



Case Series

Pulley-Augmented EIP to EPL Transfer: A Novel Solution to Prevent Ulnar Subluxation at MCPJ

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ABSTRACT

In zone 3 injuries, the Extensor indicis Pollicis to Extensor Pollicis Longus tendon transfer comes with the problem of ulnar subluxation at the metacarpophalangeal joint (MCPJ), which results in ineffective extension of the thumb, which, in the long term, results in boutonniere deformity. **Objectives:** To observe the effects of stabilizing this transferred tendon at the MCPJ by adding a tendinous pulley and achieving significant improvement in extension of the thumb. **Methods:** This descriptive case series study was approved by the Institutional Review Board of Postgraduate Medical Institute, Ameer-ud-Din Medical College, Lahore General Hospital, Lahore (Approval No: 114; dated 3rd January 2022). A Total of 12 patients were in this study with delayed presentation (i.e., 6 to 12 weeks after trauma) of zone 3 EPL injuries, over a period of 2 years. Among these patients, 8 were males, and 4 were females. Surgery was performed under local anesthesia in 10 patients and general anesthesia in 2 patients. The EIP tendon was transferred to the transected EPL with a tendinous pulley reconstructed at the MCPJ. Postoperatively, a splint was applied for 4 weeks. Physiotherapy started on the first post-op day. Mean follow-up time was 5 months. **Results:** As per the Geldmacher score, an excellent score was achieved in 7(58.3%) patients, a good score in 3(25%), and a satisfactory score in 1(8.3%) patient, a poor score in 1(8.3%) patient. No extension lag was observed in the index finger in any case. **Conclusions:** This traditional transfer done in zone 3 gives excellent results when done with the addition of a pulley at MCPJ, improving the vector of excursion of the transferred tendon by stabilization at MCPJ and inhibiting its ulnar subluxation.

INTRODUCTION

Extensor tendon injuries of the thumb are frequent, and most of the most debilitating injury is the extensor pollicis longus tendon. The extensor pollicis longus (EPL) muscle is the major extensor of the Indicis Pollicis (IP) and the MCP joints of the thumb. Its origin is on the posterior side of the end of the third of the ulna and the interosseous membrane. The tendon traverses the 3rd compartment of the extensor retinaculum, bends radially at the lister tubercle, and eventually inserts on the back of the distal phalanx base. This tendon lies centrally at the metacarpophalangeal joint (MCPJ) through the extensor

expansion with ulnar and radial attachments. It is the muscle that enables a retropulsion hyperextension of the thumb [1]. Injury leads to loss of MCPJ and IPJ extension, which is not compensable by other muscles [2]. Trauma zone 3, i.e., in MCPJ, can lead to injury of EPL, EPL extensor expansion with its ulnar or radial attachments, and EPB. The sharp trauma is the most frequent cause of EPL tendon transaction or rupture in zone 3. It may also be caused by tenosynovitis with subcutaneous rupture, ischemia caused by impaired blood supply, and/or repetitive mechanical friction/stress. It is mostly a clinical diagnosis

or, at times, diagnosed on surgical exploration [3, 4]. The response varies according to the cause of injury and the time of presentation or the period of proper diagnosis following rupture. Sharp injuries can be presented immediately, and primary tendon repair is made possible [5]. In cases of delayed presentation/diagnosis, the tendon stumps are not suitable for primary repair due to a significant defect usually present because of tendon retraction [6]. In these delayed cases, secondary reconstructive procedures are the options, such as tendon graft or tendon transfer. In comparison to tendon graft, tendon transfer comes with the advantages of minimal donor site morbidity, shorter operating time with single-pulverized weave, relatively easier technique, early healing, easy cortical reeducation as EIP is synergistic to EPL, and fewer chances of complications such as avascular necrosis and tendon adhesions [7]. The most commonly described tendon transfer is of the extensor indicis proprius (EIP) tendon to the extensor pollicis longus EPL. A lot of research work has been done on this transfer for proximal EPL injuries at the wrist, but there is less literature available on this transfer in distal injuries in Zones 3 and 2. But the donor tendon (EIP) is of adequate length and is a good transfer for these distal injuries as well [8]. In our clinical experience, this study has observed that this transfer done for zone 3 injuries come with the problem of ulnar subluxation, which results in ineffective extension of the thumb, which in the long-term results in boutonniere deformity [9] (Figure 1).



