Original Article

Functional Outcome In Repair of Zone V Flexor Tendon Injuries in a Tertiary Care Centre in Kerala

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A B S T R A C T

Objective: Zone V flexor tendon injuries are complex hand injuries frequently associated with neurovascular damage, posing significant challenges in surgical repair and rehabilitation. This study aimed to evaluate the short-term functional outcomes and quality of life following surgical repair of Zone V flexor tendon injuries using standardized outcome measures at a tertiary care centre in Kerala, India.

Methods: A prospective cohort study was conducted over a 6-month period at the Department of Plastic and Reconstructive Surgery, Government Medical College, Thiruvananthapuram. Fifty patients with isolated Zone V flexor tendon injuries were enrolled. Tendon repair was performed using the Modified Kessler four-strand technique. Functional outcomes were assessed at 1 month and 3 months postoperatively using the Buck-Gramcko and Quick DASH scoring systems. Quality of life was evaluated at 3 months using the SF-36 questionnaire. Statistical analysis was performed using SPSS version 27.0.

Results: Significant improvement in functional scores was observed from 1 to 3 months postoperatively. Buck-Gramcko scores improved by a mean of +2.2 points (p<0.001; Cohen's d=0.75), while Quick DASH scores showed a median reduction of −13 points (p<0.001; r=0.58). Younger patients (<30 years), those with higher education, non-diabetics, non-smokers, and those who underwent early surgery (<48 hours) had significantly better outcomes. Patients with nerve involvement, multiple-digit injuries, or secondary infections demonstrated poorer recovery. SF-36 scores reflected superior quality of life in younger, educated, and non-comorbid patients.

Conclusion: Zone V flexor tendon injuries, when managed with timely surgical intervention and structured rehabilitation, yield favourable short-term functional and quality of life outcomes. Early repair, absence of comorbidities, patient education, and therapy compliance are critical determinants of recovery, particularly in resource-limited settings.

Keywords: *Zone V flexor tendon injury, Buck-Gramcko score, Quick DASH, SF-36, Functional outcome, Tendon repair, Rehabilitation, Quality of life.*

INTRODUCTION

Hand injuries constitute one of the most common presentations in emergency departments worldwide, with flexor tendon injuries representing a significant proportion of upper extremity trauma. Among these, Zone V flexor tendon injuries—extending from the proximal border of the transverse carpal ligament to the musculotendinous junction in the forearm—are particularly challenging due to the anatomical complexity of this region, which houses multiple flexor tendons alongside critical neurovascular structures including the median and ulnar nerves and the radial and ulnar arteries [1,2].

The proximity of vital neurovascular structures in Zone V makes isolated tendon injuries uncommon; more frequently, combined injuries involving tendons, nerves, and vessels occur, leading to complex surgical and rehabilitative needs. Functional recovery following these injuries depends on a multitude of factors including patient demographics, injury severity, timing of surgical intervention, surgical technique, and adherence to postoperative rehabilitation protocols [3,4]. Despite advances in surgical techniques such as the Modified Kessler repair and early controlled motion protocols, functional outcomes remain variable, with poor results reported in 20–30% of cases globally [5].

The Modified Kessler four-strand technique has emerged as a widely accepted method for flexor tendon repair due to its balance of tensile strength and technical simplicity [6]. Postoperative rehabilitation involving early passive motion followed by progressive active mobilization has been shown to reduce adhesion formation and improve tendon gliding [7,8]. However, outcomes in resource-limited settings remain understudied, where challenges such as delayed presentation, higher infection rates, limited access to specialized hand therapy, and socioeconomic barriers may adversely affect recovery [9,10].

Assessment of functional outcomes traditionally relies on objective measures such as range of motion and grip strength, supplemented by validated scoring systems. The Buck-Gramcko scoring system evaluates finger pulp distance, extension deficit, and total active motion [11], while the Quick DASH (Disabilities of the Arm, Shoulder and Hand) score captures patient-reported functional disability [12]. The SF-36 (Short Form-36 Health Survey) provides a comprehensive evaluation of health-related quality of life encompassing both physical and mental health dimensions [13].

