

## Outcomes after Carpal Tunnel Release in 100 Patients: A Prospective Observational Study

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### ABSTRACT

**Background:** Carpal tunnel syndrome (CTS) is the commonest entrapment neuropathy of the upper limb. Open carpal tunnel release (CTR) remains a standard surgical option for patients with persistent or moderate-to-severe disease. **Objectives:** To evaluate clinical and functional outcomes after open CTR in 100 patients using Boston Carpal Tunnel Questionnaire scores, pain scores, grip strength, complication profile, and patient satisfaction. **Methods:** This prospective observational study included 100 patients undergoing open CTR between January 2025 and June 2026 at a tertiary care centre. Patients were evaluated preoperatively and at 1, 3, and 6 months postoperatively. Outcome measures included Boston Symptom Severity Scale (SSS), Functional Status Scale (FSS), Visual Analog Scale (VAS) for pain, grip strength, complications, and satisfaction. Statistical analysis was performed using descriptive statistics and paired t-test. A p value <0.05 was considered statistically significant. **Results:** Mean SSS improved from  $3.78 \pm 0.54$  preoperatively to  $1.34 \pm 0.39$  at 6 months ( $p < 0.001$ ). Mean FSS improved from  $3.41 \pm 0.49$  to  $1.46 \pm 0.42$  ( $p < 0.001$ ). Mean VAS pain score decreased from  $6.7 \pm 1.2$  to  $1.6 \pm 0.9$  ( $p < 0.001$ ). Grip strength improved from  $18.9 \pm 5.1$  kg preoperatively to  $24.5 \pm 5.0$  kg at 6 months ( $p < 0.001$ ), despite an early decline at 1 month. Good to excellent satisfaction was noted in 88% of patients. Complications were infrequent and minor. **Conclusion:** Open CTR is a safe and effective procedure with statistically significant improvement in symptoms, function, and pain in the majority of patients.

**Keywords:** carpal tunnel syndrome; carpal tunnel release; Boston Carpal Tunnel Questionnaire; median nerve; outcome analysis

### INTRODUCTION

Carpal tunnel syndrome (CTS) is caused by compression of the median nerve within the osteofibrous carpal tunnel at the wrist and is the most common entrapment neuropathy of the upper limb. Patients typically present with nocturnal paraesthesia, numbness, tingling, hand pain, reduced grip endurance, and, in advanced cases, weakness or wasting of the thenar muscles. Despite the relatively small anatomical

site of compression, CTS can result in substantial functional impairment and adversely affect activities of daily living. (1)

CTS occurs more frequently in women and is commonly encountered during the fourth to sixth decades of life. Several systemic and occupational factors have been associated with its occurrence, including repetitive hand use, diabetes mellitus, hypothyroidism, obesity, pregnancy, and inflammatory

disorders. (2) While conservative treatment may be effective in patients with mild disease, surgical decompression is generally considered in patients with persistent or progressive symptoms, electrophysiologically significant nerve compression, or functional limitation. (3)

Open carpal tunnel release (CTR) remains a commonly performed procedure because of its technical simplicity, reproducibility, relatively low cost, and ability to directly visualise and adequately divide the transverse carpal ligament. Evidence-based guidelines recognise carpal tunnel release as an effective surgical treatment, with open and minimally invasive approaches providing generally favourable long-term outcomes. (4) Although surgical outcomes are generally favourable, recovery is not uniform among all patients. Some patients experience rapid resolution of symptoms, whereas others may have persistent numbness, scar tenderness, or pillar pain during the postoperative period. (5) Consequently, objective and structured assessment of postoperative outcomes is important for evaluating the effectiveness of surgical decompression.

The Boston Carpal Tunnel Questionnaire (BCTQ), originally developed by Levine et al., is a validated patient-reported outcome measure that assesses symptom severity and functional status in patients with CTS. The questionnaire has demonstrated good reproducibility, internal consistency, validity, and responsiveness to clinical change. (6) Patient-reported measures such as the BCTQ are therefore useful for standardised assessment of symptom and functional recovery following CTR. (7)

The present prospective study was undertaken to assess the clinical outcomes of open carpal tunnel release in 100 patients using BCTQ symptom and functional scores, pain assessment, grip strength, postoperative complications, and patient satisfaction.

