Outcome of Carpal Tunnel Release with Longitudinal Mini Incision: A Prospective Cohort

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ABSTRACT

Objective: To determine the outcome of longitudinal mini incision (1.5 cm) for carpal tunnel release (CTR), using the Boston carpal tunnel questionnaire (BCTQ) to measure symptomatic relief, functional recovery, and postoperative complications.

Study Design: Experimental study.

Place and Duration of the Study: Department of Orthopaedic Surgery, The Aga Khan University Hospital, Karachi, Pakistan, from October 2023 to September 2024.

Methodology: A prospective analysis was conducted on 77 patients who underwent CTR with longitudinal mini incision. Parameters evaluated were the outcome with BCTQ symptoms and functional scores for patients who underwent mini-incision CTR. This was recorded preoperatively and at six months post release with the questionnaire.

Results: Seventy-five patients showed significant improvement (score value + p-value) in BCTQ symptom and functional score post-release at six months after the release of CT *via* mini-incision technique. The only complications 6 (8%) recorded were pillar pain 2 (2.7%) and complex regional pain syndrome 4 (5.3%), which resolved at 6 months postoperatively. There were no injuries to the median nerve using the mini-incision technique, and no recurrence was recorded.

Conclusion: Mini-incision technique was safe and effective for median nerve release in carpal tunnel syndrome (CTS), along with excellent outcomes at six months when evaluated with the BCTQ symptoms and functional scores.

Key Words: *Carpal tunnel syndrome, Mini incision carpal tunnel release, Boston carpal tunnel questionnaire.*

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INTRODUCTION

Carpal tunnel syndrome (CTS) arises as a result of the median nerve compression when it passes through the carpal tunnel (CT) at the wrist. CTS is the most frequent cause of nerve entrapment neuropathy and can be found within 3.8% of the general population.[1] The aetiology of CTS includes repetitive wrist movements, obesity, hypothyroidism, genetic predisposition, and autoimmune diseases.[2]

If CTS is not treated, it may progress to permanent median nerve damage and subsequent loss of hand function.[3] Primary treatment consists of practising proper hand ergonomics, counselling on weight loss, wrist orthosis, and use of painkillers. A steroid injection into the carpal tunnel may be beneficial after unsuccessful attempts at conservative therapy.[4] Those with severe CTS, as determined by the electrophysiologic testing and those who have not improved after conservative treatment, are good candidates for surgery.[5]

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A standard open CTR is the conventional surgical approach. An open CTR is done *via* an incision of approximately 5 cm in length, relieving the pressure on the median nerve and creating more space in the CT.[6] Although this method provides excellent visualisation, it may be associated with some complications such as consistent complete release of the entire retinaculum and the ability to detect anatomic variations. It can also be associated with a number of complications such as flexor tendon entrapment, scar tenderness, flexion contracture at the wrist and thenar, and hypothenar (pillar) pain, all of which are difficult to recover from.[7] A new technique has been introduced to perform CTR through a 1.5-2.0 cm incision, which also releases the median nerve.[6] This mini-open CTR approach has the advantage of a smaller scar and causes less scar pain with a lower degree of pillar discomfort.

Developed in 1993, the BCTQ evaluates symptoms and functional impairment as patient-reported, caused by CTS.[8] There are two subscales in BCTQ. Symptom severity subscale (SSS), provides information on the level of symptoms, and a functional status subscale (FSS), evaluates the level of hand function. Together, they evaluate symptoms during the night and day, and difficulty with everyday tasks, respectively. The mean score for each scale is calculated in a score between 1 and 5. Higher scores indicate worse symptoms or function. The BCTQ is simple to use, completely free, and has been translated into

other languages and validated. Using the traditional test theory, it has been rigorously examined for validity and test-retest reliability.[9]

The aim of this study was to determine the outcome of longitudinal mini incision (1.5 cm) for CTR using BCTQ to measure symptomatic relief, functional recovery and postoperative complications.

METHODOLOGY

This is a single-group prospective descriptive study conducted at the Department of Orthopaedic Surgery, The Aga Khan University Hospital, Karachi, Pakistan, from October 2023 to September 2024. Approval was obtained from the Institutional Ethical Review Committee of the Aga Khan University Hospital, Karachi, Pakistan (Approval. No: 2023-8285-26782), ensuring the reliability and ethical conduct of the research. The sample size was calculated using the OpenEpi and University of California San Francisco Clinical and Translational Science Institute (CTSI) Softwares. The minimum estimated sample size was 18, with a 20% inflation rate. The sample size chosen was 30. Informed consent was taken from the patients at the time of their procedure. Demographic and clinical data were collected preoperatively. Preoperatively, the BCTQ was used for all patients. All patients underwent mini incision CTR under local anaesthesia in the operating room as a daycare procedure. The BCTQ was again filled by the same patients at six-month follow-up after surgery.