While extensive literature exists on flexor tendon repair outcomes from developed countries, data from developing countries, particularly from the Indian subcontinent, remain scarce. Kerala, with its unique demographic and healthcare profile, presents an important setting for studying these outcomes. This study was therefore designed to prospectively evaluate the functional outcomes and quality of life following Zone V flexor tendon repair using standardized scoring systems, and to analyse the influence of patient demographics, comorbidities, and injury characteristics on recovery at a tertiary care centre in Kerala.

MATERIALS AND METHODS
Study Design and Setting
This prospective cohort study was conducted over a 6-month period at the Department of Plastic and Reconstructive Surgery, Government Medical College, Thiruvananthapuram, Kerala, India. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Sample Size
The sample size was calculated using the formula $n = Z^2pq/d^2$, based on 85% estimated proportion of excellent outcomes from a prior study by Bircan et al. [14], with 95% confidence interval and 10% absolute precision, yielding a required sample of 50 patients.

Study Population
Fifty consecutive patients presenting with Zone V flexor tendon injuries who were eligible and fit for surgical repair were enrolled. Patients of all age groups were included. Exclusion criteria comprised polytrauma, associated bony injuries, multiple levels of tendon injuries or proximal nerve injuries, pre-existing upper limb neuropathies or arthritis (osteoarthritis or rheumatoid arthritis), delayed presentation exceeding 6 months, tendon loss requiring grafting, and unwillingness to participate.

Surgical Technique
All tendon repairs were performed using the Modified Kessler four-strand technique with 3-0 or 4-0 non-absorbable polypropylene core sutures, supplemented by a 6-0 polypropylene running epitendinous suture. Associated nerve injuries were repaired using microsurgical epineural sutures with 8-0 nylon. Vascular injuries were managed as clinically indicated. Postoperatively, a dorsal block splint was applied with the wrist in 20–30° flexion.

Rehabilitation Protocol
A standardized rehabilitation protocol was followed: passive finger flexion and active finger extension within the dorsal block splint commenced from postoperative day 2. Wound inspection for surgical site infections was performed at one week. At one month postoperatively, the splint was discontinued and active flexion-extension exercises were initiated. Progressive strengthening exercises were introduced thereafter.

utcome Assessment
Functional outcomes were assessed at 1 month and 3 months postoperatively using the Buck-Gramcko scoring system (grading outcomes based on finger pulp distance, extension deficit, and total active motion) and the Quick DASH score.

Quality of life was evaluated at 3 months using the SF-36 questionnaire. Demographic data, injury characteristics, comorbidities, and rehabilitation compliance were documented for all patients.

Statistical Analysis
Data were entered into Microsoft Excel and analysed using SPSS version 27.0. Quantitative variables were expressed as mean ± standard deviation, and qualitative variables as frequencies and percentages. Paired t-tests were used for normally distributed Buck-Gramcko scores, and Wilcoxon signed-rank tests for non-normally distributed Quick DASH scores. Effect sizes were calculated using Cohen's d and rank-biserial r. Subgroup comparisons were performed using independent t-tests, one-way ANOVA with post-hoc Tukey tests, and chi-square tests as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS
Demographic and Clinical Characteristics
Of the 50 patients enrolled, 32 (64%) were males and 18 (36%) were females. The age distribution showed that 18 (36%) patients were aged <30 years, 20 (40%) were in the 30–50 years group, and 12 (24%) were >50 years. Manual labourers constituted the largest occupational group (40%), followed by other occupations (24%), unemployed individuals (20%), and students (16%). Secondary education was the most common educational level (48%), followed by primary (28%) and higher education (24%).

Accidental cuts were the most common mode of injury (32%), followed by machine cuts and assault (20% each), deliberate self-harm (16%), and road traffic accidents (12%). Regarding comorbidities, 16 (32%) patients had diabetes and 18 (36%) were smokers. The left hand was more commonly injured (60%) than the right (40%). Multiple digit involvement (≥3 digits) was seen in 22 (44%) patients, while 16 (32%) had two-digit involvement and 12 (24%) had single-digit injuries. Nerve involvement was present in 80% of cases: median nerve in 18 (36%), ulnar nerve in 16 (32%), and both nerves in 6 (12%). Secondary infection occurred in 6 (12%) patients.

