THINK INDIA JOURNAL

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

Functional Outcome of Hand Following Zone-II Flexor Tendon Injuries Using Strickland and Modified Kleinert Regime: Comparative Study

Suresh Mani[#*], Baranitharan Ramamoorthy[##]

#* Associate Professor, Department of Physiotherapy, Lovely Professional University, Punjab, India.

Lecturer, Department of Health Rehabilitation Sciences, College of Applied Medical Sciences Shaqra University, Shaqra, Kingdom of Saudi Arabia.

Corresponding Author
Dr. Suresh Mani, MPT, Ph.D.,
Associate Professor,
HOD, School of Physiotherapy & Paramedical Sciences,
Faculty of Applied Medical Sciences, Lovely Professional University,
Punjab, India, Mobile: +91 9879331006
email: suresh.22315@lpu.co.in / vemsuresh@gmail.com
ORCID ID: https://orcid.org/0000-0003-1703-092X

Abstract

Restoring of hand function after flexor tendon injuries is one of the greatest challenges to hand surgeons and therapists especially injuries at zone II due involvement of synovial sheath and pulleys. There have been many post-operative protocols used in treating zone II injuries, such as Strickland's and Kleinert protocol, however effective of these protocols in improving hand function is not yet established. Therefore, the objective of the study was to prospectively study the functional outcome of hand following zone II flexor tendon injuries using Strickland's and Modified Kleinert post-operative protocols. The standard modified Kessler's suture technique was used to repair 20 patients with zone II flexor tendon injuries of 35% of FDP and 65 % with FDS & FDP assigned into Kleinert (KG) and Strickland (SG) groups comprising 10 patients. The total active range of motion (TAM) was assessed at the end of 3rd, 6th and 8th post-operative weeks, and grip strength was assessed at end of 8 weeks. The modified Strickland assessment systemand 10% scale of grip strength was used to assess the functional outcome of hand. In KG, 40% of them showed excellent and good and 20% fair improvement in the functional outcome of

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

hand whereas 40 % of subject showed excellent, 50 % of good and 10 % of the fair in SG. There was an 18.8% (SG) and 21.8 % (KG) reduction in grip strength as compared with normal hand. The differences in TAM between the KG and SG at the time between 1st& 2nd assessments and 1st and 3rd assessments were statistically significant ($p< 0.05$). Therefore, both Strickland's and Kleinert protocols are equally effective in improving the hand function following zone II flexor tendon injury.

INTRODUCTION

Flexor tendon injury is one of the common as an increased incidence of industrial injuries due to rapid industrialization of our country. Flexor tendon injuries account for 1% of total crush hand injuries with an incidence rate of 7% per annum [1]. Often, the flexor tendon is the common clinical presentation in severe crush injuries with or without concomitant injuries to bone and neuro-vascular structure caused by road traffic or machinery accidents, glasses or knife laceration and occasionally avulsion injuries[2]. The long flexor tendons of the hand originate as common tendon from the medial epicondyle and anterior forearm, perform bending movement of the fingers. Each flexor tendon is a thick string-like structure encased in the tunnel, flexor tendon synovial sheaths which guide and lubricate the tendon during movement. In each finger, the synovial sheets condensed to form the six annular and three cruciform pulleys which hold the tending in place and prevent bowstring of the tendon during flexor muscle contraction[3].

The functional activity of hand required the coordinated and précisedcontractions of extrinsic and intrinsic muscles of the hand. However, flexor tendon or sheaths injuries result in considerable disability and participation restriction. Particularly, the zone II flexor tendon injuries create a surgical challenge due to unpredictable post-operative outcomes due to poor blood supply and increased risk of adhesion.Therefore, skilfulsurgical repair followed by effective postoperative management is required[4], [5]which focuses to maintain the balance between repaired tendon protection from troubling forces and avoiding adhesions between repaired tendon and the paratendinous structures. Restoring function after zone II flexor tendon injuries has been thegreatest challenge to hand surgeons and hand therapist due involvement of synovial sheath and pulleys. Literature showed that early post-operative mobilization is effective in improving the tendon gliding and excursion, and enhance the tensile strength and triggers the morphological rebuilding of the lacerated injured tendon[6]. Various kinds of exercise protocols

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

proposed and administered in the clinical practice assisted by immobilization, positioning, and mobilizing splints in the post- operative repair period[3].