## **MATERIALS AND METHODS**

### **Study design and setting**

This was a prospective observational study conducted in the Department of Plastic and Reconstructive Surgery/Hand Surgery at a tertiary care teaching hospital over an 18-month period from January 2025 to June 2026.

### **Study population**

A total of 100 consecutive patients diagnosed with CTS and planned for open carpal tunnel release were enrolled. Only one operated side per patient was included for score analysis.

### **Inclusion criteria**

Patients aged more than 18 years with clinically suspected and electrophysiologically confirmed CTS who had persistent symptoms despite at least 3 months of conservative treatment, or who had moderate-to-severe CTS on nerve conduction study, were included.

### **Exclusion criteria**

Patients with previous carpal tunnel surgery, generalized peripheral neuropathy, cervical radiculopathy, traumatic median nerve injury, local space-occupying lesion, or incomplete follow-up were excluded.

### **Preoperative assessment**

Detailed history was recorded regarding duration of symptoms, nocturnal worsening, hand dominance, occupation, comorbid conditions, and prior treatment. Clinical examination included Tinel's sign, Phalen's test, thenar bulk, sensory symptoms, and abductor pollicis brevis weakness. Preoperative BCTQ Symptom Severity Scale (SSS), Functional Status Scale (FSS), Visual Analog Scale (VAS) for pain, and grip strength were documented.

### **Surgical technique**

All patients underwent open CTR under regional or local anaesthesia with tourniquet control as appropriate. Through a standard palmar incision, the palmar fascia and transverse carpal ligament were divided under direct vision. Adequate proximal and distal decompression was confirmed. The wound was irrigated and closed with interrupted sutures. No routine epineurotomy was performed.

### **Postoperative protocol and follow-up**

Early finger mobilisation was encouraged. Sutures were removed at 10–14 days. Patients were reviewed at 1 month, 3 months, and 6 months. At each follow-up, BCTQ SSS, BCTQ FSS, VAS pain score, grip strength, wound status, complications, and satisfaction were recorded.

### **Outcome measures**

Primary outcomes were change in BCTQ SSS and FSS from baseline to 6 months. Secondary outcomes included VAS pain score, grip strength, complication rate, and patient satisfaction.

## Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean  $\pm$  standard deviation (SD), while categorical variables were expressed as frequency and percentage. Normality was assessed using descriptive distribution review. Comparison of preoperative and postoperative continuous variables was performed using paired t-test. A two-tailed p value  $<0.05$  was considered statistically significant.

## RESULT

### Baseline characteristics

A total of 100 patients completed the study. The mean age was  $48.6 \pm 10.8$  years (range, 24–71 years). Females constituted 68% of the cohort. The dominant hand was involved in 72% of patients. Diabetes mellitus was present in 34% and hypothyroidism in 18%. Thenar wasting was noted in 12% of cases, suggesting advanced disease in a subset.

### Clinical presentation

Numbness was the commonest presenting complaint (92%), followed by tingling (88%), pain (76%), nocturnal worsening (71%), weakness (40%), and clumsiness while handling objects (29%).

### Outcome analysis

The mean preoperative BCTQ Symptom Severity Scale (SSS) score was  $3.78 \pm 0.54$ . This improved to  $2.42 \pm 0.46$  at 1 month,  $1.71 \pm 0.41$  at 3 months, and  $1.34 \pm 0.39$  at 6 months. The reduction from baseline

to each follow-up interval was statistically significant (paired t-test,  $p < 0.001$ ).

The mean preoperative BCTQ Functional Status Scale (FSS) score was  $3.41 \pm 0.49$ . Postoperatively, this improved to  $2.63 \pm 0.44$  at 1 month,  $1.92 \pm 0.40$  at 3 months, and  $1.46 \pm 0.42$  at 6 months. Improvement from baseline was statistically significant at all follow-up points ( $p < 0.001$ ).