Figure 1: Ulnar Subluxation of the Transferred EIP to the EPL Tendon at the MCPJ

As Zone 3 injuries of the thumb may cause direct injury to the EPL extensor expansion or the EPL extensor expansion

may need to be sacrificed surgically to achieve sufficient length of the distal stump of the tendon for pulverate weave, which results in instability of the EPL tendon at the metacarpophalangeal joint and causes ulnar subluxation, which in turn causes extension lag.

There is a dearth of literature on EIP-to-EPL tendon transfer in zone 3 extensor injuries; most studies have been done on proximal injuries at the wrist. The issue of ulnar subluxation at MCPJ after this transfer in distal injuries has not been previously studied or measured. The small size (n=12) restricts the statistical power and generalizability, but it is explained by the infrequency of delayed zone 3 EPL injuries. Lahore General Hospital is limited to a single-center design, which limits its applicability to other populations and surgical environments. This study aims to overcome this instability of EPL at the metacarpophalangeal joint or ulnar subluxation and resultant extension lag by adding a pulley at the metacarpophalangeal joint, which stabilizes the EPL tendon and improves its vector of excursion, which in turn corrects extension lag at the MCPJ and IPJ of the thumb (Figure 2).

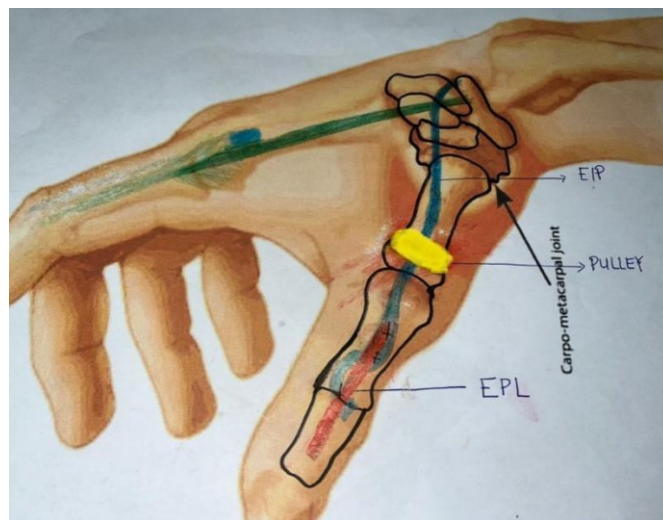


Figure 2: Stabilization of Transferred EIP to EPL Tendon at MCPJ by Reconstruction of the Pulley at the Head of the Metacarpal

METHODS

This descriptive case series study was approved by the Institutional Review Board of Postgraduate Medical Institute, Ameer-ud-Din Medical College, Lahore General Hospital, Lahore (Approval No: 114; dated 3rd January 2022). Written informed consent was obtained from all participants before enrollment. Data were obtained from 12 patients who underwent tendon transfers for EPL tendon rupture from January 2022 to December 2023. The patients in this study had delayed rupture presentation or transaction of the EPL tendon 6 to 12 weeks after trauma. Twelve patients (8 males and 4 females), with 32 years

mean age of (20 to 45 years), presented with loss of extension of the thumb after trauma (Table 2). These patients presented with missed diagnosis, inadequate repair, loss of tendon tissue, or unnoticed injury of the EPL tendon. Among these, mostly were sharp cuts and a few blunt traumata, due to RTA or domestic accidents. One patient had infective arthritis of the metacarpophalangeal joint, which resulted in EPL rupture. The average time interval between the transaction and the procedure was 8.4 weeks, with a range of 6 to 12 weeks. Diagnoses of all patients were made clinically. The presence of EIP and its function were evaluated before surgery. These patients underwent tendon transfer under local anesthesia, except for a few cases, which were done under general anesthesia due to accompanying other injuries. Five months was the average follow-up duration. Postoperative assessments were conducted at 3 to 5 months postoperatively by more than one observer using a standardized protocol. However, a formal inter-observer reliability analysis was not performed. The functional outcome of the thumb was assessed using the Geldmacher evaluation scheme, which evaluates four key components of thumb function. Each parameter is graded on a point-based scale, with higher scores indicating better function (Table 1).