Table 1: Baseline demographic and clinical characteristics of study participants (n=50)

| Variable	Category	n (%)
Sex	Male	32 (64%)
	Female	18 (36%)
Age (years)	<30	18 (36%)
	30–50	20 (40%)
	>50	12 (24%)
Mode of Injury	Accidental Cut	16 (32%)
	Machine Cut	10 (20%)
	Assault	10 (20%)
	DSH	8 (16%)
	RTA	6 (12%)
Diabetes	Yes	16 (32%)
	No	34 (68%)
Smoking	Yes	18 (36%)
	No	32 (64%)
Nerve Involvement	Median	18 (36%)
	Ulnar	16 (32%)
	Both	6 (12%)
	None	10 (20%)
Digits Involved	1	12 (24%)
	2	16 (32%)
	≥3	22 (44%)
Secondary Infection	Yes	6 (12%)
	No	44 (88%)
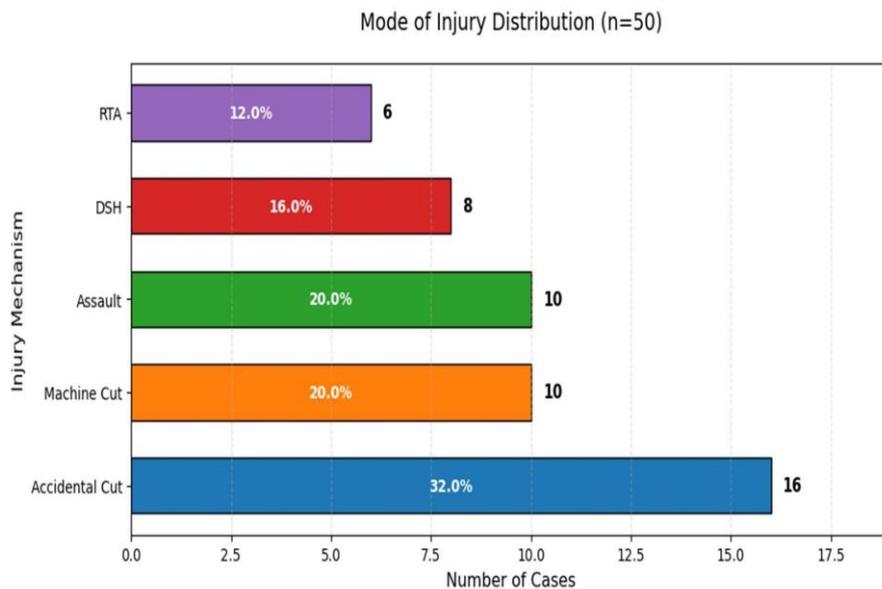
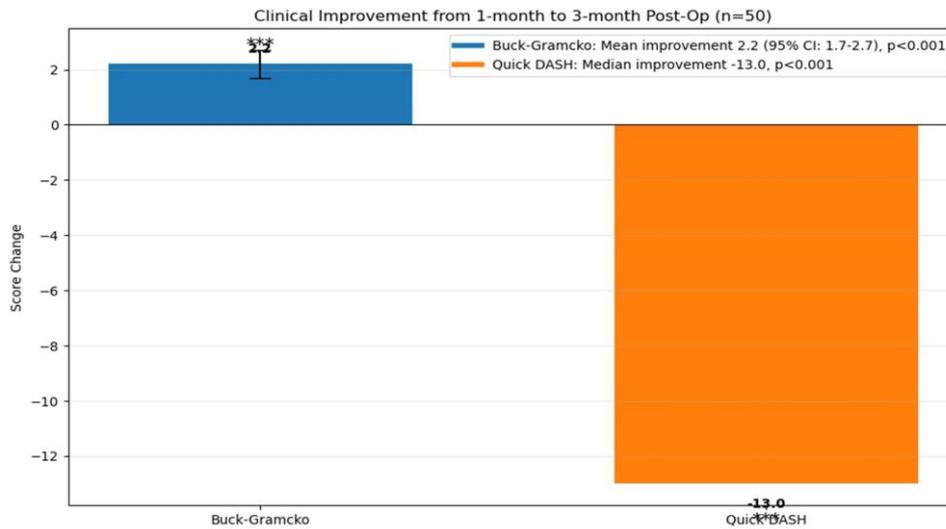**Figure 1: Distribution of study sample based on mode of injury (n=50)**

Functional Outcomes: Buck-Gramcko and Quick DASH Scores

Significant functional improvement was observed from 1 month to 3 months postoperatively. The median Buck-Gramcko score increased from 11.0 (IQR: 9.0–13.0) at 1 month to 13.0 (IQR: 11.0–14.0) at 3 months, with a mean improvement of +2.2 points (95% CI: 1.7–2.7; $p < 0.001$, paired t-test). The effect size was moderate-to-large (Cohen's d = 0.75), indicating that 77% of patients improved beyond the median baseline score. At 3 months, 25% of patients achieved the maximum Buck-Gramcko score of 15.