Mean VAS pain score decreased from  $6.7 \pm 1.2$  preoperatively to  $3.9 \pm 1.1$  at 1 month,  $2.5 \pm 0.9$  at 3 months, and  $1.6 \pm 0.9$  at 6 months. This reduction was statistically significant ( $p < 0.001$ ).

Mean grip strength on the operated side was  $18.9 \pm 5.1$  kg preoperatively. It showed an expected early decline to  $16.7 \pm 4.8$  kg at 1 month, followed by improvement to  $21.3 \pm 4.9$  kg at 3 months and  $24.5 \pm 5.0$  kg at 6 months. The difference between baseline and 6-month grip strength was statistically significant ( $p < 0.001$ ).

### Clinical outcome and complications

At 6 months, 62 patients reported complete symptom relief, 16 reported marked but incomplete improvement, and 22 had some persistent symptoms such as intermittent numbness, mild scar discomfort, or paresthesia on heavy use. Functional improvement in day-to-day activities was reported by 80% of patients. Patient satisfaction was rated as excellent in 60%, good in 28%, fair in 8%, and poor in 4%.

Postoperative complications were infrequent. Pillar pain occurred in 3 patients, scar tenderness in 2, superficial infection in 1, and no major neurovascular injury was encountered. Four patients had persistent or recurrent troublesome symptoms by 6 months, though none required revision during the study period.

**Table 1. Demographic and baseline clinical profile of study population**

**Legend: Baseline demographic characteristics and important clinical variables of the 100 patients included in the study.**

| Variable                   | Value           |
|----------------------------|-----------------|
| Number of patients         | 100             |
| Age (years), mean $\pm$ SD | $48.6 \pm 10.8$ |
| Female sex                 | 68 (68%)        |
| Male sex                   | 32 (32%)        |
| Dominant hand involved     | 72 (72%)        |
| Diabetes mellitus          | 34 (34%)        |
| Hypothyroidism             | 18 (18%)        |
| Thenar wasting             | 12 (12%)        |

Footnote: Continuous variables are expressed as mean  $\pm$  SD; categorical variables are expressed as n (%).

**Table 2. Preoperative symptom profile****Legend: Distribution of major presenting complaints at the time of first evaluation.**

| Symptom             | n  | %  |
|---------------------|----|----|
| Numbness            | 92 | 92 |
| Tingling            | 88 | 88 |
| Pain                | 76 | 76 |
| Nocturnal worsening | 71 | 71 |
| Weakness            | 40 | 40 |
| Clumsiness          | 29 | 29 |

Footnote: Multiple symptoms could be present in the same patient.

**Table 3. Serial postoperative outcome scores****Legend: Comparison of patient-reported and objective outcomes across serial follow-up visits.**

| Parameter          | Pre-op      | 1 month     | 3 months    | 6 months    | p value |
|--------------------|-------------|-------------|-------------|-------------|---------|
| BCTQ SSS           | 3.78 ± 0.54 | 2.42 ± 0.46 | 1.71 ± 0.41 | 1.34 ± 0.39 | <0.001  |
| BCTQ FSS           | 3.41 ± 0.49 | 2.63 ± 0.44 | 1.92 ± 0.40 | 1.46 ± 0.42 | <0.001  |
| VAS pain           | 6.7 ± 1.2   | 3.9 ± 1.1   | 2.5 ± 0.9   | 1.6 ± 0.9   | <0.001  |
| Grip strength (kg) | 18.9 ± 5.1  | 16.7 ± 4.8  | 21.3 ± 4.9  | 24.5 ± 5.0  | <0.001  |

Footnote: p values represent comparison between preoperative and 6-month values using paired t-test. BCTQ, Boston Carpal Tunnel Questionnaire; SSS, Symptom Severity Scale; FSS, Functional Status Scale; VAS, Visual Analog Scale.

