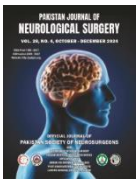

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Original Research

Comparative Study of Post-Operative Functional Outcomes of Open Carpal tunnel Release vs. Arthroscopic Carpal tunnel Release

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ABSTRACT

Objective: This study aimed to compare treatment modalities OCTR and ACTR in treating carpel tunnel syndrome. This study assesses the important key indicators including symptom severity, functional status, pain intensity, time of recovery, and rate of complications.

Methods: 80 patients presented in the hospital diagnosed with moderate to severe CTS were included over one year. Both surgical groups were assigned 40 patients and data was collected using the pre-operation and post-operation assessments utilizing the Shoulder and Hand Score, Disabilities of Arm, Visual Analog Scale for pain, Boston Carpel Tunnel Questionnaire, grip strength recovery, time taken to work again and incidence of complications.

Results: DASH Score: At six months post-surgery, the mean DASH score for ACTR (21.85) was slightly better than OCTR (23.91). BCTQ Scores: ACTR had better outcomes in both the symptom severity (mean 1.99 vs. 2.21) and functional status (mean 2.29 vs. 2.54). Pain Levels: Patients undergoing ACTR reported lower pain levels (VAS mean 2.65 vs. 2.92). Grip Strength Recovery: ACTR showed a significant advantage with patients regaining 89.07% of baseline grip strength compared to 84.60% for OCTR. Recovery Time: ACTR patients returned to work sooner (mean 39.28 days) compared to OCTR (mean 45.55 days), and ACTR exhibited a lower complication rate (7.46% vs. 9.53%).

Conclusion: Both OCTR and ACTR are highly effective surgical techniques for CTS treatment, offering significant symptom relief and functional recovery. While ACTR consistently demonstrated better benefits.

Keywords: Carpel Tunnel Syndrome, DASH (Disabilities of the Arm, Shoulder, and Hand) Score, BCTQ (Boston Carpal Tunnel Questionnaire), Open Carpal Tunnel Release (OCTR), Arthroscopic Carpal tunnel Release (ACTR).

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INTRODUCTION

Carpal tunnel syndrome (CTS) is characterized by compression of the median nerve in the wrist while crossing under the flexor retinaculum[1]. This condition affects 1-5% of the general population.[2]

If untreated, CTS can cause hand dysfunction and nerve damage which can be permanent.[3]

Carpal tunnel syndrome (CTS) affects a large number of populations, particularly individuals engaged in repetitive wrist movements like typists, and piano players as well as individuals with higher incidence of metabolic problems including diabetes, hypothyroidism, and obesity.[4] Women are negatively impacted with a higher prevalence rate due to anatomical and hormonal variances.[5]

Symptoms of CTS include numbness, pain in the hand in the median nerve innervated area, tingling, and atrophy of the hypothenar muscles in severe cases. Advancement of the disease may result in functional impairment and reduced grip strength.[6] Non-operative conservative management includes activity modification, Hyperextension splints, NSAIDs, and physiotherapy. Intralesional corticosteroid injection may yield transient relief in symptoms but decompression of the nerve is difficult in moderate to severe cases.[7]

A definitive treatment of CTS is median nerve decompression surgery when conservative management proves insufficient. The median nerve can be decompressed by the release of Transverse Carpal Ligament either by gold standard traditional Open Carpal tunnel Release (OCTR) or by new minimally invasive Arthroscopic Carpal tunnel Release (ACTR).[8,9]

OCTR is a time-tested Surgical treatment for CTS but it has many possible complications like hypertrophic scars at the incision site, tenderness at the incision site, hand weakness, slow recovery, and persistent pain.[10,11]

Endoscopic (Arthroscopic) carpal tunnel release is a minimally invasive procedure that has fewer complications such as less pain at the incision site, minimal scar formation, and faster recovery [12]. In an open procedure, there is a higher risk for iatrogenic injury to the thenar motor branch of the median nerve which lies more ulnarly in the palm.[17] With time, knowledge about wrist anatomy has improved, and different surgical methods and instruments have been presented. However, there is a lack of high-quality evidence.[20]

Certain anatomical variations can cause a higher risk of neurovascular injuries during minimally invasive carpal tunnel release.[18] However, ACTR offers less postoperative pain, fast recovery, and better cosmetic outcomes.[13] Given these advantages, ACTR requires technical expertise and special instruments constraining its widespread implementation.