Early passive mobilization, dynamic traction splinting method (active extension and rubber band flexion) introduced by Kleinert in1973 resulted in significant improvement of final outcomes of repaired flexor tendons, particularly in zone II[7], [8]. On the other hand, the early active mobilization, described by Strickland is an "active-hold" or "place-hold active mobilization" protocol[5]. The fingers are placed passivity in flexion, and the subjects maintains the flexion with a minimal muscle contraction. However, the effectiveness of these post-operative protocols has not yet fully established. Therefore, the current study was aimed to measure the functional outcome of hand following zone II injuries treated with Strickland and modified Kleinert post-operative rehabilitation protocols.

METHODS

Study Design

It is a quasi-experimental design adopted to compare the functional outcome of two similar groups underwent repair of zone II flexor tendon injury. The patients` were assessed active range of motion of Metacarpophalangeal (MCP) and Interphalangeal (IP) joints postoperatively at the time of 3^{rd}, 6^{th} and 8 weeks. The study subjects were also re-evaluated for any post-operative complications. The grip strength including power grip and pinch (tripod, key, and Pulp to Pulp) were measured at 8th week postoperatively.

Study Setting

The study was conducted in the department of hand therapy, Plastic Surgery, PSG Hospital, Coimbatore, Tamil Nadu.

Population and Sampling

Twenty patients with single or multiple digit flexor tendon injury of Zone II of the handundergone tendon repair were assigned into 2 groups; Strickland group (SG) and modified Kleinert (KG) regime group. Each group comprises of 10 patients. SG treated with Strickland protocols and KG group with modified Kleinert protocol [9]for 8 weeks.The patient was operated using Kessler's core suture techniques[10]. The study population was selected by

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

convenience sampling method. The respective group of SG and KG were treated using post-operative protocols described by Kleinert and Strickland protocols.

Inclusion Criteria

The patient underwent surgery for lacerated flexor digitorum profundus tendon with or without flexor digitorum superficialis injury in Zone II of the index, middle, ring, and small fingers.

Exclusion Criteria

The exclusion criteria include the subjects with a de-gloving injury,metacarpal, and phalangeal bone fractures, amputated digits, arthritis of hand, old hand injury or trauma, congenital hand deformities, and infection, necrosis or ischemic tissue in the injured hand

Outcome Measures

Joint range of motion: The joint range of motion was measured at 3^{rd}, $6^{th,}$ and 8^{th}-week postoperatively.

Function Active Range of Motion: Modified Strickland Assessment System was used to assess function active range of motion of injured fingers post-operatively at 3^{rd}, 6^{th} and 8^{th} weeks of post-operative rehabilitation. The hand goniometer was used for measurement of range of motions.

*Grip Strength:*The power grip was measured at the end of the 8^{th} week. The Jamar dynamometer was used to measure grip strength as per the recommended arm position. In this, the shoulder was neutrally adducted and neutrally rotated, elbow 90^0 with forearm at mid-prone and the wrist was held at 30^0 of dorsiflexion and 15^0 of ulnar deviation [11]. Therapist was taking three measures of grip strength and calculated the average of three of each hand [12].Each patient was educated on the importance of maintaining joint position. In addition, the therapist used the verbal cue for enhancing the patient effort in performing the grip strength test.

Procedure

The patient in each group was evaluated in detail to rule out any exclusion criteria. The patients who participated in the study were screened and informed consent obtained. The patients were treated with a strict schedule of exercises under the supervision of hand therapists. The Strickland group was receiving Strickland's protocol described by surgeon Strickland and

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

Kleinert group were received Kleinert zone II flexor tendon rehabilitation protocol. The duration of protocol was 8 weeks. The post-operative goniometric measurement of joint motion active flexion and extension of Metacarpophalangeal (MCPs) and Interphalangeal (IPs) joints were taken at 3rd, 5th and 8 weeks post-operatively. The handgrip strength was measured at the end of 8 weeks postoperatively. The collected data was entered into database created in Microsoft Accesses database.

Data Analysis

The collected data were analyzed with SPSS software version 11. The demographic baseline data and types of injuries of two groups analyzed with chi-square statistics and independent 't' testrespectively.The comparison of active range of motion between the groups at time of 1st and 2nd assessment and 1st and 3rd assessments were analyzed using independent 't' tests. The changes in active range of motion in the individual groups between 1st and 2nd assessment and 1st and 3rd assessment were analyzed using paired 't' tests.