Inclusion criteria were patients presenting to the outpatient orthopaedic surgery clinic with suspicion of CTS. The criteria for CTS were paraesthesia or pain in the median nerve territory, paraesthesia at night, aggravation of this paraesthesia by activities such as holding a cell phone or book or while opening a jar, and paraesthesia relieved by shaking the hand (positive flick sign).[10] Exclusion criteria were pregnancy, patients with known cases of hereditary neuropathy, and age less than 18 years. Before the procedure, patients underwent a nerve conduction velocity test for definite diagnosis and a severity evaluation by a single experienced hand surgeon as recommended by Mooar *et al*.[11]

An experienced orthopaedic hand surgeon performed all the surgical procedures. Intraoperatively, 10 ml of injection 2% lidocaine with adrenaline and 10 ml of injection 0.5% bupivacaine were instilled at the surgical site. The patients' position was supine with the arm abducted on the hand trolley with the forearm supinated to give exposure to the wrist. No tourniquet was applied. Simple instruments were utilised, including a size 15 blade for skin incision, a second size 15 blade for releasing the transverse carpal ligament (TCL), bipolar diathermy for haemostasis, small size retractors, fine tissue dissecting scissor, Debakey forceps, and a McDonald dissector. Longitudinal 1.25 to 1.5 cms palmar incision was marked at the point between the thenar and hypothenar eminence distal to the distal wrist crease (Figure 1). Incision was given as marked, dissection was done till the TCL, and McDonald dissector was passed inferior to the TCL to protect the median nerve. Size 15 blade was utilised to release the TCL from proximal to distal over the McDonald dissector with the curved part set as the distal limit of dissection (Figure 2A, B). This technique reduced the risk of iatrogenic median nerve injury as it was covered by the McDonald dissector at all times. After TCL was released, complete release was verified by the direct visual observation of the median nerve (Figure 3). The wound was closed with Prolene 4-0 suture and a bulky non-compression bandage was applied. No brace or splint was given, and movement of fingers was encouraged immediately postoperatively. The patients were discharged home on the same day. Follow-up for wound inspection was advised on 5th and 10th post-operative day. The patient was allowed to restart light work two weeks after the surgery.

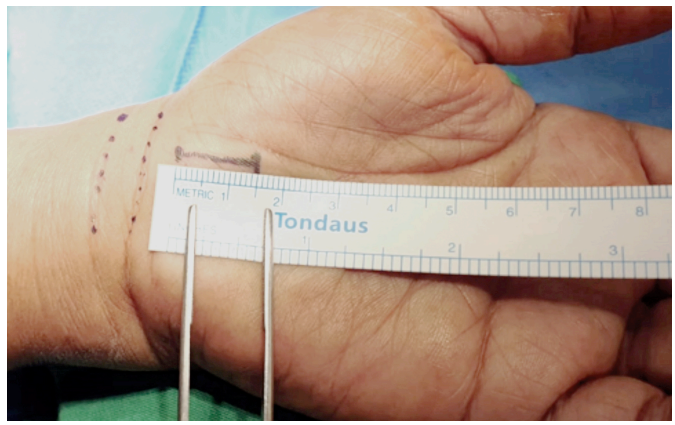

Figure 1: Incision for carpal tunnel release.

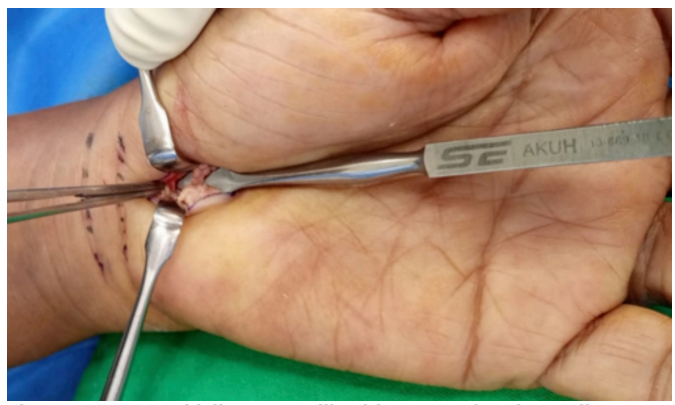

Figure 2A: McDonald dissector utilised for protecting the median nerve proximally.