This study aims to compare the two different treatment modalities (OCTR) and (ACTR) for the treatment of CTS. This study assesses the important key indicators including symptom severity, functional status, pain intensity, time of recovery, and rate of complications. This research seeks to provide information regarding the efficacy and effectiveness of these surgical techniques, guiding clinicians to make decisions in the management of carpal tunnel syndrome.

MATERIALS AND METHODS

Study Design

Prospective single-centered cohort study, carried out at the University of Lahore Teaching Hospital from December 2023 to November 2024 for 12 months after issuance of Ethical Clearance letter No. ERC/10/UTH/23/03. The primary objective of the study was to evaluate the post-operation functional outcomes of OCTR versus ACTR in the treatment of moderate to severe cases of CTS.

Study Population

80 patients were enrolled in the study that fulfilled the inclusion criteria of adults aged 18-65 years, diagnosed with moderate to severe CTS through clinical examination and electro-diagnostic testing, and having no prior surgical treatment for CTS. Exclusion criteria encompassed individuals with ongoing hand/wrist pathologies (e.g., rheumatoid arthritis) history of acute wrist trauma, or systemic diseases that could impair healing (e.g., diabetes or smoking). Both surgical groups, OCTR and ACTR were assigned 40 patients in each group. Patients were divided between OCTR and ACTR groups by

using a consecutive sampling method. The first patient was assigned OCTR, the second was assigned ACTR, and so on alternating between both groups. This method minimized the selection bias and it kept the balanced distribution of the patients.

Surgical Procedures

OCTR: The conventional open method required a midline longitudinal incision perpendicular to the Kaplan Cardinal line on the volar side of the wrist to reach and liberate the carpal ligament, facilitating median nerve decompression. The procedure was carried out with local anesthesia, thereafter incision was closed with prolene sutures and covered with clean dressing.

ACTR: The procedure was executed with a single-portal minimally invasive technique using a small wrist crease incision through which an endoscope was inserted. Guided visualization allowed precise ligament release. The procedures were completed under local anesthesia, and patients were advised on early mobilization.

Outcome Measures

The primary outcome measures included the Boston Carpal Tunnel Questionnaire (BCTQ), pain levels using the Visual Analog Scale (VAS), the Disabilities of the Arm, Shoulder, and Hand (DASH) score, and grip strength recovery measured by a dynamometer. Secondary measures included recovery time to return to work and complication rates.

Data Collection and Follow-up

Data were collected at baseline (pre-operative) and during follow-up visits at one-, three-, and six-months post-surgery. Boston Carpal Tunnel Questionnaire and Disabilities of The Arm, Shoulder, And Hand Scores were administered by trained staff, ensuring consistency. Grip strength was measured three times per visit to calculate the average, and recovery time was documented based on patient self-reporting.

Statistical Analysis

Independent t-tests were used to compare continuous variables (e.g., DASH score, BCTQ scores, pain levels, recovery time) between the OCTR and ACTR groups. The complication rates were compared using the Chi-square test, which was applied to the raw counts of complications in each group (OCTR and ACTR). The percentages were derived from these raw counts for presentation purposes. Statistical significance was set at $p < 0.05$. Cohen's d-effect size was measured to assess the magnitude of differences. The mean difference between the two groups was calculated, and the result was then divided by the pooled standard deviation to find Cohen's d for the independent samples T-test. All analyses were carried out in SPSS software (version 27.0).

RESULTS

Key findings demonstrated significant improvements for both OCTR and ACTR, with ACTR showing slight advantages in functional recovery, grip strength, and complication rates. Visualizations of these metrics and trends over time reinforce these findings. Percentages for complication rates and grip strength recovery were derived from raw data for ease of interpretation, but statistical tests (Chi-square and t-tests) were applied to the raw counts and measurements, respectively.