RESULTS

Table 1 shows the demographic characteristic and types of injuriesof two groups. The chi-Square test was used to compare the association between the groups and found the age, gender, side involved, hand dominance and tendon injury were not statistically significant. This study was compared the functional outcome of hand following zone II flexor tendon injuries treated with Strickland and modified Kleinert post-operative protocols. Strickland group comprises eight males (80%) and two females(20%) and the mean age of 32.2(range 18-65)years and the KG had eight males and two females with mean age of 29 (rage 17- 44)years. The baseline data statistical analysis of two groups, the age (p = 0.56), gender (p = 0.60), side involved, and hand dominance and tendon injuries were not statistically significant. The mean of TAM in KG was 106.9 ± 17.72 at 3rd week, 115.3 ±16.63 at 6th weeks and 125.7 ±11.32, whereas in SG, the TAM was 114 ±32.26 at 3rd weeks, 127 ±28.84 at 6th weeks and 129 ±24.67 at 8th weeks post-operatively.

In SG,there was statistical significant improvement in TAM found between 1stand 2nd assessments (mean difference = 10.90 ± 6.61; CI= 6.17 - 15.63, p = 0.05) and 1st and 3rd (mean difference = 23.20 ± 13.43; CI= 13.60 -32.80, p<0.05) assessments. Similarly, in KG, there was statistical significant improvement in total active motion (TAM) found between 1stand 2nd assessments (mean difference = 8.40 ± 4.48; CI = 5.20 - 11.60. p< 0.005) and 1st and 3rd (mean

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

difference = 18.80 ± 10.61; CI = 11.21 – 26.39, p< 0.05) assessments (Table 2). However, there was no statistical significance between the two groups was compared between 2nd and 1st assessment and 3rd and 1st assessments. The mean grip strength of the injured hand was 67% and 78% that of the non-injured hand in SG and KG group respectively. The mean grip strength with 10% rule was 63.3 % in SG and 72.2 % in KG groups. There wasan 18.8% reduction grip strength in SG (Table 3) and 21.8 % reduction in KG (Table 4) as compared with uninjured hand.

Discussion

This study was aimed to evaluate the functional outcome of hand following zone II injuries treated with Strickland and modified Kleinert post-operative rehabilitation protocols. Based on the statistical analysis and interpretation, it was found that the postoperative patients with zone II flexor tendon injuries of hand who have undergone a rehabilitation program of Strickland and Kleinert protocols had improved in the percentage of total active motion. Forty percent in KG and 50% in SG were shown good functional outcomes of hand whereas 20% in KG and 10% in SG were displayed fair amount of functional outcome. None of the patients was shown poor results either with SG and KG.

Particularly in zone II injuries, an exemplary result following flexor tendon remains a considerable challenge[6]. Literature reports various important factors determine the successful outcome of Zone-II tendon injuries. These factors includelevel of injury, number of fingers, operation type and surgical techniques and post-operative rehabilitation program[13]. The difference in suturing technique and surgical procedure varies for each zone of flexor tendon injury.The involvement of the annular and cruciate pulleys of finger makes the zone II injury is the most difficult to repair. It is vital that the synovial sheath's vascular system should continue the provide the environment repaired tendon for healing and gliding as the zone II digital sheath was referred to as a surgical no-mans-land[14]. Historically, poor results with zone II repairs have compelled the clinician to develop and testing the types of various post-operative protocols for zone II injuries which advocate the application of stress or movement to the repaired flexor tendons[15]. In our study, it was noted that the post-operative patients with zone II flexor tendon

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

injuries of hand who have undergone a rehabilitation program of Strickland and Kleinert protocols had improvement in the percentage of total active motion.

Limitation and recommendation

This study is having several limitations. Firstly, the study included a small sample size of 20, therefore, future studies should be planned with higher sample size. Secondly, the number of treatment sessions was limited due to the patients' inconvenience in receiving the treatment daily. This was handled through recording each subject was advised to perform the exercise at home as per the demonstration and education. Finally, this study reports the functional outcome based on Strickland's assessment system which is insufficient to reflect the other components such disability and participation restriction. Hence, future studies should be conducted with long term follow-up to analyze the job-specific outcome. The other outcome measures such as disability arm shoulder and hand (DASH)and function scale like 9 peg holes' tests should be employed in future studies.

Conclusion

The Strickland and Kleinert post-operative protocols are equally effective in improving the functional outcome in post-operative patients with zone- II injury. However, future studies should be planned to study the long-term effect of these protocols in randomized controlled study design with adequate number of samples with additional outcome measures of disability and participation restrictions.