Table 1: Geldmacher Evaluation Scheme

Function		Score (Points)
Radial abduction angle (angle between thumb and index finger)(°)	>70	6
	51-70	4
	31-50	2
	9-30	0
Elevation deficit (cm)	1.0-1.0	6
	1.1-2.0	4
	2.1-3.0	2
	>3	0
Opposition distance (distance of thumb tip to MP of the little finger)(cm)	1.0-2.5	6
	2.5-4.0	4
	4.1-6.0	2
	>6	0
Flexion extension deficit (difference from non-operated hand)(°)	0-5	6
	6-30	4
	31-60	2
	>60	0

Radial abduction was measured as the angle between the thumb and index finger. Angles >70° scored 6 points, 51-70° scored 4, 31-50° scored 2, and 9-30° scored 0. Elevation deficit was assessed as the loss of thumb elevation from the plane of the palm and measured in centimeters. Deficits of 0-1.0 cm scored 6 points, 1.1-2.0 cm scored 4, 2.1-3.0 cm scored 2, and >3 cm scored 0. Opposition was measured as the distance between the thumb tip and the metacarpophalangeal joint of the little finger. Distances of 0-2.5 cm scored 6 points, 2.5-4.0 cm scored 4, 4.1-6.0 cm

scored 2, and >6 cm scored 0. Flexion-extension deficit was calculated as the difference in total range of motion between the operated and contralateral thumb. Differences of 0-5° scored 6 points, 6-30° scored 4, 31-60° scored 2, and >60° scored 0. Based on the cumulative Geldmacher score (maximum 24 points), functional outcomes were categorized as follows: excellent (19-24 points), good (13-18 points), satisfactory (7-12 points), and poor (≤6 points). EIP function was assessed and marked preoperatively by asking the patient to extend the index finger while the other 3 fingers were held in a flexed position (Figure 3).



Figure 3: Incision Marked for EIP to EPL Transfer

Most of the patients were operated on with wide awake local anesthesia, except for a few who had other injuries as well, along with EPL tendon injury. Local anesthetics with adrenaline were given, and 3 incisions were marked. Through a first small transverse incision given at the metacarpophalangeal joint, EIP is identified ulnar to EDC. The anatomical variation of the EIP tendon should be kept in mind. A tiny transverse incision was made on the wrist's radial side, and EIP was identified as it glides when pulled distally through the first incision. EIP is cut at the metacarpophalangeal joint and retrieved through the second incision. The third incision was given at the base of the thumb or previous scar and extended accordingly to get enough length of the distal stump of EPL (in doing so, ulnar and radial attachments of EPL at the metacarpophalangeal joint may be sacrificed). The EIP tendon is then retrieved through the third incision by the subcutaneous route. A pulley is reconstructed and sutured with 5/0 Prolene to the periosteum just proximal to the MCPJ (the tendon graft pulley was reconstructed with a redundant portion of the EIP tendon, the EPL tendon, or with the transacted EPB tendon). The EIP tendon was passed through the pulley and sutured to the EPL by using the Pulvertaft weaving technique with 4/0 Prolene. Tension of repair is adjusted

such that "the thumb is in full flexion when the wrist is in full extension, and the thumb is in full extension when the wrist is in full flexion". Skin closed and dressing applied. Splint given in a position of thumb in full extension, wrist in 30-degree extension, MCPJ of other fingers in 60-degree flexion, and IPs straight (Figure 4).



Figure 4: Final Position of the Thumb in the Splint

Splint was continued for 4 weeks. Within the splint, passive extension of the thumb started from the first post op day. Active motion started after 1 week, with an increase in the flexion angle of the splint at the MCPJ every week. Splint discontinued after 4 weeks. The results were scored using the Geldmacher scheme.

RESULTS

The study included 12 patients with a male predominance (8 males, 4 females). The age range was 20–45 years, with most patients in their third decade of life, indicating that young, working-age individuals were primarily affected. The most common etiologies were road traffic accidents (RTA) and blunt trauma, followed by sharp injuries such as knife and glass cuts. One case was secondary to infective osteoarthritis. The time lag before presentation ranged from 6 to 12 weeks, with the majority presenting between 6 and 8 weeks, suggesting delayed referral or late reconstruction in most cases (Table 2).