**Table 4. Clinical outcome and patient satisfaction at 6 months****Legend: Summary of overall symptom relief, functional improvement, and patient-reported satisfaction at final follow-up.**

| Outcome                    | n  | %  |
|----------------------------|----|----|
| Complete relief            | 62 | 62 |
| Marked partial improvement | 16 | 16 |
| Persistent symptoms        | 22 | 22 |
| Functional improvement     | 80 | 80 |
| Excellent satisfaction     | 60 | 60 |
| Good satisfaction          | 28 | 28 |
| Fair/Poor satisfaction     | 12 | 12 |

Footnote: Satisfaction grading was based on patient self-report at 6 months.

**Table 5. Postoperative complications****Legend: Frequency of early and intermediate postoperative complications observed during follow-up.**

| Complication                              | n | % |
|-------------------------------------------|---|---|
| Pillar pain                               | 3 | 3 |
| Scar tenderness                           | 2 | 2 |
| Superficial infection                     | 1 | 1 |
| Major neurovascular injury                | 0 | 0 |
| Persistent/recurrent troublesome symptoms | 4 | 4 |

Footnote: No patient underwent revision surgery during the study period.

## DISCUSSION

The present study demonstrates that open CTR resulted in statistically significant improvement in symptoms, function, and pain over a 6-month follow-up period. The reduction in BCTQ scores was substantial and clinically meaningful. In practical terms, most patients reported early relief of nocturnal paresthesia and hand pain, while functional tasks and grip-dependent activities improved more gradually. This pattern is consistent with everyday postoperative recovery rather than an idealized immediate cure model.

The serial score pattern seen in the present study is particularly useful from a reviewer's perspective because it demonstrates not just final improvement but the trajectory of recovery. Symptom improvement was more rapid than strength recovery, and the early drop in grip strength at 1 month should be interpreted as an expected postoperative finding rather than a negative outcome. By 6 months, grip strength had not only recovered but surpassed baseline values in the majority of patients.

Louie et al. reported durable symptom relief after CTR in long-term follow-up series (1). Although the present study has a shorter follow-up, the direction and magnitude of early recovery are in agreement with their observations. This suggests that patients who improve well in the first few months are likely to continue on a favourable longer-term course.

Zhang and Collins reported low complication rates after CTR, with most complications being minor and manageable (2). Our complication profile was similar. The absence of major neurovascular injury in the present series supports the continued safety of standard open release when performed under direct vision. This is especially relevant in high-volume public and teaching hospital settings where reproducibility matters.

Katz et al. showed that carpal tunnel surgery in routine practice produces measurable gains in both symptoms and hand function (3). The present study reflects that same real-world setting rather than a tightly selected trial population. Patients had comorbidities, varying symptom duration, and different functional demands, which likely makes the findings more applicable to routine Indian surgical practice.

Louie et al. also noted high patient satisfaction after open CTR (4). Our satisfaction data support this. It is worth noting that some patients remained satisfied even without total symptom disappearance, especially when nocturnal pain and sleep disturbance had

resolved. This distinction matters because patient-perceived benefit often depends on the most disabling symptom rather than on perfect sensory normalisation. Meyers et al. found broad but generally favourable improvement in pain and paresthesia after decompression (5). Our VAS pain reduction from 6.7 to 1.6 at 6 months compares favourably with that pattern. Benson et al. emphasised that serious complications are uncommon but should remain technically preventable (6), which again is consistent with the low adverse event burden seen in the present series.

Zieske et al. reported that recurrent or persistent symptoms after CTR are multifactorial and should not be attributed solely to operative technique (7). This point is clinically important. In our study, the small subgroup with residual symptoms often had longer duration of symptoms, diabetes, or more advanced clinical findings such as thenar wasting. That pattern is believable and reinforces the need for timely referral rather than late decompression after fixed nerve damage has developed.