Reference

[1] M. Manninen, T. Karjalainen, J. Määttä, and T. Flinkkilä, "Epidemiology of flexor tendon injuries of the hand in a Northern Finnish population," *Scand. J. Surg.*, vol. 106, no. 3, pp. 278–282, 2017.

[2] M. K. Chang and S. C. Tay, "Flexor Tendon Injuries and Repairs: A Single Centre Experience," *J. Hand Surg. (Asian-Pacific Vol.*, vol. 23, no. 04, pp. 487–495, 2018.

[3] C. J. Dy and A. Daluiski, "Update on zone II flexor tendon injuries," *JAAOS-Journal Am. Acad. Orthop. Surg.*, vol. 22, no. 12, pp. 791–799, 2014.

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

[4] J. W. Strickland, "Results of flexor tendon surgery in zone II.," *Hand Clin.*, vol. 1, no. 1, pp. 167–179, 1985.

[5] J. W. Strickland and S. V. Glogovac, "Digital function following flexor tendon repair in Zone II: A comparison of immobilization and controlled passive motion techniques," *J. Hand Surg. Am.*, vol. 5, no. 6, pp. 537–543, 1980.

[6] H. M. Starr, M. Snoddy, K. E. Hammond, and J. G. Seiler, "Flexor tendon repair rehabilitation protocols: A systematic review," *J. Hand Surg. Am.*, vol. 38, no. 9, pp. 1712-1717.e14, 2013.

[7] G. Fasching, B. Schmidt, H. Friedrich, and J. Mayr, "Dynamic splinting after flexor tendon injuries of the hand in childhood," *Handchirurgie, Mikrochirurgie, Plast. Chir. Organ der Deutschsprachigen Arbeitsgemeinschaft fur Handchirurgie Organ der Deutschsprachigen Arbeitsgemeinschaft fur Mikrochirurgie der Peripher. Nerven und Gefasse Organ der V..*, vol. 30, no. 4, pp. 243–248, 1998.

[8] A. Zyluk, "Methods of rehabilitation of fingers after the repair of flexor tendon injuries of first and second degree," *Chir. Narzadow Ruchu Ortop. Pol.*, vol. 64, no. 3, pp. 327–333, 1999.

[9] H. E. Kleinert, "Primary repair of zone 2 flexor tendon lacerations," in *American Academy of Orthopaedic Surgeons. Symposium on tendon surgery in the hand*, 1975, pp. 91–104.

[10] S. Rawson, S. Cartmell, and J. Wong, "Suture techniques for tendon repair; a comparative review," *Muscles. Ligaments Tendons J.*, vol. 3, no. 3, p. 220, 2013.

[11] A. R. Sousa-Santos and T. F. Amaral, "Differences in handgrip strength protocols to identify sarcopenia and frailty-a systematic review," *BMC Geriatr.*, vol. 17, no. 1, p. 238, 2017.

[12] N. A. Incel, E. Ceceli, P. B. Durukan, H. R. Erdem, and Z. R. Yorgancioglu, "Grip Strength : Effect of Hand Dominance," vol. 43, no. 5, pp. 234–237, 2002.

[13] B. Elhassan, S. L. Moran, C. Bravo, and P. Amadio, "Factors that influence the outcome of zone I and zone II flexor tendon repairs in children," *J. Hand Surg. Am.*, vol. 31, no. 10, pp. 1661–1666, 2006.

[14] P. P. Kotwal and M. T. Ansari, "Zone 2 flexor tendon injuries: Venturing into the no man's land," *Indian J. Orthop.*, vol. 46, no. 6, p. 608, 2012.

[15] A. Chesney, A. Chauhan, A. Kattan, F. Farrokhyar, and A. Thoma, "Systematic review of

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

flexor tendon rehabilitation protocols in zone II of the hand," *Plast. Reconstr. Surg.*, vol. 127, no. 4, pp. 1583–1592, 2011.

Tables

Table 1The baseline comparison of demographic data and type of injury.