Table 2: Patient Characteristics

Sr. No.	Gender	Age (Years)	Etiology	Time Lag
1	Female	38	Knife Cut	8 Weeks
2	Male	27	Rta	6 Weeks
3	Male	25	Glass Cut	7 Weeks
4	Male	20	Rta	8 Weeks
5	Female	45	Knife Cut	6 Weeks
6	Male	30	Blunt Trauma	12 Weeks
7	Female	30	Grinder Injury	8 Weeks
8	Male	40	Blunt Trauma	10 Weeks

9	Male	24	Blunt Trauma	11 Weeks
10	Female	40	Infective Osteoarthritis	12 Weeks
11	Male	26	Rta	7 Weeks
12	Male	21	Glass Injury	6 Weeks

The functional outcome was measured by the Geldmacher scheme. Individual scoring of each patient for each variable. The functional outcomes demonstrated overall favorable recovery. The mean total score was 20.0 ± 5.26 , with an interquartile range (IQR) of 6, indicating clustering toward higher functional performance. Mean scores for radial abduction and elevation deficit were 5.17 ± 1.34 each (IQR = 2), reflecting near-normal thumb positioning in most patients. Flexion-extension deficit and opposition distance showed mean scores of 4.83 ± 1.59 (IQR = 2), indicating mild residual limitations (Table 3).

Table 3: Functional Outcome Results

Patients	Radial Abduction in Angle	Elevation Deficit	Flexion Deficit	Opposition Distance	Total Score	Outcomes
1	6	6	4	4	20	Good
2	6	6	6	6	24	Excellent
3	6	4	6	6	22	Excellent
4	4	6	4	4	18	Good
5	6	6	6	6	24	Excellent
6	4	4	2	2	12	Satisfactory
7	4	6	6	6	22	Excellent
8	2	2	2	2	8	Poor
9	6	6	6	6	24	Excellent
10	6	6	6	6	24	Excellent
11	6	4	4	4	18	Good
12	6	6	6	6	24	Excellent
Mean $\pm$ SD	5.17 ± 1.34	5.17 ± 1.34	4.83 ± 1.59	4.83 ± 1.59	20 ± 5.26	—
IQR	2.00	2.00	2.00	2.00	6.00	—
Min	2.00	2.00	2.00	2.00	8.00	—
Max	6.00	6.00	6.00	6.00	24.00	—

Results of this study based on the Geldmacher score were excellent in 7 (58.3%) patients, good in 3 (25%), satisfactory in 1 (8.3%), and poor in 1 (8.3%) patient (Figure 5).

