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EXTENSOR TENDON RECONSTRUCTION VS. TENDON TRANSFER: A COMPARATIVE ANALYSIS OF OUTCOMES IN ZONE 6-8 COMPLEX EXTENSOR TENDON INJURIES

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ABSTRACT

Injuries to the extensor tendons are frequently seen, and while primary repair yields the best possible outcomes, management of tendon gap is challenging. It can be managed by reconstruction with a tendon graft or tendon transfer. This study aims to compare the outcomes of management of complex extensor tendon injuries of fingers with tendon graft and tendon transfer in zone 6, 7.

PATIENTS & METHODS:

This is a retrospective analysis conducted at our institution. Patients who underwent treatment for extensor tendon injuries in zones 6, 7, and 8 with tendon loss between January 2023 and December 2023 were included in the study. Tendon reconstruction (n=12) group and tendon transfer group (n=9) were compared. Outcomes analysed were metacarpophalangeal joint extension lag, total active motion and pulp to palm distance.

RESULTS:

The mean extension lag at MP joint of fingers was 13.3° (range 0-25°) in reconstruction group while extension lag 9.1° (range 0-20°) in tendon transfer group. There was no significant difference between the outcomes in both groups. A general preference towards tendon transfer was seen in cases with longer time lapse from injury to reconstruction as proximal muscles had atophied or loss was present. Miller's criteria in both groups showed good outcomes. Secondary procedures were more common in the reconstruction group.

CONCLUSION:

This study demonstrates that both techniques can provide comparable functional outcomes. While tendon transfer has a slight advantage in terms of complication rates, the choice between the two techniques should be based on individual patient factors and injury characteristics.

Key words:
Tendon Injuries / surgery
Tendon Transfer
Hand Injuries / surgery
Range of Motion, Articular

Treatment Outcome Introduction:

Tendon injuries of the hand can significantly impact overall function, necessitating careful consideration of treatment options. The extensor and flexor tendon systems work in concert to provide precise control and positioning of the fingers. While much attention has been given to flexor tendon injuries, restoration of optimal extensor function is important for balanced hand function[(1)]. Extensor tendon reconstruction and tendon transfer represent two primary surgical approaches for addressing extensor tendon injuries, each with distinct advantages and potential outcomes. This comparative analysis examines the efficacy and long-term results of these techniques in restoring finger extension and overall hand function.

Review of Literature:

The superficial location of the extensor tendons over the dorsum of hand make them susceptible to injury[(2)]. The most common cause of extensor tendon defects is friction injury from road traffic accidents or injuries[(3)]. While simple lacerations may be repaired primarily, crush or avulsion injuries that may involve tendon loss or gaps require more attention.

Complex flexor and extensor tendon injuries are those with significant associated bony or soft tissue compromise that require consideration of reconstructive techniques beyond those limited to the tendons alone. The treatment options for tendon injury include primary repair, secondary repair, immediate reconstruction with tendon graft, staged tendon reconstruction, and tendon transfer[(4)].

Carty and Blazar defined three key interventions in complex injuries, which include (1) restoration of reliable vascularity, (2) stabilization of the wound bed, and (3) reestablishment of skeletal continuity[(4)].

Klienert and Verdan classified the extensor tendons into 8 anatomical zones, which guide appropriate management and additional zone 9 was proposed by Doyle[(5)].

Zone 6 injuries are proximal to the metacarpophalangeal joint. When the injury is proximal to juncturae, the proximal stump may be retracted into the forearm, thus complicating the management. However, the prognosis is often better than in more distal injuries. Zone 7 extensor injuries involve the extensor retinaculum. In these zones, the extensor tendons become more rounded, there are more excursions, and the tendons show a parallel course. Zone 8 and 9 injuries occur to the musculotendinous junction or to the muscle belly[(6)].

There are multiple factors that guide the surgical choices for addressing extensor tendon gap. These include the injury itself, the functional deficit, the time since the initial injury and conditions related to the patient (age, comorbidities, joint stiffness, scars, and surrounding soft tissues status)[7].

