intrinsic muscles. Many static and dynamic reconstructive tendon transfer surgeries have shown good results with improvement in functional deficits.2,3

Planned management with interdisciplinary teamwork, adherence to precautions, and postoperative rehabilitation are essential to achieve good outcomes. There is a lack of literature regarding the systematically planned postoperative management of patients after flexor digitorum superficialis (FDS) tendon transfer surgery for the correction of claw hand.

Our case series presents the detailed postoperative management of 3 patients with different etiologies of ulnar nerve palsy, involved in different occupations with different levels of skill demand and their functional outcomes 16 weeks after surgery.

Case Report

Three patients (A, B, and C) with claw deformity following traumatic upper limb injury were managed at the hand therapy center of a tertiary care hospital after tendon transfer surgery. These patients presented with residual ulnar nerve palsy after treatment elsewhere. Table 1 describes their health status and impairments.4 Written informed consent was obtained from the patients for using their hand images and information for research and educational use. Patient A complained of difficulty in precision activities such as writing, making morsels of Indian bread or rice, taking the morsel to the mouth, and power-grip activities, such as holding a broom and making a full fist. Patient B, 2.5 years after injury, complained of pain in the ulnar aspect of the hand at rest and during activities such as grooming, household, and farming. Patient C had a brachial plexus injury that was managed...
conservatively and had recovery in the axillary, musculocutaneous, radial, median, and ulnar nerves up to the forearm; the patient had difficulty using his hand in all activities of daily living.

There was a complete claw hand (Fig. 2), with a flexion contracture at the proximal interphalangeal (PIP) joint of 30° in the ring finger and 20° in the little finger. This contracture was corrected to 15° in the ring and 0° in the little finger by preoperative hand therapy. Rigid static orthosis fabrication with plaster of Paris cast (finger cylinder cast) was applied by giving 3-point pressure to the ring and middle fingers such that the PIP joint was stretched according to the patient’s tolerance. This rigid, static orthosis fabrication produced continuous stretching of the soft tissues at the PIP joint level and was changed every 24 hours. Before reaplication of the plaster cast, active and passive mobility exercises and passive stretching exercises were continued. Paraffin wax bath, a superficial heating modality (temperature checked with the unaffected hand and then applied on the affected hand to prevent injury because of heat), and ultrasound therapy, a deep heating modality (frequency 3 MHz, intensity 1 W/cm², and duration 7 minutes) at the PIP joint of the ring finger, were used to make the hand supple. Maitland mobilization (anteroposterior glide) and prolonged stretching of the PIP joint in extension were performed, followed by strengthening of the extensor digitorum communis (EDC) to improve the active range of motion of the PIP joint.

**Surgical procedure**

-FDS 4-tail transfer

The surgery was performed under the axillary block with a tourniquet application at the arm. Longitudinal incisions were marked on the radial side of the little, ring, and middle fingers and on the ulnar side of the index finger just dorsal to the midlateral line.
and over the middle 2 quarters of the proximal phalanx to access the extensor expansion (Fig. 3A). A transverse incision was made just proximal to the PIP joint crease of the middle finger to withdraw the donor FDS tendon. A second transverse incision was made just proximal to the distal palmar crease, the skin was retracted, and the FDS tendon was identified. Two slips of FDS tendons were withdrawn through these incisions (Fig. 3B). This tendon was split longitudinally into 4 equal tails (Fig. 3C). Extensor expansion was identified at the proximal phalanx through the longitudinal incision (Fig. 3D). A tunneller was passed proximally along the edge of the lateral band through the lumbrical canal anterior to the deep, transverse metacarpal ligament until it reached the palmar incision. The FDS tendon slip was grasped and withdrawn through the lumbrical canal (Fig. 3E). The graft was then sutured to the lateral band of the extensor expansion of each finger with appropriate tension (Fig. 3F). Tension was adjusted the wrist in 10°–20° of flexion, MCP joint at 90° of flexion, and IP joint extension (Fig. 3G). Next, the index finger slip was pulled until movement was discernible on the suture placed on the little finger, and the index finger was fixed at that tension. The middle and ring finger tension was intermediate to these two. In the end, the cascade was tested, and any excess or shortfall was readjusted before closure. The hand was splinted in a plaster cast, with the wrist at 10°–20° of flexion, MCP joint at 90° of flexion, and IP joint extension (Fig. 3H). The transferred FDS mimics the paralyzed intrinsic muscles in their course of action and function as their substitute to cause MCP joint flexion and IP joint extension. This tendon transfer was performed for all 4 fingers of patients A and B.

