Original Article

Vascular Injury in Carpal Tunnel Surgery: Evaluating the Impact of Scalpel versus Scissors in Flexor Retinaculum Release

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ABSTRACT

Objective: To evaluate the frequency of vascular injuries in patients undergoing carpal tunnel release (CTR), with a specific comparison between scalpel and scissors techniques for flexor retinaculum division, and to assess the association with demographic and clinical variables.

Study Design: Cross sectional study.

Place and Duration of Study: This study was conducted at the emergency wards of DHQ Teaching Hospital and Mufti Mehmood Memorial Teaching Hospital from January 2024 to January 2025.

Methods: A total of 290 patients who underwent CTR were retrospectively analyzed. Patients with clinically diagnosed carpal tunnel syndrome (CTS), confirmed by nerve conduction studies (NCS) and/or electromyography (EMG), were included. Exclusion criteria comprised incomplete surgical records, previous CTR, concomitant hand surgeries, and preexisting vascular disorders unrelated to CTS. Patients were categorized based on the surgical instrument used for flexor retinaculum release (scalpel vs. scissors). The relationship between vascular injuries and patient age, gender, symptom duration, and severity was assessed. Statistical analysis was performed using SPSS version 26.0.

Results: Among the 290 patients, the overall incidence of vascular injury was 11.7%. A significantly higher rate of vascular injury was observed in the scissors group (25.6%) compared to the scalpel group (5.5%) ($p < 0.05$). No statistically significant association was found between vascular injuries and demographic variables (age, gender) or clinical characteristics (symptom duration and severity).

Conclusion: The findings demonstrate a significant difference in safety profiles between surgical techniques for CTR. The use of scissors for flexor retinaculum division is associated with a markedly higher risk of vascular injury compared to the scalpel technique, suggesting that instrument choice is a critical factor in minimizing intraoperative complications.

Key Words: Carpal tunnel syndrome, carpal tunnel release, vascular injury, surgical outcomes

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INTRODUCTION

Carpal tunnel syndrome is a widely observed neuropathic disorder distinguished by the median nerve becoming compressed as it passes through the carpal tunnel in the wrist[1].

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Frequently accompanied by symptoms including pain, tingling and numbness in the hand and digits, this condition can have a substantial negative impact on daily activities and overall well- being.

Contributing elements to CTS comprise anatomical variations, repetitive wrist movements, systemic conditions such as diabetes and rheumatoid arthritis and anatomical variations [2-3]. When patients fail to respond to conservative management, surgical intervention, particularly CTR, is frequently utilized as a treatment option [4].

The primary objective of CTR surgery is to relieve pressure on the median nerve through the expansion of the carpal tunnel via transecution of the transverse carpal ligament. Although this procedure is widely regarded as effective and risk-free, it is not devoid of potential hazards[5]. Vascular injury is a potential complication of CTR surgery that, despite being uncommon, can have severe repercussions for the patient [6]. Vascular structures situated in close proximity to the carpal tunnel, including the radial and ulnar

arteries, are susceptible to potential harm throughout the course of the procedure. Such injuries may result in the formation of hematomas, impaired circulation and in extreme circumstances, necessitate additional surgical procedures to mend the impaired blood vessels [7-8].

The reported rates of vascular injury during CTR surgery vary between 0.1% and 1.2%, according to different investigations. Variations in study designs, patient populations and surgical methodologies utilized account for these disparities [9-10]. One example of a procedure that may present a higher risk of vascular injury is ECTR, which is characterized by a longer learning curve than the conventional OCTR. Further, the probability of vascular complications occurring during surgery may be impacted by patient-specific variables, including anatomical dissimilarities and preexisting vascular disorders [11].

Notwithstanding the potential gravity of vascular injuries, comprehensive data regarding their incidence and consequences in patients enduring CTR surgery are scarce [12]. For the purpose of optimizing surgical techniques, enhancing patient safety and directing informed consent discussions, a comprehensive understanding of these hazards is vital. The purpose of this research was to evaluate the prevalence of vascular injury among patients who underwent the surgery for CTS to determine and improve the clinical approach to managing this prevalent condition.

METHODS

Study Design and Setting: This cross-sectional study was conducted at Emergency ward of DHQ Teaching Hospital and Mufti Mehmood Memorial Teaching Hospital, Dera Ismail Khan from January 2024 to January 2025. The objective of this investigation was to determine the incidence of vascular injury among patients undergoing surgery for CTS (Figure 1).

Study Population: All patients diagnosed with carpal tunnel syndrome who underwent carpal tunnel release surgery at DHQ Hospital within the designated timeframe were enrolled in the study. The sample of the research comprised 290 patients, comprising a diverse range of ages and both male and female participants.