The median Quick DASH score decreased from 45.5 at 1 month to 24.5 at 3 months ($\Delta = -21.0$ points). The Wilcoxon signed-rank test confirmed statistically significant improvement ($p < 0.001$), with an effect size (rank-biserial r) of 0.58 (moderate). The minimal clinically important difference (MCID) of a 10-point reduction was exceeded in 78% of patients. Persistent high Quick DASH scores in a subset of patients suggested a non-responder subgroup.
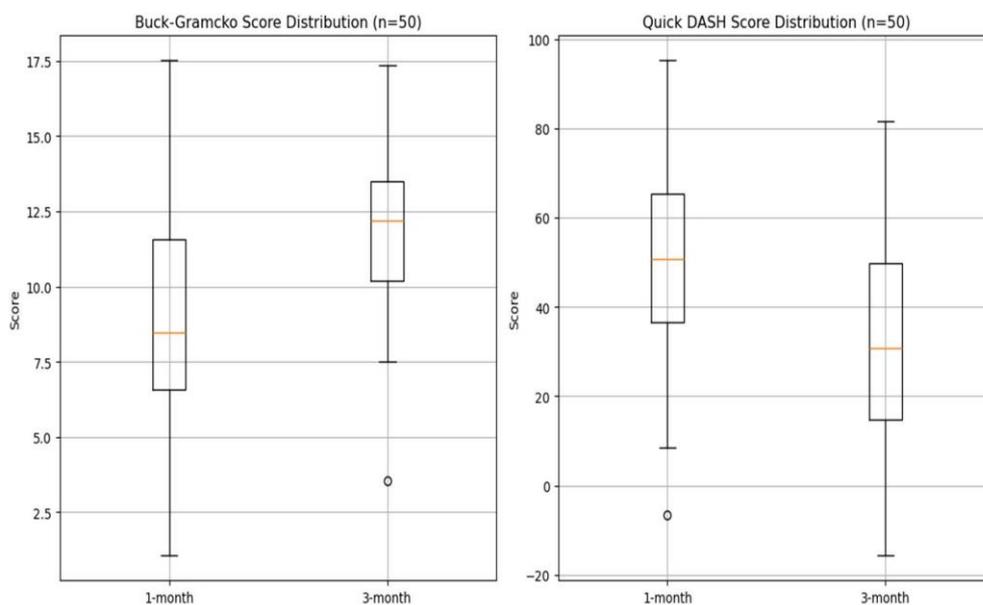
Figure 2: Box plots comparing Buck-Gramcko and Quick DASH scores at 1 month and 3 months postoperatively

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1717

Figure 3: Clinical improvement visualization from 1 month to 3 months postoperatively with Buck-Gramcko and Quick DASH scores

Subgroup Analysis of Functional Outcomes

Subgroup analyses revealed several factors significantly influencing functional recovery (Table 2). Younger patients (<30 years) showed significantly greater improvement in both Buck-Gramcko (Δ+2.5) and Quick DASH (Δ−14.2) scores compared to older patients (p<0.05). Higher education was positively correlated with functional outcomes (p=0.01 for Buck-Gramcko; p=0.005 for Quick DASH). Students demonstrated the greatest improvement among occupational groups (Buck-Gramcko Δ+2.6, Quick DASH Δ−15.1; p<0.05).

Diabetic patients showed significantly lower improvement (Buck-Gramcko Δ+1.5 vs. Δ+2.4 in non-diabetics; p=0.001; Quick DASH Δ−9.8 vs. Δ−14.5; p<0.001). Non-smokers also demonstrated superior outcomes compared to smokers (p<0.05). There was no statistically significant difference based on sex or hand dominance.