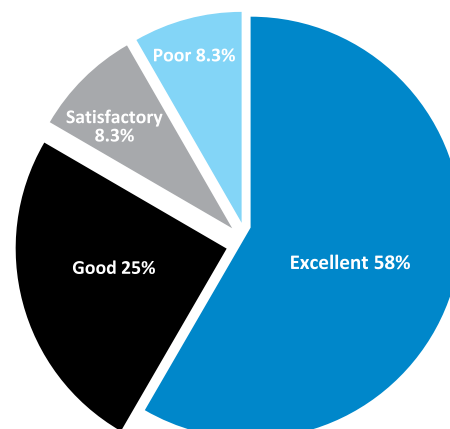


Figure 5: Results of This Study Based on the Geldmacher Score

DISCUSSION

EPL is the prime extensor of the MCPJ and IP of the thumb. The injury results in dropped thumb deformity with loss of elevation of the thumb to the plane of the palm. Injuries in the extensor Zone 3 of the thumb may involve the EPL tendon, the extensor expansion (extensor hood), or the Extensor pollicis brevis [10]. In zone 3, due to the broad width of the extensor apparatus at the metacarpophalangeal joint, incomplete lacerations are common [11]. On the other hand, partial lacerations can be easily missed because the remaining tendon may be able to extend the thumb. Still, with continuous use (repetitive trauma), the tendon may rupture completely [12]. Also, Injury to the extensor expansion itself results in instability of the EPL tendon over the MCPJ. Infective osteoarthritis may also result in tendon rupture. Delayed presentation of transacted EPL results in significant retraction of the proximal stump of the transacted tendon [13]. So, tendon ruptures and delayed presentations result in a significant gap between the two cut ends of the tendon, making primary repair difficult. For chronic or longstanding EPL rupture, the only available treatments are tendon graft and tendon transfer [14]. Both treatment options come with their own advantages and disadvantages. EIP is generally not offered to high-demanding patients, e.g., musicians, and these patients usually are offered an intercalated palmaris tendon graft. According to Atilgan et al. the comparison showed no significant difference in the outcome of thumb function between the Extensor indicis proprius transfer and the Palmaris longus tendon graft [15]. But in most of the undemanding cases, EIP is the first choice, as it comes with the advantages of a simple and easy procedure, a single suture site, quick healing, easy cortical reeducation, and a lower chance of avascular necrosis [16, 17]. Trauma in the extensor Zone 3 of the thumb may cause direct injury to the extensor expansion (extensor hood) or during operative procedure EPL attachments at MCPJ may also be sacrificed to achieve adequate length of distal tendon stump for pulvertaft weave, which results in initialization of repaired tendon at MCPJ during active extension and causes ulnar subluxation because it comes to lie palmar to the center of rotation of the metacarpophalangeal joint to act as a flexor instead of an extensor [18]. To stabilize the tendon at MCPJ, a tendon graft pulley is reconstructed at the head of the metacarpal, which gives effective extension of the thumb by improving the vector of excursion. As in Extensor zone 5 injuries of other fingers, chronic degenerative sagittal band rupture may require a tendon graft pulley for stabilization of the extensor tendon at the MCPJ [19, 20]. The functional outcome of the thumb was used in this study; it was measured using the Geldmacher scheme. Four functions

are to be scored under this scheme, which include: radial abduction angle, deficit of elevation, distance of opposition, flexion, and deficit of extension of the MP and IP joints. Postoperative thumb extension was achieved in all patients, with functional scores detailed. The 12 patients showed no extension lag in the index finger (i.e., no donor site morbidity in any case). The thumbs of both hands were comparable in terms of function and full range of motion (except in one patient with a poor outcome). There were no notable complications after surgery. Results of this study based on the Geldmacher score were excellent in 7 (58.3%) patients, good in 3 (25%), satisfactory in 1 (8.3%), and poor in 1 (8.3%) patient.

This study has several limitations. The small sample size, inherent to the rarity of delayed zone 3 EPL injuries, may limit the generalizability of the results. Its single-center design and lack of a control group prevent direct comparison with standard EIP-to-EPL transfer or tendon graft techniques. Functional assessment using the Geldmacher score, although validated, includes subjective elements and may be prone to observer bias. In addition, the relatively short follow-up may not fully reflect long-term outcomes or late complications. Larger, prospective, comparative studies are needed to further establish the role of MCPJ pulley reconstruction in chronic zone 3 EPL injuries. A novel technical report presenting promising preliminary results by presenting evidence for its effectiveness in enhancing functional results for patients with delayed presentation of zone 3 EPL injuries, this study provides a useful clinical perspective into tendon transfers. The addition of a tendinous pulley at MCPJ has produced encouraging results, with 83.3% patients having excellent or good results using the Geldmacher score. Also, there was no lag in extension in the index finger in all the patients, indicating the success of this method.

CONCLUSIONS

This procedure of EIP to EPL transfer is an excellent, simple, and easy technique for delayed presentation of distal EPL tendon ruptures. This technique is a very good option when used particularly for zone 3 EPL injury, as the donor tendon is of adequate length for these distal injuries, but it comes with a problem of extension lag at MCPJ and IP due to instability and ulnar subluxation of the transferred EIP to EPL tendon at MCPJ. But just adding a simple pulley at MCPJ improves the vector, allowing linear excursion of the EPL tendon in the right direction, which helps to achieve full extension at MCPJ and IPJ of the thumb.

Authors' Contribution

Conceptualization: SI

Methodology: SF, HRA, AL

Formal analysis: RA, MN, MAA

Writing and Drafting: SI

Review and Editing: SI, RA, MM, MAA, SF, HRA, AL

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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