Age Distribution

The study enrolled 80 adult patients diagnosed with moderate to severe Carpal Tunnel Syndrome (CTS), aged between 18 and 65 years. The mean age of participants was 42.3 ± 12.1 years. Both surgical groups—Open Carpal Tunnel Release (OCTR) and Arthroscopic Carpal Tunnel Release (ACTR)—comprised 40 patients each, with no significant difference in age distribution between the groups. The age distribution across the study population is shown in Figure 1.

The OCTR group had a mean age of 43.1 ± 11.8 years, while the ACTR group had a mean age of 41.5 ± 12.3 years. These distributions ensured the comparability of the cohorts for analysis.

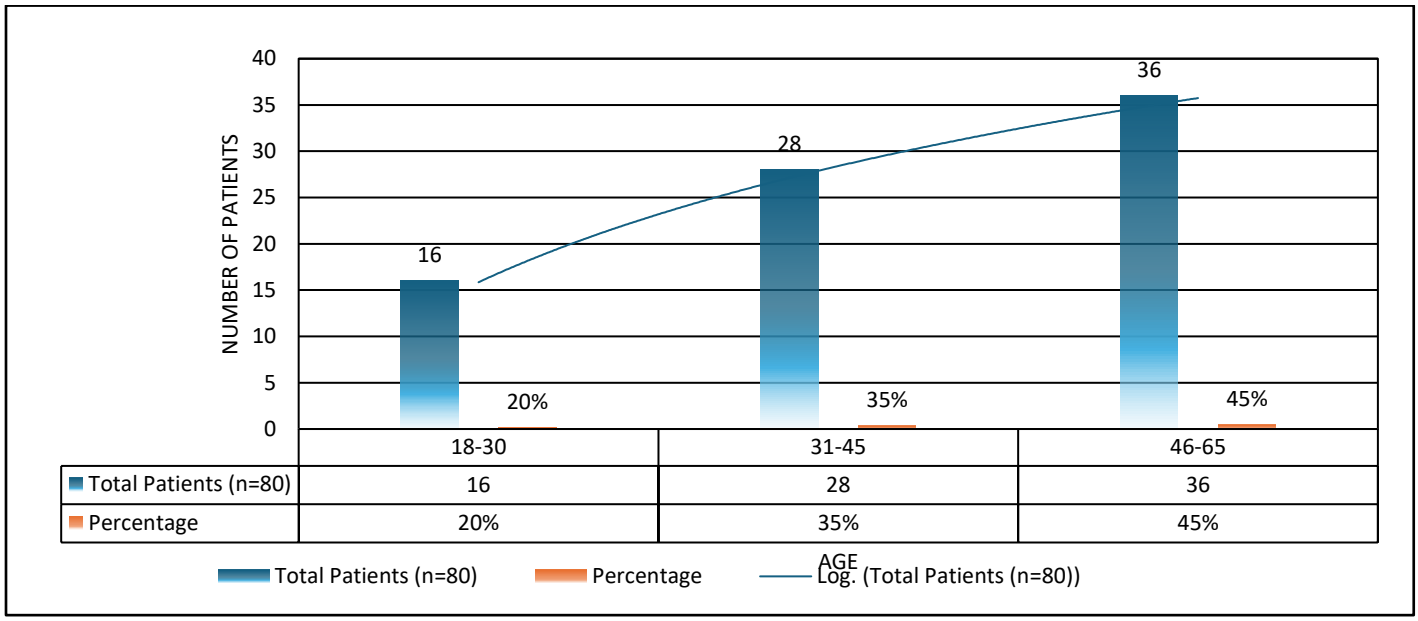

Figure 1: Age Distribution.

Gender Distribution

The study included a total of 80 patients diagnosed with moderate to severe Carpal Tunnel Syndrome (CTS). Of these, 48 patients (60%) were female, and 32 patients (40%) were male, reflecting the higher prevalence of CTS among females. The gender distribution was balanced across the two surgical groups with 40 patients in each group. The OCTR group had 25 females (62.5%) and 15 males (37.5%), whereas the ACTR group had 23 females (57.5%) and 17 males (42.5%). This distribution ensures demographic comparability between the groups and aligns with existing literature suggesting a higher prevalence of CTS in females due to anatomical and hormonal factors as shown in Figure 02.