Extensor tendon loss can be addressed by two primary approaches are commonly employed: tendon reconstruction and tendon transfer. Tendon reconstruction involves using either autologous tissue or allografts to bridge the gap. The palmaris longus tendon is frequently utilized as a graft source due to its accessibility and minimal donor site morbidity and fascia lata graft[8]. Other potential graft sources include the plantaris, extensor digitorum longus of the toes, and accessory abductor pollicis longus tendons. Other methods include tendon turnover technique which employs an L-shape cut that is flipped over and two-stage extensor tendon reconstruction using a silicone rod. The use of synthetic tendon has also been reported although the number of cases reported are less[9].

Tendon transfer procedures, on the other hand, involve rerouting a functioning tendon to replace the role of the injured extensor. It is used to substitute function of non-functional defective tendon when reconstruction is not an option such as musculotendinous avulsion, loss of proximal muscle, and prolonged duration between injury and reconstruction causing muscle atrophy. Common donor tendons for transfer include the flexor carpi radialis (FCR), Flexor carpi ulnaris (FCU) for finger extension[2].

The choice between tendon grafting and tendon transfer depends on various factors, including the extent of the injury, the specific zone affected, and the availability of suitable donor tendons. Both techniques have demonstrated efficacy in restoring extensor function when applied appropriately. In this study we aim to compare the outcomes between tendon reconstruction with autograft and tendon transfer for complex extensor tendon injuries.

Aim of the study

1. To compare the outcomes of management of complex extensor tendon injuries of fingers with tendon graft and tendon transfer in zone 6, 7 and 8
2. To analyse the advantages and disadvantages of each method

Patients and Methods

Study design and timeline

This is a retrospective analysis conducted at our institution. Patients who underwent treatment for extensor tendon injuries in zones 6, 7, and 8 with tendon loss between January 2023 and December 2023 were included in the study.
Exclusion criteria were:

- Age below 18 or above 65 years
- Thumb extensor injuries
- Systemic diseases affecting tendon healing (e.g., rheumatoid arthritis)

The patients were classified into two groups

1. Tendon reconstruction group: Underwent free tendon grafting using fascia lata autograft. (Image 1)
2. Tendon transfer group: Underwent Flexor carpi radialis to extensor digitorum communis transfer

Demographic details, type of injury, time from injury to reconstruction was documented for all patients.

All surgeries were performed by experienced hand surgeons under regional anesthesia. For the reconstruction group, the fascia lata was harvested and used to bridge the gap in the injured extensor tendon using the Pulvertaft weave technique. In the transfer group, the FCR tendon was transferred and sutured to the distal stump of the extensor tendon in an end to end fashion (Image 1-3).

Both groups followed institution rehabilitation protocol. Patients were immobilized in extension for 4 weeks, followed by controlled active motion exercises under the guidance of a hand therapist. Night splinting was continued for an additional 2 weeks.

Image 1: a. pre-operative picture with skin loss and extensor loss; b. EDC Reconstruction with fascia lata graft; c.d follow up photo with ROM

Image 2: a, Preop photo with skin loss and extensor loss; b,c Intraop photos of tendon reconstruction; d, post op follow up

Image 3: a, Preoperative picture; b,c Intraop reconstruction with Fascia lata graft; d, Postoperative result .

Outcome measures

Patients were evaluated at 3, 6, and 12 months postoperatively. The following outcome measures were assessed:

- Extension lag and Range of motion (ROM) at metacarpophalangeal joint (MCPJ) of the affected digit
- Total Active Motion (TAM) of the involved digit based on the ASSH criteria
- Pulp to palm distance
- Miller's criteria[10]

Statistical analysis

Data were analyzed using SPSS version 25.0. A p-value < 0.05 was considered statistically significant.

Results

A total of 21 patients were included in the study, with 12 patients in the tendon reconstruction group and 9 patients in the tendon transfer group (Figure1). The mean age of patients was 37 years (range 18-60) in the reconstruction group and 36.1 years (range 25-49) in the transfer group. In the reconstruction group most injuries were secondary to road traffic accidents (n=7) followed by workspot injuries (n=4). Road traffic accident injuries were the most common in tendon transfer group (n=6). All patients underwent staged procedures. In patients with skin loss pedicled flap cover was done in first stage followed by reconstruction/ tendon transfer. Time from injury to reconstruction ranged from 6 weeks to 6 months (Table 1).