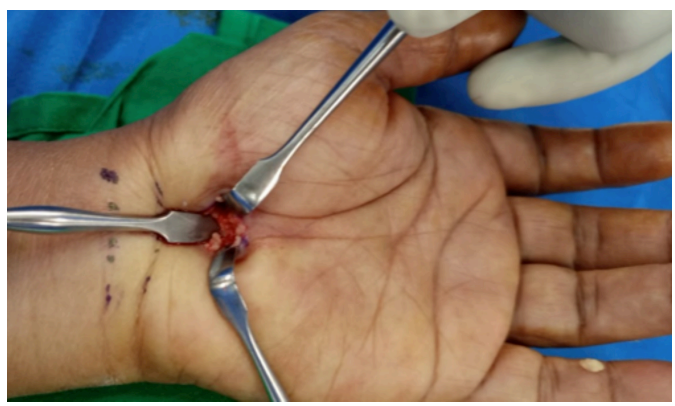

Figure 2B: McDonald dissector utilised for protecting the median nerve

distally.

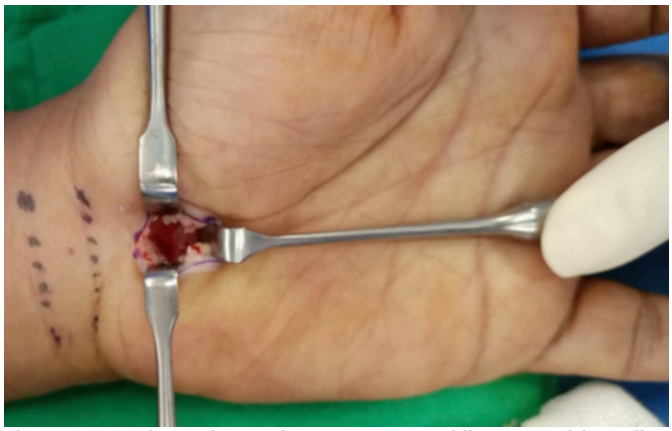

Figure 3: Complete release of transverse carpal ligament with median nerve visible.

Data were recorded on a preformed structured proforma. Demographic variables included age, gender, laterality, hand dominance, BMI, comorbidities, and employment status. Perioperative data included electromyography and nerve conduction velocity (EMG-NCV) results summarised into mild, moderate, and severe neuropathy, duration of surgery, and any complications during or after surgery. Functional and symptomatic improvement was recorded as the difference between the pre- and postoperative BCTQ scores.

Data entry and analysis was done via Stata (version 17.2). Continuous variables were expressed as mean ± standard deviation after assessing for normality, and categorical data were expressed as frequency and percentages. Independent t-test was applied to assess the mean difference in improvement of BCTQSS functional and symptoms score between the categorical variables such as gender, hand dominance, laterality, and EMG findings. Simple linear regression analysis was also performed to assess the magnitude of the effect of predictor variables on the outcome keeping the level of significance at 5%.

RESULTS

A total of 77 CTR procedures were performed using the described technique from October 2023 to September 2024. Two patients were lost to follow-up. The patients' cohort revealed a higher number of female patients *i.e.* 61 (81.3%) compared to male patients 14 (18.7%). The average age of the patients was 49.5 ± 9.6 years (ranging 32-78 years). The right hand was affected in 53 (70.7%) of the patients as compared to left hand (n = 22, 29.3%). Right-hand dominance was found in 62 (82.7%) patients. Forty-three (57.3%) of the patients had no comorbidities, whereas 15 (20%) of the patients had Diabetes mellitus, 12 (16%) had hypertension, 2 (2.7%) had hypothyroidism, and 3 (4%) had rheumatoid arthritis. Mean BMI was 33.5 kg/m^2 ± 3.8. The mean duration of the patients' symptoms was 9.6 months ± 5.5. Forty-two (56%) of the patients were non-working individuals and 30 (40%) of the patients were working, while only 3 (4%) were retired (Table I).

Table I: Patient characteristics.