Regarding injury characteristics, patients with accidental cuts achieved the best outcomes, while road traffic accidents yielded the poorest results (p<0.05). Single-digit injuries had significantly better recovery than multi-digit injuries (p<0.05). Patients without nerve involvement showed the greatest improvement (Buck-Gramcko Δ+2.6, Quick DASH Δ−15.8), while combined median and ulnar nerve injuries resulted in the worst outcomes (p<0.05). Early surgical intervention (<48 hours) was associated with significantly better scores than delayed repair (p<0.01). Secondary infection severely impaired outcomes, with infected patients showing minimal improvement (Buck-Gramcko Δ+0.8, Quick DASH Δ−4.5; p<0.001).

Table 2: Functional outcome changes (Δ) from 1 to 3 months by key clinical factors

Factor	Subgroup	Buck-Gramcko Δ	Quick DASH Δ	p-value
Age	<30 years (n=18)	+2.5	−14.2	0.04*
	30–50 years (n=20)	+2.1	−13.5	
	>50 years (n=12)	+1.8	−11.0	
Diabetes	Yes (n=16)	+1.5	−9.8	<0.001*
	No (n=34)	+2.4	−14.5	
Smoking	Yes (n=18)	+1.9	−11.2	0.02*
	No (n=32)	+2.3	−14.5	
Nerve Injury	None (n=10)	+2.6	−15.8	0.02*
	Median (n=18)	+1.9	−12.0	
	Ulnar (n=16)	+2.0	−12.5	
	Both (n=6)	+1.5	−9.8	
Timing	Early <48h (n=45)	+2.2	−13.5	0.001*
	Delayed (n=5)	+1.2	−8.2	
Infection	Yes (n=6)	+0.8	−4.5	<0.001*
	No (n=44)	+2.3	−14.0	
Digits	1 (n=12)	+2.5	−15.3	0.01*
	2 (n=16)	+2.2	−13.8	
	≥3 (n=22)	+1.8	−10.5	

Statistically significant (p<0.05)
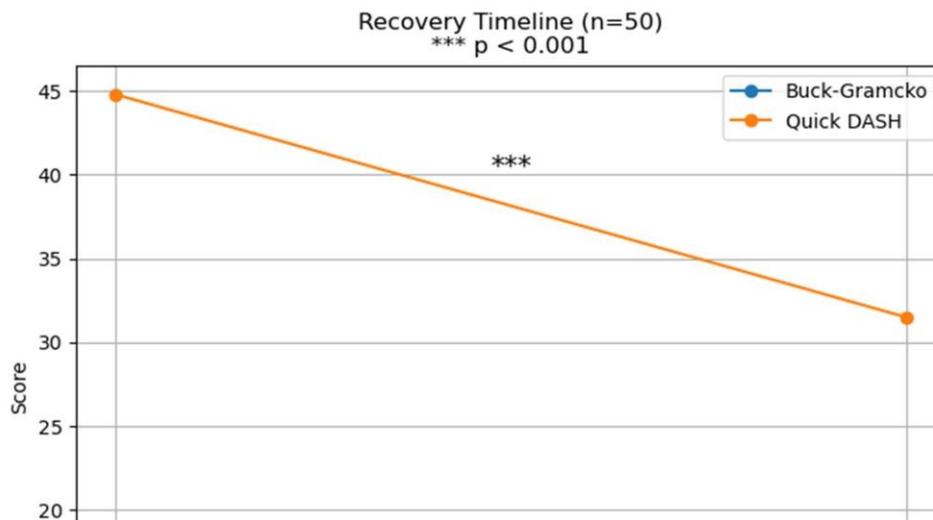
Figure 4: Combined improvement timeline showing Buck-Gramcko and Quick DASH score trends from 1 month to 3 months postoperatively

## Quality of Life Assessment: SF-36 Scores

Quality of life assessed at 3 months using the SF-36 questionnaire showed significant variations across demographic and clinical subgroups (Table 3). Younger patients (<30 years) reported the highest mean SF-36 scores (95.2) compared to the 30–50 years group (87.4) and >50 years group (76.1; p<0.001). No significant sex-based differences were observed (males: 85.3 vs. females: 88.7; p=0.42). Higher education was associated with superior SF-36 scores (92.7 vs. 78.3 in primary education; p=0.01). Manual labourers scored lowest among occupational groups (82.1; p=0.03).