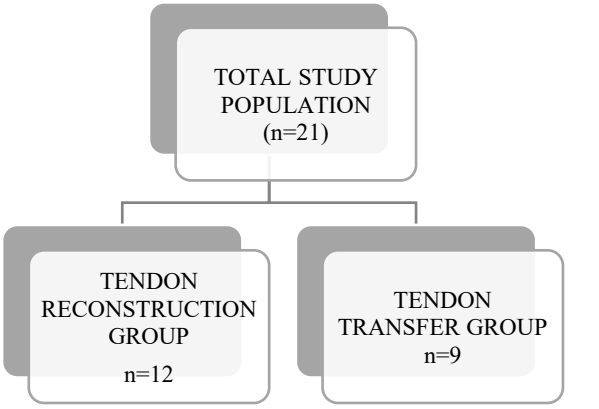

Figure 1: Overview of Study Population

TIME TO RECONSTRUCTION	RECONSTRUCTION GROUP	TENDON TRANSFER GROUP
6 WEEKS	4	1
6 WEEKS TO 3 MONTHS	4	1
3-6 MONTHS	4	6
>6 MONTHS	0	1

Table 1: Time from injury to Reconstruction between two groups

The primary outcome measure was the extension lag at the metacarpophalangeal (MP) joint of the affected fingers, measured with a goniometer at the 12-month follow-up. The outcome data is summarized in (Figure 2). Mean extension lag in tendon reconstruction group was 13.3° (range 0-25°) and in tendon transfer group it was 9.1° (range 0-20°) (Image 4,5). The difference in mean extension lag between the two groups was not statistically significant (p = 0.2106).

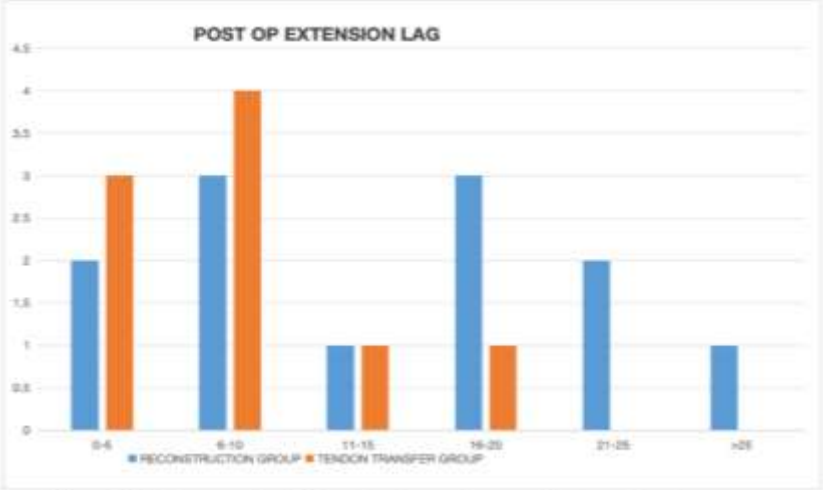

Figure 2: Post operative Extension Lag outcomes between the two groups

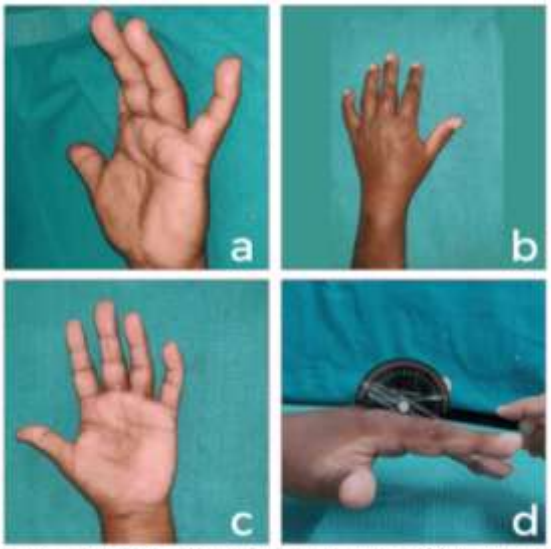

Image 4: a. Preoparative photo with extension lag; b,c Tendon transfer post op follow up; d. Post op result