Variables	All (n = 75)
Gender, n (%)	-
Male	14 (18.7%)
Female	61 (81.3%)
Age, mean (SD)	49.5 (9.6)
Body mass index, kg/m^2, mean (SD)	33.5 (3.8)
Comorbidities	-
None	43 (57.3%)
Diabetes mellitus	15 (20%)
Rheumatoid arthritis	3 (4%)
Hypothyroid	2 (2.7%)
Hypertension	12 (16%)
Employment status, n (%)	-
Employed	30 (40%)
Unemployed	42 (56%)
Retired	3 (4%)
Hand dominance / operated site, n (%)	-
Right	62 (82.7%) / 53 (70.7%)
Left	13 (17.3%) / 22 (29.3%)
Duration of symptoms (months)	-
1– 6	27 (36.0%)
6–12	32 (42.7%)
>Z12	16 (21.3%)

Table II: Association of predictive variables and Boston carpal tunnel symptoms score improvement points.

Variables	Mean ± SD	95% CI	Significance p <0.05*
Gender	-	-	-
Male	25.8 ± 7.0	21.7–29.8	0.39
Female	24.3 ± 5.5	22.9–25.7	
Hand Dominance	-	-	-
Right	24.5 ± 5.9	23.0–26.1	0.90
Left	24.8 ± 5.1	21.7–27.8	
Site of Surgery	-	-	-
Right	24.6 ± 5.9	23.0–26.3	0.90
Left	24.5 ± 5.5	22.0–26.9	
EMG Report	-	-	-
Moderate	21.4 ± 4.8	20.0–22.9	<0.001
Severe	29.1 ± 3.7	27.7–30.4	

**Independent student t-test.*

Table III: Association of predictive variables and Boston carpal tunnel functional score improvement points.

Variables	Mean ± SD	95% CI	Significance p <0.05*
Gender			
Male	14.9 ± 5.1	11.9–17.8	0.10
Female	17.0 ± 4.1	15.9–18.0	
Hand Dominance			
Right	16.3 ± 4.4	15.3–17.5	0.41
Left	17.4 ± 4.1	15.01–19.9	
Site of Surgery			
Right	16.8 ± 4.0	15.7–18.0	0.37
Left	16.0 ± 5.0	13.6–18.1	
EMG Report			
Moderate	16.0 ± 4.1	14.7–17.2	0.15
Severe	17.4 ± 4.6	15.7–19.1	

**Independent student t-test.*

Preoperatively, the EMG-NCS of patients 44 (58.7%) categorised into moderate degree of median nerve mononeuropathy and 31 (41.3%) as severe. Average time for the unilateral CTR was 17.2 ± 8.1 minutes (ranging 7-45 minutes).

Preoperatively, the mean BCTQSS was 40.1 ± 7.1 (ranging 25-54), which improved to a mean of 15.7 ± 3.5 (ranging 11-27). Preoperatively, the mean Boston CT questionnaire functional score (BCTQFS) was 30.2 ± 4.8 (ranging 12-40), which improved to 13.6 ± 3.8 (ranging 8-23). At the six-month follow-

up, the BCTQSS showed a mean improvement of 24.6 ± 5.8 points with a range of 12-41 points, and the BCTQFS showed a mean improvement of 16.6 ± 4.3 points with a range of 1-27 points.

Postoperatively, no patient experienced any early complications (infection, haematoma, and wound dehiscence). At 3 months, 4 (5.3%) patients developed complex regional pain syndrome Type-1, and 2 (2.7%) patients developed pillar pain (pain at the base of the thenar and hypothenar eminences). At 6-month follow-up, these symptoms resolved, and patients had no complications. Till their last follow-up at 6 months, none of the patients had a recurrence of their preoperative symptoms, and no patients required re-exploration.

Independent t-test was utilised for the assessment of BCTQS symptoms improvement points (Table II) and functional score improvement points (Table III), which showed a positive significance of severity on EMG-NCS on the BCTQSS improvement points mean. The rest of the variables showed no positive significance. Linear regression analysis was also performed. Simple linear regression results revealed that the B-intercept for improvement in BCTQSS symptoms component for severe neuropathy on EMG-NCV was 7.63 more as compared to the moderate findings on EMG-NCV ($p < 0.001$; CI = 5.5-9.7), which was significant. Moreover, regression results showed a trend towards improvement in BCTQSS functional component with a B-intercept of 1.46 more for severe neuropathy as compared to the patients with moderate findings; however, not significant ($p = 0.15$; CI = -0.54-3.47). The rest of the predictor variables had no significant association with the improvement scores as well.

DISCUSSION

This prospective, single-centre study verified the benefits of a mini-open CTR under local anaesthesia. The results showed improvement in terms of recovery, function, and symptoms in the long term (6 months). Improvements were of both clinical and statistical relevance.