Among clinical factors, diabetes reduced SF-36 scores by approximately 18% (73.8 vs. 91.5; p<0.001), while secondary infections caused the most severe decline (68.3 vs. 89.6; p=0.002). Patients with combined median and ulnar nerve injuries had the lowest quality of life scores (71.2; p=0.001). Early surgery was associated with significantly higher SF-36 scores compared to delayed intervention (89.4 vs. 74.2; p=0.01). SF-36 scores declined progressively with increasing number of digits involved (p=0.003).

Table 3: Mean SF-36 scores at 3 months by demographic and clinical factors

Factor	Group	N	Mean SF-36	p-value
Age	<30 years	15	95.2	<0.001*
	30–50 years	20	87.4	
	>50 years	15	76.1	
Education	Primary	12	78.3	0.01*
	Secondary	20	86.5	
	Higher	18	92.7	
Diabetes	Yes	14	73.8	<0.001*
	No	36	91.5	
Infection	Yes	6	68.3	0.002*
	No	44	89.6	
Nerve Injury	None	12	96.1	0.001*
	Median	15	82.3	
	Ulnar	10	84.5	
	Both	13	71.2	
Timing	Early	42	89.4	0.01*
	Delayed	8	74.2	

Statistically significant (p<0.05)
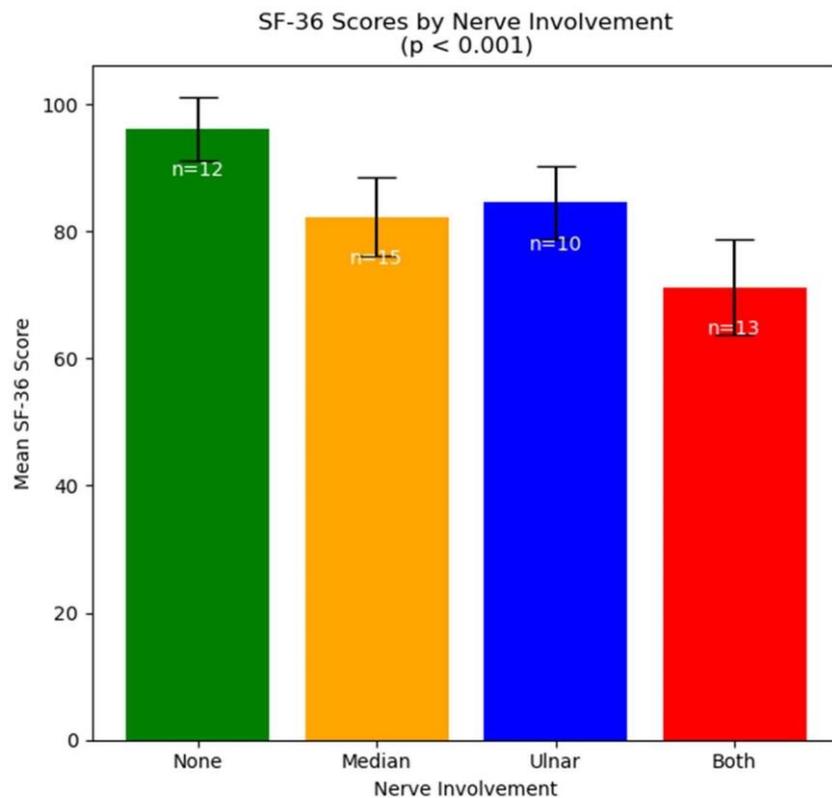
Figure 5: Mean SF-36 quality of life scores at 3 months based on nerve involvement status

Figure 6: Intraoperative photograph showing Zone V flexor tendon injury with lacerated FDS and FDP tendons

DISCUSSION

This prospective study provides comprehensive data on the functional and quality of life outcomes following Zone V flexor tendon repair using validated outcome measures in a tertiary care setting in Kerala. The results demonstrate significant improvement in both Buck-Gramcko and Quick DASH scores from 1 to 3 months postoperatively, with a moderate-to-large effect size, affirming the efficacy of the Modified Kessler four-strand technique combined with structured early rehabilitation.

The finding that younger patients (<30 years) achieved significantly superior functional outcomes is consistent with prior reports from specialized hand centres [14,15]. Enhanced tissue healing capacity, better therapy compliance, and fewer comorbidities in this age group likely contribute to their favourable recovery trajectory. Similarly, the positive correlation between educational level and outcomes (p=0.01 for Buck-Gramcko; p=0.005 for Quick DASH) underscores the critical role of health literacy in rehabilitation adherence and overall recovery [16].