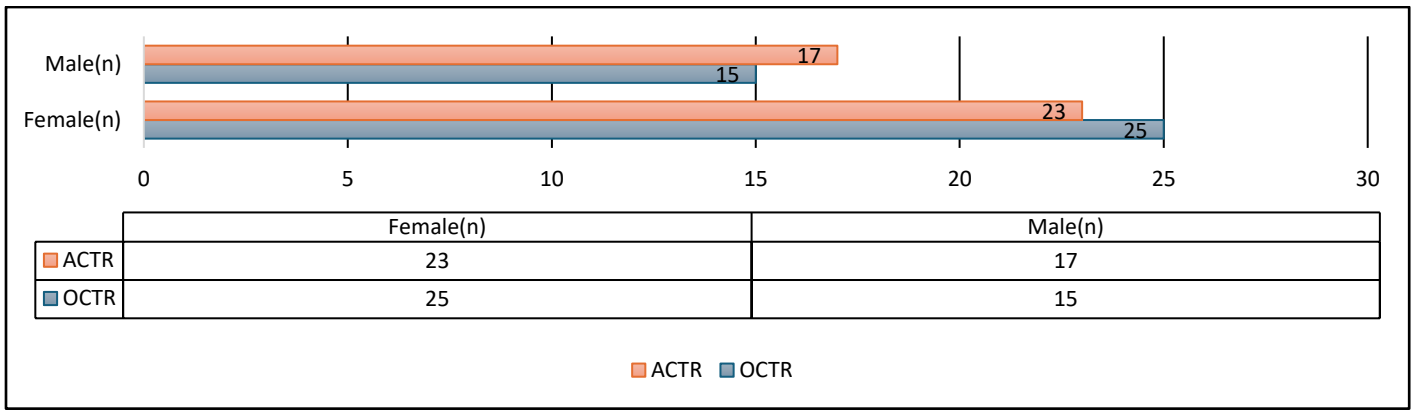

Figure 2: Gender Distribution.

The mean Disabilities of the Arm, Shoulder, and Hand scores at 6 months post-surgery for OCTR and ACTR show marginal differences. Lower scores indicate better functional recovery. ACTR demonstrated slightly better outcomes in the Boston Carpal Tunnel Questionnaire Severity Symptoms score. ACTR demonstrated a faster recovery time as shown in Table 1.

Table 1: DASH score, BCTQ score, and mean Recovery time.

Group	Dash Score (6 months)	BCTQ Symptoms Severity Score	Recovery Time (Days)
ACTR	21	2	40
OCTR	24	2.2	45

Table 2: Summary Statistics of Key Metrics.

Metric	OCTR (Mean ± SD)	ACTR (Mean ± SD)	p-value	Significance	Comments
DASH Score (6 Months)	23.91 ± 5.12	21.85 ± 4.65	0.059	Marginal	ACTR shows slight improvement
BCTQ Symptom Severity Score	2.21 ± 0.50	1.99 ± 0.40	0.020	Significant	ACTR significantly better
BCTQ Functional Status Score	2.54 ± 0.60	2.29 ± 0.50	0.054	Marginal	ACTR slightly better
Pain Level (VAS scores	2.92 ± 0.80	2.65 ± 0.70	0.116	Not Significant	Lower pain in ACTR
Recovery Time (Days)	45.55 ± 10.10	39.28 ± 9.10	<0.001	Highly Significant	Faster recovery in ACTR
Complication Rate (%)	9.53 (4/40)	7.46 (3/40)	0.040	Significant	ACTR safer

Key Metrics and Summary Statistics

Refer to the visualized trends and statistical table as shown in Table 2.