The standard conventional open CTR is a routine procedure for effective CTR, but it utilises a 5-7 centimetre incision. Due to the large incision size, postoperative wound complications are more common as compared to a minimally invasive CTR.[12] Open CTR is associated with higher rates of postoperative wound infection and dehiscence and painful scarring. The desire to avoid these complications and get good clinical results while minimising the incision and exposure size has driven to the advancement of new minimally invasive surgical techniques. Various approaches have been modified to minimise these problems associated with the open CTR.[13]

Limited mini-incision CTR approach with this technique has been shown to have improved practicality and productivity as compared to the standard open CTR technique.[14] Minimally invasive CT surgery has been developed for complete release of the CT. The mini-open CTR technique has been refined by different surgeons *via* using different instruments. This study's technique involves the utilisation of a 1-1.5 cm incision at the valley between the hypothenar and thenar eminences, 0.5 cm distal to the distal palmar crease along with simple instruments (McDonald dissector) for the execution of the procedure, this is similar to Anbarasan *et al*.[15] Mini-open CTR is easier to perform and safe as compared to endoscopic CTR and does not require any special equipment and instrument.[16] The mini-incision CTR is also less invasive with a lesser rate of complications, shorter operative time, and is more cost-effective as it does not require any special instruments. A few studies have also reported this technique to decrease swelling of the mean nerve and scar formation at the inlet of the CT.[17] Numerous publications report the endoscopic CTR to have a greater risk of nerve injury and a higher cost as compared to the mini-open CTR.[18]

The study showed a mean age of 49.5 years, which is comparable to Ngoc *et al*.'s study.[19] Literature shows a higher incidence of CTS in females, which was also seen in the present study, with 81.3% of the patients being female. This study population had a mean duration of symptoms of 9.6 months which is similar to literature-reported mean duration of symptoms of 10.8 to 13.3 months.[20] Mean surgical time of the procedure in the present study was 17.2 minutes which is higher as compared to the reported-literature time of 10.8 and 12.0 minutes.[12]

The BCTQSS improved from 40.1 to 15.7 points postoperatively at the 6-month follow-up, with an improvement in mean point score of 24.6. This showed better improvement than the study by Yetis *et al*., whose BCTQSS improved from 42.3 to 25.8.[21] A study by Murthy *et al*. also showed post CTR BTCQSS of 12.9 and a BCTQFS of 9.4, which is comparable to the present study's post mean CTR scores of 15.7 and 13.6, respectively.[22]

Anbarasan *et al*. showed that the patients were happier with a mini surgical incision, and none of the patients encountered any complications such as motor branch nerve injury or cutaneous nerve injury,[15] similar results were seen in the present study. Lengthier incisions are also associated with longer healing times and, in some cases, even scar tenderness.[23] Minimally invasive CTR has other risks such as partial release and recurring events,[24] although in the present study, there were no recurrences and no partial release. This study showed early complication rates of 8%, which is comparable to Soltani *et al*.'s study which showed that 11% of the patients had an early complication. Literature reports complication rates in the range of 1 to 25%.[24] Complications of neurovascular injuries can be avoided by having a sound knowledge of CT anatomy, and careful dissection around the fragile structures (median nerve and superficial palmar arch cutaneous and motor branches). The authors utilised the technique to drive the blade softly towards the third intermetacarpal space and to stop as soon as no resistance is felt indicating complete division of the TCL, similar to Murthy *et al*.[22]

The strengths of this study are that it is a prospective cohort with all the cases being performed by a single experi-

enced surgeon, thereby limiting any confounding factors. The limitations of this study were relatively small sample size and a lack of comparison groups for techniques and different surgeons. However, this study warrants recommendations for future studies to include a comparison group and large sample size for better generalisability.

CONCLUSION

The mini-incision 1.5 cm technique demonstrated effectiveness and safety for release of the median nerve in CTS, with it being minimally invasive with a short operative time and low rates of complications and adverse events, as well as rapid return to hand movements with short surgical time.

ETHICAL APPROVAL:

Ethical approval was obtained from the Institutional Ethical Review Committee of the Aga Khan University Hospital, Karachi, Pakistan (Approval No: 2023-8285-26782).

PATIENTS' CONSENT:

Informed consent was obtained from all the patients.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

MAS, AG, MZ, MOF, MSI, PMH: Contribution to the conception, design of the work, acquisition, analysis, interpretation of the data, drafting of the work, and revision of the manuscript for important intellectual content.

All authors approved the final version of the manuscript to be published.

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