**Zancolli lasso procedure**

An axillary block was administered, and a tourniquet was fixed on the right arm. An oblique incision was made on the proximal phalanx of the right ring finger to identify the FDS and flexor digitorum profundus (FDP) tendons. Patient C also had median nerve palsy. Thus, the FDS of the ring finger was used as a donor to preserve

**Figure 2.** Preoperative images of a patient C. A Complete claw in open hand position. B Intrinsic minus hand, lumbrical position. C Thumb to index finger opposition.

**Figure 3.** FDS 4-tail transfer surgery. A Marking of the longitudinal incision over the proximal phalanx. B Donor FDS tendon through a transverse incision just proximal to the distal palmar crease. C FDS tendon split into 4 tails. D Exploration of the extensor expansion. E FDS tendon slips in extensor expansion. F Tension adjustment. G Sutured FDS slip to lateral band. H Plaster of Paris cast, with wrist at 10°–20° flexion, MCP joint at 90° flexion, and IP joint extension.
the strength of the middle finger, power grip, and hand function. Two slips of FDS were isolated around the FDP and were cut. A longitudinal incision was made over the proximal palm, and the FDS of the ring finger was identified and brought out through the incision. The FDS was split into 4 slips, 1 for each finger (Fig. 4A). A transverse incision was made along the distal palmar crease, and dissection was continued until the A1 pulleys were visualized. A parallel subcutaneous tunnel was made between these 2 incisions. The 4 tendon slips were passed through the subcutaneous tunnel from the proximal and the distal incisions on the palm (Fig. 4B). Once the tendon slips were brought out through the distal palmar crease incision, they were manipulated into passing through the A1 pulley of each finger and sutured back onto themselves forming a lasso (Fig. 4C), keeping the hand in the proper cascade. The tension was adjusted in the same way as in an FDS 4-tail transfer. The slips were sutured using 4-0 ethilon. All incisions were closed. The dressing was performed, and the hand splinted with the wrist in 10°–20° flexion, MCP joints were flexed to 90°, and IP joints were extended.

Patients A and B were operated on by a senior and experienced plastic and reconstructive hand surgeon (M.R.T.) having more than 35 years of experience at a private multispecialty tertiary care hospital situated in Mumbai, India. Patient C was operated on by a young plastic and reconstructive hand surgeon (A.D.S.) at an academic, government multispecialty tertiary care hospital in the metropolitan city of Mumbai. The Zancolli lasso procedure was the surgeon’s preference for patient C because it is a relatively simple procedure.

Postoperative management

Immobilization (4 weeks)

After surgery, the hand was immobilized in a cast with the wrist 10°–20° flexed, MCP joint 90° flexed, and the IP joints extended.

Activation of new muscle–tendon unit (4–6 weeks)

Dorsal blocking orthosis with the wrist in neutral, MCP joint 90° flexed, and IP joint extended was used as night orthosis (Fig. 5A). Dorsal wrist neutral orthosis with free MCP joints (Fig. 5B) was used during the day to protect the coaptation of the transferred tendon.

The IP joints were maintained in neutral using a finger cylinder cast (Fig. 5C) to prevent clawing (as mentioned above). Because of the absence of intrinsic muscles, their function at the IP joints was performed by the newly coapted slip of FDS (used to power extensor expansion at the lateral hand) in the 4-tail transfer. For the lasso procedure, an extension at the IP joints was performed only by the EDC. Prevention of MCP joint extension was accomplished by both tendon transfer procedures, as the donor was sutured under tension. The IP joint extension was trained by inhibiting the force of the EDC at the MCP joint (blocking the MCP joint in flexion) and transferring the force to the IP joint for extension (Fig. 5D). Patients were asked to flex and extend the MCP joints as the finger cast maintained the IP joint extension, simulating intrinsic plus hand position (Fig. 6A). Patients were taught to actively maintain an open hand (wrist neutral, MCP joint neutral, and IP joint extended) and lumbrical position (MCP joint 90° flexed, IP joint extended) (Fig. 6C). Active adduction of the fingers was performed within the orthosis with IP joint extension.

The finger cylinder cast was discontinued when patients could maintain IP joint extension without assistance (no latent clawing). A precaution to be taken after removing the wrist and finger restraints was avoiding wrist and MCP joint extension to protect the transferred tendon from being stretched. The use of hand in daily activities was avoided for 12 weeks.