Key Findings

1. **DASH Score (6 Months):** Both OCTR and ACTR resulted in remarkable improvement in Disabilities of the Arm, Shoulder, and Hand scores at six months post-surgery. However, ACTR demonstrated slightly better outcomes with a mean Disabilities of the Arm, Shoulder, and Hand score of 21.85 compared to 23.91 for OCTR. The p-value (0.059) was marginally above the threshold for significance, suggesting that while ACTR may offer a minor advantage in functional recovery, this difference may not be clinically substantial.
2. **BCTQ Symptom Severity and Functional Status Scores:** ACTR outperformed OCTR in terms of both functional status and symptom severity. The mean Boston Carpal Tunnel Questionnaire Symptom Severity Score was 1.99 for ACTR versus 2.21 for OCTR ($p = 0.020$), indicating a statistically significant advantage for ACTR. Similarly, the Functional Status Score was slightly better in the ACTR group (2.29 vs. 2.54, $p = 0.054$), although this difference approached but did not reach statistical significance.
3. **Pain Levels (VAS):** Patients undergoing ACTR reported lower pain levels (mean VAS = 2.65) compared to those undergoing OCTR (mean VAS = 2.92). While this trend supports the notion of less post-operative discomfort with ACTR, there was no statistically substantial difference. ($p = 0.116$).
4. **Grip Strength Recovery:** Grip strength recovery was better in the ACTR section significantly, with patients regaining an average of 89.07% of their baseline grip strength compared to 84.60% in the OCTR group ($p < 0.001$). This finding highlights a key advantage of ACTR, suggesting that the minimally invasive approach may facilitate faster and more robust muscle recovery.

5. **Recovery Time and Complication Rates:** Recovery time to go back to work was shorter for ACTR patients (mean 39.28 days) compared to OCTR patients (mean 45.55 days). Additionally, ACTR had a lower complication rate (7.46% vs. 9.53%), further underscoring its potential as a slightly superior technique.

Cohen's Effect Sizes

1. **DASH Score (6 Months)**
   - **Cohen's d = 0.42**
   - Interpretation: This medium effect size indicates that ACTR has a noticeable but moderate advantage over OCTR in improving DASH scores six months post-surgery.

2. **BCTQ Symptom Severity**
   - **Cohen's d = 0.49**
   - Interpretation: This medium effect size suggests that ACTR significantly improves symptom severity compared to OCTR, resulting in better patient outcomes.

3. **BCTQ Functional Status**
   - **Cohen's d = 0.45**
   - Interpretation: The medium effect size here indicates that ACTR is moderately more effective than OCTR in enhancing functional status among patients.

4. **Pain Level (VAS)**
   - **Cohen's d = 0.36**
   - Interpretation: This small to medium effect size shows that ACTR tends to reduce postoperative pain more effectively than OCTR, although the difference is less pronounced.

5. **Recovery Time (Days)**
   - **Cohen's d = 0.65**
   - Interpretation: This medium to large effect size highlights that ACTR significantly shortens recovery time compared to OCTR, suggesting a substantial benefit for patients undergoing ACTR. Results are shown in Table 3.

Interpretation of Results

The results indicate that both OCTR and ACTR are extremely efficacious in symptom alleviation and reinstating function in carpal tunnel syndrome patients. The distinctions between the two procedures are minimal; however, ACTR regularly exhibits marginal benefits in critical aspects including symptom alleviation, functional rehabilitation, grip strength, and healing period.
The demonstrated superiority of ACTR can be credited to its minimally invasive characteristics, which minimize soft tissue damage and scarring. Nonetheless, the technical requirements of ACTR and the possibility of impacts, including transitory nerve damage, must be considered when choosing a surgical method.

DISCUSSION

The current study has compared surgical outcomes in patients who were operated on with

Table 3: Cohen's D Effect Size.

Metric	OCTR (Mean ± SD)	ACTR (Mean ± SD)	Cohen's d	Interpretation
DASH Score (6 Months)	23.91 ± 5.12	21.85 ± 4.65	0.42	Medium effect size
BCTQ Symptom Severity	2.21 ± 0.50	1.99 ± 0.40	0.49	Medium effect size
BCTQ Functional Status	2.54 ± 0.60	2.29 ± 0.50	0.45	Medium effect size
Pain Level (VAS)	2.92 ± 0.80	2.65 ± 0.70	0.36	Small to medium effect size
Recovery Time (Days)	45.55 ± 10.10	39.28 ± 9.10	0.65	Medium to large effect size