The detrimental impact of diabetes on functional recovery, with diabetic patients demonstrating significantly lower improvements across all outcome measures (p<0.001), aligns with established evidence on impaired microvascular circulation, delayed collagen remodelling, and increased infection susceptibility in diabetic patients [17]. Smoking

similarly compromised outcomes (p<0.05), consistent with the known effects of nicotine on tissue oxygenation and collagen synthesis [18]. These findings reinforce the importance of preoperative counselling regarding smoking cessation and glycaemic control.

The significant association between early surgical intervention (<48 hours) and better outcomes (p<0.01) confirms the well-established principle that timely repair minimizes tendon retraction, muscle fibrosis, and adhesion formation [19]. In our study, 90% of patients underwent early repair, likely reflecting the advantages of a tertiary care centre with round-the-clock surgical services. The markedly poor outcomes in the delayed surgery group highlight the need for efficient referral pathways to specialized centres.

Nerve involvement emerged as a critical determinant of both functional outcomes and quality of life. Patients with combined median and ulnar nerve injuries showed the worst Buck-Gramcko improvement (Δ+1.5) and the lowest SF-36 scores (71.2), consistent with the findings of Rogers et al. who reported full range of motion in only 50% of cases with simultaneous median and ulnar nerve lacerations [4]. The sensory and motor deficits resulting from nerve injuries necessitate prolonged rehabilitation incorporating sensory re-education strategies.

Secondary infection, though observed in only 12% of patients, had a devastating impact on outcomes (Buck-Gramcko Δ+0.8; Quick DASH Δ−4.5; SF-36 mean 68.3; p<0.001). This finding is particularly relevant for resource-limited settings where infection rates may be higher due to delayed presentation, limited sterile resources, and challenges in wound care management [9]. Strict adherence to aseptic protocols and early infection detection are paramount.

The quality of life assessment using SF-36 revealed that demographic and clinical factors extend their influence beyond physical function to affect psychological well-being and social participation. The significantly lower SF-36 scores in older patients, those with comorbidities, and those with complex injuries emphasize the need for a holistic, patient-centred approach to rehabilitation that addresses not only physical recovery but also psychosocial support [20].

The findings of this study are consistent with prior reports from high-volume hand centres that emphasize early surgery, nerve-sparing repair, and early mobilization protocols [14,21]. However, this study contributes uniquely by providing data from a resource-limited setting in southern India, highlighting the additional barriers to optimal recovery such as delayed presentation, limited therapy access, and socioeconomic challenges specific to developing countries. The use of multiple standardized outcome tools (Buck-Gramcko, Quick DASH, and SF-36) provides a comprehensive perspective on recovery that encompass both clinical and patient-reported dimensions.

LIMITATIONS
This study has certain limitations that merit consideration. The follow-up period was limited to 3 months, which may not capture late complications such as tendon adhesions, stiffness, or late rupture. Being a single-centre study with a relatively small sample size (n=50), the generalizability of findings to other populations and healthcare settings may be limited. Patient-reported outcome measures (Quick DASH and SF-36) are subject to recall and subjective bias. Furthermore, while a standardized rehabilitation protocol was advised, individual variations in therapy adherence could not be uniformly quantified or controlled across all subgroups.

CONCLUSION
This study demonstrates that Zone V flexor tendon injuries, when managed with timely surgical intervention using the Modified Kessler four-strand technique and structured rehabilitation, can achieve significant improvement in hand function over 3 months as assessed by Buck-Gramcko and Quick DASH scores. Younger age, higher education level, absence of comorbidities (diabetes, smoking), early surgical repair (<48 hours), limited tendon involvement, and absence of infection were consistently associated with better functional outcomes. Conversely, nerve injuries, multi-digit involvement, delayed surgery, and secondary infections significantly impaired recovery.

The SF-36 quality of life assessment confirmed that the same factors influencing functional recovery also impact perceived physical and mental well-being. These findings underscore the multifactorial nature of recovery following Zone V flexor tendon injuries and the necessity for a comprehensive, patient-centred approach addressing surgical technique, comorbidity management, patient education, and consistent rehabilitation. Future multicentre studies with larger sample sizes and longer follow-up are warranted to validate these findings and develop context-specific rehabilitation protocols for resource-limited settings.

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