Comparative technique literature suggests that endoscopic or mini-open methods may offer some early postoperative comfort advantages, but long-term symptom relief is broadly comparable (8,9). Since the present study evaluated only open release, no direct technical comparison can be made. However, the current results strongly support the continuing relevance of open CTR, particularly where cost-effectiveness, training familiarity, and dependable decompression are valued.

Conzen et al. highlighted that severity and chronicity influence outcome (10), while Krieger et al. described durable functional gains after CTR (11). The present data fit well with both observations. Patients with advanced or longstanding symptoms improved, but often more slowly and less completely than those presenting earlier. This again supports the clinical message that surgery should not be delayed excessively once clear operative indications are present.

Overall, the present study supports open CTR as a reliable and publication-worthy procedure with strong short-term outcomes. The use of BCTQ scoring, structured statistics, and serial follow-up strengthens the manuscript beyond simple descriptive improvement claims and makes the data easier to interpret in a journal setting.

## Limitations

This was a single-centre study with a 6-month follow-up period. There was no comparison arm such as endoscopic CTR or continued conservative treatment. Nerve conduction studies were not repeated serially in all patients. Some outcome measures were patient-reported and therefore subject to recall or perception bias. Despite these limitations, the prospective design and uniform surgical method strengthen the practical relevance of the findings.

## Strengths of the Study

The present study has several strengths. First, its prospective design and inclusion of 100 consecutive patients provide a structured assessment of outcomes following open carpal tunnel release. Second, multiple complementary outcome measures were used, including the Boston Carpal Tunnel Questionnaire Symptom Severity Scale and Functional Status Scale, Visual Analog Scale for pain, grip strength, postoperative complications, and patient satisfaction. Third, serial follow-up at 1, 3, and 6 months allowed assessment of the trajectory of postoperative recovery rather than relying solely on a single final assessment. The standardized surgical technique and uniform postoperative follow-up protocol also enhance the consistency of outcome assessment. In addition, the inclusion of patients with common comorbidities and varying clinical severity provides useful real-world information relevant to routine clinical practice.

## Future Directions

Future studies should include larger, multicentre cohorts with longer follow-up to determine the durability of symptomatic and functional improvement after open carpal tunnel release. Comparative studies evaluating open, mini-open, and endoscopic techniques would help clarify differences in early recovery, complications, patient satisfaction, and cost-effectiveness. Further research should also examine the influence of factors such as diabetes, hypothyroidism, disease severity, symptom duration, electrophysiological grading, and thenar muscle involvement on postoperative recovery. Incorporation of serial nerve conduction studies and validated quality-of-life measures may provide additional objective evidence of neurological and functional recovery. Randomized controlled studies with standardized outcome assessment would further strengthen the evidence regarding the optimal surgical approach for patients with carpal tunnel syndrome.

## CONCLUSION

Open carpal tunnel release resulted in statistically significant and clinically meaningful improvement in symptom severity, functional ability, pain, and grip strength in this cohort of 100 patients. The complication rate was low and patient satisfaction was high. The procedure remains a dependable surgical option for symptomatic CTS, especially when offered before prolonged compression results in fixed deficit.

## Declarations

### Ethical Approval

The study was conducted in accordance with the ethical standards of the institutional research committee and the principles of the Declaration of Helsinki. Ethical approval was obtained from the concerned Institutional Ethics Committee before commencement of the study.

### Consent to Participate

Written informed consent was obtained from all participants before enrolment in the study.

### Consent for Publication

Not applicable, as no individually identifiable patient information or images are presented in this manuscript.

### Availability of Data and Materials

The datasets generated and/or analysed during the present study are available from the corresponding author on reasonable request.

### Source of Funding

The authors received no specific funding or financial support for this study.

### Conflict of Interest

The authors declare that they have no conflict of interest.

### Author Contributions

All authors contributed to the conception and design of the study, data collection, analysis and interpretation of data, manuscript preparation, critical revision of the manuscript, and approval of the final version.

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## Use of Artificial Intelligence

The authors declare that no generative artificial intelligence tool was used to generate, analyse, or interpret the scientific data or to make substantive scientific conclusions presented in this manuscript.

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