Strengthening of the transferred muscle (6–8 weeks)

Strengthening of the extensor expansion (powered by the transferred muscle) was started by applying resistance during IP joint extension with MCP joint at 90° of flexion. Extension of PIP and distal interphalangeal (DIP) joints (tendon blocking) was also performed with the hand placed on the table and by blocking the segment proximal to the joint (Fig. 6D). The strengthening protocol was progressed using a resistance loop, therapy putty with variation in the MCP joint flexion angle (Fig. 6C, H). Patients were asked to repeat exercises several times throughout the day to prevent fatigue.

Once the extensor expansion was able to maintain the IP joints in extension during MCP joint flexion, training to make a fist began by flexing the MCP joint before the IP joint began to flex.

Active range of motion (ROM) exercises and gentle activities, such as paper crumpling and rolling a cloth, were performed to improve ROM (Fig. 6E, F). It would have been difficult for the donor finger to flex at the PIP joint. Hence, the FDP was trained to perform the FDS action, that is, PIP joint flexion with the DIP joint held in extension.

Maintaining the balance between the strength of long flexors and extensors is crucial because fingers may fall or rest in flexion
after grasping exercises. Long flexors are stronger than the EDC, as EDC is in a stretched position because of claw deformity. Exercises were planned such that the strengthening of flexors was followed by extension exercises to maintain the tone of the EDC.

**Use of hand in functional activities and return to work after 12 weeks**

The strengthening of flexors, extensors, and thenar muscles was performed with resisted exercises to improve the grip strength. Simulated work activities were started gradually depending on the strength and skill required to perform the task.2,5

This protocol was followed for all patients. Patients visited the therapist on alternate days during the fifth and sixth weeks after surgery. Patient A visited twice a week thereafter till 12 weeks. Patients B and C received telehealthtrim till 12 weeks after surgery because they went to their native place 6 weeks after surgery. Plaster cylinders for all fingers were required and were applied till the sixth week for patients A and C and till the fifth week for patient B. For patient C, vigorous stretching of the PIP joint

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Figure 5. Orthoses used after the surgery. A Dorsal blocking orthosis wrist is neutral, MCP joints are 90° flexed, and IP joints are extended. B Dorsal blocking orthosis wrist is neutral and MCP and IP joints are free (day orthosis). C Plaster of Paris finger cylinder.

Figure 6. Exercises. A Activation of the EDC by blocking the MCP joint at 90° flexion. B Lumbrical position to train the MCP joint flexion and extension as IP joints are extended with the help of a finger cylinder cast. C Open hand and intrinsic plus position without assistance. D Isolated strengthening of the EDC at the PIP joint by blocking (blue arrow) the finger at the proximal phalanx (similarly, isolated strengthening of the EDC at the DIP joint is performed by the extension of the DIP joint while blocking the middle phalanx). E Active ROM exercise with a cloth. F Newspaper crumpling; a piece of newspaper is held with both hands, affected hand is placed at one end of the paper and the other hand holds the diagonally opposite end. Both upper limbs are supported. The patient is asked to crumple the paper with the affected hand without losing contact as per the directions shown by the arrow. This mass action is to be continued till the paper softens. G Strengthening of the EDC with a resistance loop; avoid hyperextension at the MCP joint. H Exercises with theraputty; holding the putty with the IP joints extended. The same action is performed with a book or cardboard.
of the ring and little fingers was needed because of preoperative joint stiffness. Before the reapplication of the plaster cast, active and passive mobility exercise, PIP joint stretching, and strengthening of the EDC were performed for all patients. To prevent stiffness in patient C, active ROM exercises and PIP joint stretching were emphasized.

Results

The patients were assessed by the surgeons (M.R.T. and A.D.S.) for the assisted angle of all 4 fingers before surgery and at 16 weeks after surgery (Table 2). In patient A, the ring and little fingers had an assisted angle of 20°, completely corrected 16 weeks after surgery. In patient B, the little finger had an assisted angle of 5° that was also completely corrected by 16 weeks after surgery. In patient C, the index and middle finger had assisted angle of 10°, which was reduced to 0°; further, assisted angle of 45° (contracture angle 30°) in the ring finger was reduced to 15°, and assisted angle of 40° (contracture angle 20°) in the little finger was reduced to 5° (contracture angle 0°) 16 weeks after surgery. The contracture of 15° persisted in the ring finger even after hand therapy treatment.

The functional assessment of the hand for 3 basic maneuvers was performed using the Brand criteria. Open hand, the closed fist position, and mechanism of closing were graded as poor, fair, good, and excellent. For open hand function before surgery, all patients were graded as poor. After surgery, patients A and B were graded as excellent and patient C was graded as good. For closed fist function before surgery, all patients were graded as good. After surgery, they were graded as excellent. For the mechanism of closing before surgery, patients A and B were graded as fair and patient C was graded as good. After surgery, all patients were graded excellent. Figure 7 shows the postoperative images with an open hand and intrinsic plus position at 4 and 12 weeks. The grades of individual patients are described in Table 2. All patients returned to work after 12 weeks.