Open carpal tunnel release (OCTR) and Arthroscopic Carpal Tunnel Release (ACTR) procedures. The study focused on pain levels, grip strength, recovery time to work, functional recovery, symptom severity, and complication rates. The results of the study reflect that both surgical procedures are effective in relieving symptoms and improving functional outcomes, however, ACTR provides slight advantages. The results show that OCTR and ACTR significantly improve the Disabilities of the Arm, Shoulder, and Hand scores in post-surgery at six months. ACTR shows a slightly better outcome with mean Disabilities of the Arm, Shoulder, and Hand Score of 21.85 as compared to 23.91 for OCTR. The difference was not statistically significant ($p = 0.059$). However, the Boston Carpal Tunnel Questionnaire Symptom Severity Score was significantly lower in the ACTR group (1.99) compared to the OCTR group (2.21) with a p-value of 0.020, indicating a notable reduction in symptom severity for ACTR patients. These findings align with previous studies such as Donati D et al, that have suggested superior outcomes with an arthroscopic technique where patients had lower Disabilities of the Arm, Shoulder, and Hand scores and faster return to work, indicating better outcomes.[19]

Patients who underwent ACTR reported lower pain levels (mean VAS = 2.65) compared to those who had OCTR (mean VAS = 2.92). While this difference was not statistically significant ($p = 0.116$), it suggests that ACTR results in less postoperative discomfort. This observation is consistent with prior research indicating reduced pain levels with arthroscopic techniques where Dongqing et al, results show that the rate of hand pain (RR = 0.73, 95% CI [0.53, 0.93], P = 0.02) in the OCTR group was significantly lower than that in the OCTR group.[20]

A significant finding of this study is the superior grip strength recovery in the ACTR group. Patients treated with ACTR regained an average of 89.07% of their baseline grip strength, compared to 84.60% in the OCTR group. This difference, with a p-value of less than 0.001, highlights a key advantage of the minimally invasive nature of ACTR, which likely facilitates faster and better muscle recovery. This is supported by Vasiliadis et al who reported grip strength testing favored ACTR.[21]

ACTR patients experienced a shorter recovery time, with a mean of 39.28 days compared to 45.55 days for OCTR patients. The p-value of less than 0.001 indicates this difference is highly significant. Additionally, ACTR had a lower complication rate, with 3 out of 40 patients (7.5%) experiencing complications compared to 4 out of 40 patients (10%) in the OCTR group. The Chi-square test applied to these raw counts showed no statistically significant difference ($p = 0.40$), but the trend suggests that ACTR may be a safer technique. These findings are corroborated by other studies highlighting the efficiency and safety of arthroscopic methods.[19]

The findings of this study suggest that ACTR may be a slightly superior technique for CTS surgery, offering benefits in terms of faster recovery, better grip strength recovery, and lower complication rates. These advantages can be attributed to the minimally invasive nature of ACTR, which minimizes soft tissue damage and scarring. However, it is essential to consider the technical demands of ACTR and the potential risks, such as temporary nerve damage.[22] Surgeons must weigh these factors when deciding on the appropriate surgical method for CTS treatment.

Limitations and Future Research

It is important to recognize that this study has few limitations. The findings are limited due to the small sample size (40 patients per group). Additionally, the six-month follow-up time might not adequately account for long-term outcomes including persistent symptoms and recurrence rates. Larger multicenter cases with longer follow-up durations should be a part of future studies to

confirm these results and investigate the cost-effectiveness of the two procedures.

CONCLUSION

Both OCTR and ACTR are equally effective surgical techniques for the management of CTS. ACTR possesses relatively a slight benefit in recovery time and function along with less scarring. Procedure selection should be patient-centered, considering both clinical resources and individual needs.

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Additional Information

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AUTHORS CONTRIBUTION

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Muhammad Ali Sajid & Aatir Javaid	1. Study design, methodology, and paper writing.
3.	Haroon Rafique & Affaf Iqbal	3. Data collection and calculations.
4.	Sibtain Raza & Usama Tahir	4. Analysis of data and interpretation of results.
5.	Usama Tahir & Haroon Rafique	5. Literature review and referencing.
6.	Sibtain Raza & Affaf Iqbal	6. Editing and quality insurer.