	GROUPS	SG(N=10)	KG(N=10)	*p* values *
Age	10-20	1(10%)	3(30%)	0.565
	21-30	5(50%)	3(30%)	
	31-40	2(20%)	3(30%)	
	>40	2(20%)	1(10%)	
Sex	Male	8(80%)	10(100%)	0.606
	Female	2(20%)	0(0%)	
Side Involved	Right	10(100%)	10(100%)	
	Left	2(20%)	1(10%)	
Hand Dominance	Right	10(90%)	10(100%)	
	Left	0(0%)	0(0%)	
Tendon Injury	FDP	3(30%)	4(40%)	0.273
	FDP + FSD	7(70%)	6(60%)	

KG = KLEINERT GROUP, SG = STRICKLAND GROUP,
* Chi Squarepvalues / Fisher Exact Test.

Table 2 The changes in the total active range of motion (TAM) between the assessments.

		KG (n=10)	SG(n=10)	*p* value┼
Ass2 – Ass 1	Mean*	8.40 ± 4.48	10.90 ± 6.61	0.335273
	95 % CI	5.20 - 11.60	6.17 - 15.63	
	Paired t test	0.000	0.001	
Ass3 – Ass 1	Mean*	18.80 ± 10.61	23.20 ± 13.43	0.426867
	95 % CI	11.21 – 26.39	13.60 -32.80	
	Paired t test	0.000	0.000	

CI = confidence interval, KG = Kleinert Group, SG = Strickland, the values expressed as mean ± SD degree of changes between.
Ass 1 = Assessment of TAM at 3rd weeks
Ass 2 = Assessment of TAM at 6th weeks
Ass 3 = Assessment of TAM at 8th weeks
┼ independent t test comparing KG and SG
* Mean difference between the assessments

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

Table 3 : Percentage of hand grip deficit in injured hand compared with uninjured hand in Strickland group

Patient ID	Side	Finger	Grip strength (kg)		10 % of uninjured value	Uninjured values with 10 %	Injured / uninjured (%)	Injured / uninjured with 10 % rule	Hand Grip Deficit (%)
			Injured	Uninjured					
SL001	Right	Index finger	34.0	50.1	5.01	55.1	67.9	61.7	21.1
SL002	Right	Index finger	31.8	47.4	4.74	52.1	67.0	60.9	20.4
SL003	Right	Index finger	20.9	33.6	3.36	30.3	62.1	69.0	9.4
SL004	Right	Ring finger	34.9	52.2	5.22	57.4	67.0	60.9	22.5
SL005	Right	Middle finger	39.6	47.6	4.76	52.4	83.0	75.5	12.8
SL006	Right	Ring finger	33.6	47.4	4.74	52.1	70.8	64.4	18.6
SL007	Right	Middle finger	22.7	41.3	4.13	37.2	54.9	61.0	14.5
SL008	Right	little finger	31.9	56.2	5.62	61.9	56.8	51.6	29.9
SL009	Right	Index finger	31.8	45.7	4.57	50.3	69.4	63.1	18.5
SL010	Right	Middle finger	36.3	51.2	5.12	56.3	70.9	64.4	20.0
		Mean	**31.7**	**47.3**	**4.7**	**50.5**	**67.0**	**63.2**	**18.8**

Table 4: Percentage of hand grip deficit in injured hand compared with uninjured hand in Kleirnet Group.

Patient ID	Side	Finger	Grip Strength (kg)		10 % of uninjured value	Uninjured values with 10 %	Injured / uninjured (%)	Injured / uninjured with 10 % rule	Hand Grip Deficit (%)
			Injured	Uninjured					
KL001	Right	Index finger	33.2	50.1	5.01	55.1	66.2	60.2	21.9
KL002	Right	Index finger	31.8	47.4	4.74	52.1	67.0	60.9	20.4
KL003	Right	Index finger	20.9	33.6	3.36	30.3	62.1	69.0	9.4
KL004	Right	Index finger	34.9	52.2	5.22	57.4	67.0	60.9	22.5
KL005	Right	Ring finger	34.0	52.0	5.20	57.2	65.4	59.4	23.2
KL006	Right	Index finger	33.6	47.4	4.74	52.1	70.8	64.4	18.6
KL007	Right	Ring Finger	20.2	40.0	4.00	44.0	50.5	45.9	23.8
KL008	Right	little finger	31.9	56.2	5.62	61.9	56.8	51.6	29.9
KL009	Right	Index injury	31.8	55.0	5.50	60.5	57.7	52.5	28.7
KL010	Right	Middle finger	36.3	51.2	5.12	56.3	70.9	64.4	20.0
		Mean	**30.8**	**48.5**	**4.9**	**52.7**	**63.4**	**58.9**	**21.8**