Table 3 shows patient-rated outcome measures, which were assessed as a recall of preoperative status on the first visit to the hand therapist and at 16 weeks after surgery (via video calling). The cross-culturally adapted Hindi version of Patient-Rated Wrist/Hand Evaluation is a 15-item questionnaire measuring pain (5 items) and function (10 items). Patients were asked to rate pain and difficulty in function on a scale of 0–10. The pain and function subscale score ranges from 0 (worst score) to 50 (best score) each, making a total score of 0–100. The lesser the score, the lesser the disability. All patients reported improvement in function subscale and total score, as shown in Table 3.

Patient-Specific Functional Scale is a self-reported outcome measure that evaluates the 5 most difficult activities according to patients on a scale of 0–10. A score of zero indicates that the patient is unable to perform an activity, and a score of 10 indicates that the patient can perform an activity at a preinjury level. The higher the score, lesser the disability. There was an improvement in straightening the fingers lifting round objects and cupping the hand to some extent in all patients. However, there was no improvement in the activity of eating rice with the involved hand in all patients (Table 3).

Patient A continued craft activities with modifications but changed his job from carpenter to light motor vehicle driver because of a weak grip. He still has difficulty eating rice with his right hand and adducting his fingers. Drawing and writing activities (pulp–to-pulp prehension) were limited because of weak thenar muscles and absent adductor pollicis, leading to difficulty in holding a pen. A swollen neck deformity developed in the middle finger (FDS donor) because of hyperactivity of FDP at the DIP joint in the absence of FDS. Patient B reported 60% improvement in grooming and household activities. She currently complains of difficulty in forceful grasping activities such as wringing clothes, farming activities, weakness while lifting heavy objects weighing more than 5 kg, and difficulty adducting the fingers. Patient C resumed his work, including lifting light weights and gentle grasping activities.

Discussion

All patients could achieve IP joint extension, intrinsic plus position, and full fist with normal movement patterns. Patients were able to actively make cylindrical, spherical, and hook grips. All of them have successfully returned to work. All 3 patients had difficulty eating rice with their hands, which is an important method for having a meal in the Indian culture. The coning of the hand in which all fingers and thumb have pulp-to-pulp pinch to grasp a morsel of rice was affected because of intrinsic minus hand. With the correction of clawing, this impairment was corrected to some extent in our patients. Because of poor adduction of fingers even after tendon transfer and the absence of adductor pollicis, this grasp is still weak. Grip strength is ideally assessed 12 weeks after surgery. According to the subjective review of patients, there was no improvement in grip strength after 16 weeks. We could not compare the grip strength before and after surgery because patients A and B presented to our hospital after surgery and patients B and C had returned to their native homes before the postoperative assessment. The chances of recurrence of latent clawing could be higher in patient C if he did not adhere to the precautions than in those who underwent 4-tail transfer, which provides facilitation to the lateral band. The reasons for flexion contracture at the PIP joint could be overstretching of the extensor mechanism, shortening of the long finger tendons, volar plate contracture, or tightness of the collateral ligaments. We could reduce this to some extent by stretching and strengthening exercises.

Neuroplasticity plays a vital role in motor retraining in tendon transfer surgeries as the function of the donor tendon is changed. Good patient education and a home exercise program with high
repetition of the trained movement (flooding) and its integration into functional activities help in strengthening the new muscle–tendon unit.

Flexor digitorum superficialis 4-tail transfer with lateral band insertion has been the preferred choice of surgery because the greatest correction of clawing deformity can be obtained, especially in patients with long-standing paralysis. In a study comparing FDS 4 tail, extensor carpi radialis longus 4-tail, and Zancolli lasso surgeries, the extensor carpi radialis longus and Zancolli procedures were the most efficacious in patients with short standing paralysis, with an improvement in grip strength in all patients. However, studies have shown that grip strength may remain the same or decrease with an FDS donor. Swan neck deformity has also been noted in digits with an FDS donor. The modified total intrinsic rehabilitation procedure addressed the deficits of cupping and coning the hand with 3 sets of tendon transfers performed in a single-stage correction and abduction of fingers. Preoperative rehabilitation is crucial for balancing the strength of donor and antagonistic muscles of the recipient’s muscles. Despite deformity correction, complete restoration of function in ulnar nerve palsy is difficult.

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