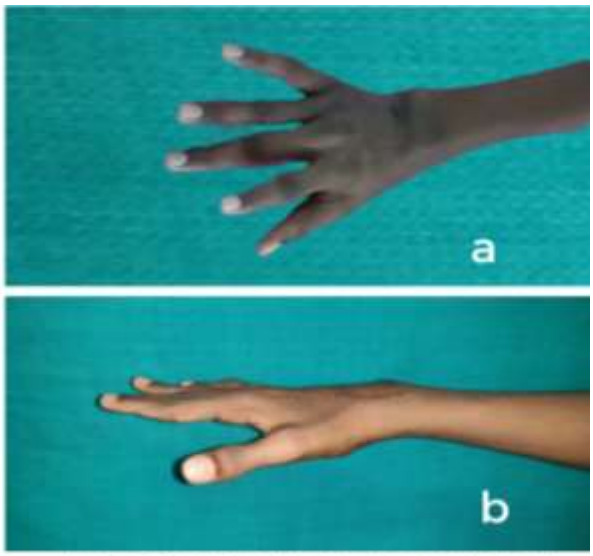

Image 5: a. Preoperative photo showing extensor lag; b. post reconstruction result with no lag

Additional functional outcomes assessed included Range of motion (ROM) of the affected digit. In the tendon reconstruction group mean total active motion (TAM) was 214°(range 165-260°)and in tendon transfer group: Mean TAM of 235° (range 190-255°). The difference in TAM between the two groups was not statistically significant (p= 0.609) (Figure 3).

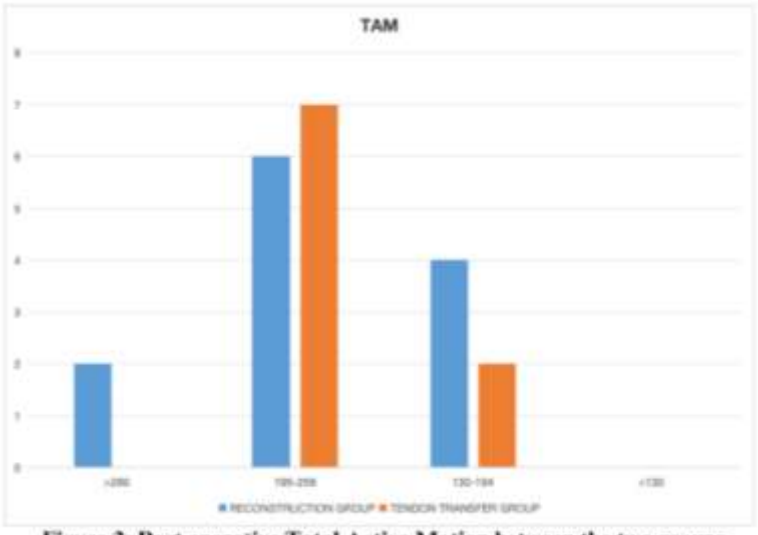

Figure 3: Post operative Total Active Motion between the two groups

Pulp to palm distance:
Tendon reconstruction group: Mean distance of 12.1mm (Range 5-22mm)
Tendon transfer group: Mean distance of 10.4mm(Range 5-20mm)
Miller's criteria was used to assess the outcomes between both groups. Majority of the patients obtained good outcomes. (Table 2)

MILLER'S CRITERIA	RECONSTRUCTION GROUP	TENDON TRANSFER GROUP
EXCELLENT	1	1
GOOD	5	5
FAIR	6	3
POOR	0	0

Table 2: Comparison of Miller's criteria between the two groups

In the tendon reconstruction group, three patients developed adhesions requiring tenolysis at 6 months post-surgery and one patient requiring tension readjustment. In the tendon transfer group, one patient underwent tension readjustment.

Discussion

The results of this study demonstrate comparable outcomes between extensor tendon reconstruction and tendon transfer techniques for zone 6-8 finger extensor tendon injuries. Both approaches achieved satisfactory functional restoration, with some differences worth noting.

Extension lag at the metacarpophalangeal joint, a key indicator of functional recovery, showed a slight advantage for the tendon transfer group (9.1°) compared to the reconstruction group (13.3°). However, this difference was not statistically significant. These findings align with previous research indicating that both techniques can effectively restore extensor function[11].

Range of motion outcomes were comparable between the two groups, with mean total active motion of 214° for the reconstruction group and 221° for the tendon transfer group. This suggests that both techniques can achieve adequate restoration of finger mobility. The similarity in outcomes is consistent with earlier studies that have reported equivalent results for tendon grafting and transfer procedures[12].

Pulp to palm distance was slightly better in the transfer group (10.4mm) compared to the reconstruction group (12.1mm). This difference was not statistically significant.

The Miller's criteria results further support the efficacy of both techniques, with the majority of patients in each group achieving good outcomes in both groups.

One notable difference between the two techniques was the complication rate. The tendon reconstruction group experienced three cases of adhesion formation requiring tenolysis, while no major complications were reported in the transfer group. This observation suggests that tendon transfer procedures may be associated with a lower risk of post operative complications, particularly adhesion formation. The reduced risk of adhesions in tendon transfer may be attributed to the ability to initiate earlier active range of motion exercises[13].

It is important to note that the choice between tendon reconstruction and transfer should be individualized based on factors such as the specific injury characteristics, availability of donor tendons, and patient-specific functional requirements. For instance, in cases where preservation of independent finger extension is crucial, such as for musicians, tendon reconstruction may be preferred[12].

Factors influencing technique selection. The choice between tendon reconstruction and tendon transfer for extensor tendon injuries depends on several key factors:

- Injury char

acteristics: Injuries in zones 6-8 may be more ame

nable to both techniques, while more distal injuri

es may favor reconstruction(14). Extensive soft t

issue damage may favor tendon transfer.

- Presence of

suitable donor tendons for transfer in the setting

g o f m u l t i p l e i n j u r i e s t o t h e s a m e l i m b .

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may offer slight advantages in grip strength reco

very (12)

- Chronic injuries may be more suitable for

tendon transfer due to potential muscle atrophy. Co

mpliance with post-operative physiotherapy and reh

abilitation will determine outcomes regardless of

the surgery done. Earlier mobilization may be done

in tendon transfers(14).

- Risk of tendon adhesion f

ormations is more common with reconstruction (13)

- Donor site morbidity should be considered in both

techniques

In some cases, a combination of techniques may be employed. For instance, in complex injuries with both tendon and soft tissue defects, a staged approach using silicone rods followed by free flap coverage and subsequent tendon grafting have been described. Recent advancements have expanded the options for tendon reconstruction including synthetic tendon grafts and allografts[15].

Advantages and disadvantages of each method

Tendon reconstruction

Advantages of tendon reconstruction:

- Preserves independent finger extension, which is crucial for tasks requiring precise digit control
- Allows for restoration of the original tendon anatomy
- Can address larger tendon gaps
- Suitable for both acute and chronic injuries
- Avoids altering the biomechanics

Disadvantages of tendon reconstruction:

- Technically more demanding procedure
- Additional donor site morbidity
- Higher risk of adhesion formation
- Longer recovery time and rehabilitation

Tendon transfer

Advantages of tendon transfer:

- Technically simpler procedure compared to reconstruction
- Allows for earlier active range of motion exercises, potentially reducing adhesion formation
- Can restore function in chronic injuries with muscle atrophy
- May result in better grip strength recovery

Disadvantages of tendon transfer:

- Combined action of all four fingers
- Learning to activate the tendon transfer
- Potential for donor site morbidity
- Altered biomechanics

The choice between tendon reconstruction and transfer should be tailored to the specific needs of the patient, the nature of the injury, and the surgeon's expertise. Both techniques have demonstrated efficacy in restoring extensor function when applied appropriately.

Limitations of the study

This study has several limitations that should be considered when interpreting the results. The small sample size limits the statistical power affecting the generalization of the findings. Short follow-up period may not capture long-term outcomes. Due to the retrospective nature of the study the patients in two study groups could not be matched.This is a single institution study and hence institution protocols for choice of techniques and rehabilitation may affect the outcomes.

Conclusion

This comparative study of extensor tendon reconstruction versus tendon transfer in zone 6-8 finger extensor tendon injuries demonstrates that both techniques can provide comparable functional outcomes. While tendon transfer may offer a slight advantage in terms of complication rates, the choice between the two techniques should be based on individual patient factors, specific injury characteristics and surgeon expertise. Further research is warranted to confirm these findings in larger patient populations and to assess long-term outcomes.

Disclosure

The authors declare no conflict of interest
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