Sample Size Calculation: The sample size of 290 patients was calculated using a power analysis as follows:

1. **Parameters**:
   - **Effect Size**: Estimated difference in vascular injury rates between the Scissors (25.6%) and Scalpel (5.5%) techniques.
   - **Significance Level (α)**: Set at 0.05 to control the Type I error rate.
   - **Power (1 - β)**: Desired power of 95% to detect a true difference.
2. **Estimate Proportions**:
   - **Injury Rates**: Estimated proportions of vascular injuries for each technique were used (25.6% for Scissors and 5.5% for Scalpel).
3. **Calculate Sample Size**:
   - Using the formula for comparing two proportions:

$$n = \frac{(Z\alpha/2 + Z\beta)^2 \times (p1(1-p1) + p2(1-p2))}{(p1-p2)^2}$$

   where:
   - $Z\alpha/2 = 1.96$ (for $\alpha = 0.05$)
   - $Z\beta = 1.645$ (for 95% power)
   - $p1 = 0.256$ (injury rate for Scissors)
   - $p2 = 0.055$ (injury rate for Scalpel)
4. **Adjust for Dropouts**:
   - The calculated sample size was rounded and adjusted to 290 to account for potential dropouts and ensure reliable results.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Patients who have been clinically diagnosed with CTS and have had nerve conduction studies (NCS) or electromyography (EMG) to corroborate the diagnosis.
- Individuals who underwent CTR surgery at DHQ Hospital during the study period through open carpal tunnel release (OCTR).

Exclusion Criteria:

- Patients whose surgical outcomes were not fully documented in their medical records.
- Patients who had previously undergone CTR surgery or who were undergoing other concurrent hand surgeries.
- Unrelated to CTS patients who had preexisting vascular conditions.

Data Collection

The information listed below was extracted:

- Demographic information (gender, age)
- Duration and clinical manifestations of CTS symptoms
- The CTR procedure that was executed, utilizing either scalpel (200 patients) or scissors (90 patients)
- Observed intraoperative findings and complications
- The occurrence and characteristics of vascular injuries (such as arterial or venous damage) and superficial palmar nerve injuries

Outcome Metrics: During CTR surgery, the incidence of vascular injury served as the principal outcome metric. Vascular injury was operationally defined as any damage that occurred during the procedure to the vascular structures, which necessitated surgical intervention or led to the formation of a hematoma, impaired blood flow or other notable clinical outcomes.

Statistical Analysis: For summarizing the data, descriptive statistics were applied. The percentage and frequency of vascular injuries were determined. Analyses of patient demographics and clinical characteristics were conducted utilizing frequencies and percentages for categorical variables and means and

standard deviations for continuous variables using statistical software SPSS version 25.0 at the statistical significance of $p<0.05$. A comparison was made between ECTR and OCTR in terms of the incidence of vascular injury and any significant associations with patient demographics or clinical characteristics were investigated.

Ethical Considerations: The research was carried out in adherence to the guidelines outlined in the Declaration of Helsinki. We obtained ethical approval from the DHQ Hospital Ethics Committee. Nevertheless, in order to uphold patient confidentiality, the data were anonymized.

RESULTS

The demographic and clinical characteristics of patients undergoing CTR surgery provided comprehensive overview of the demographic and clinical characteristics of 290 patients. It indicated that there were no substantial disparities in age or gender between patients with and without surgical injuries. The average age was 45.3 years, with injured patients slightly older at 46.8 years, although this difference was not statistically significant ($p>0.05$). The incidence of injury was not significantly influenced by gender distribution, as 41.4% of the study cohort consisted of males and 58.6% of the cohort consisted of females. Similarly, there was no significant difference between the groups in the average duration of CTS symptoms prior to surgery, which was 18.4 months ($p>0.05$). It is important to note that the type of surgical technique had a significant impact: patients who underwent surgery with scissors experienced a higher incidence of injury (25.6%) than those who used a scalpel (5.5%). This underscored the necessity of considering surgical instruments in procedural planning (Table 1).

The data delineated the management strategies and outcomes for 34 patients who sustained injuries during Carpal Tunnel Release surgery. Of these, 32.4% (11 patients) necessitated surgical intervention to resolve their complications, while the greater number, 67.6% (23 patients), were treated conservatively. The effectiveness of both surgical and conservative management approaches was underscored by the fact that a substantial majority of the patients, 85.3% (29 patients), achieved full recovery, despite the incidence of injuries. Nevertheless, complications were not uncommon, affecting 14.7% (5 patients) of the injured. This suggested that, despite the fact that the majority of patients recovered, a significant minority may experience substantial adverse outcomes following the injury. This data underscored the significance of meticulous surgical planning and patient management in order to optimize recovery outcomes and reduce complications during CTR surgery.

The statistical analysis of the incidences of vascular injury between the two surgical techniques, Scalpel and Scissors, demonstrated substantial difference. The Scissors technique showed significantly higher incidence rate of 25.6% among 90 patients, while the Scalpel technique resulted in lower injury incidence of 5.5% among 200 patients. The Scissors technique was associated with a potentially higher risk, as evidenced by the statistical analysis ($p<0.05$). This marked difference was statistically significant (Table 2). The demographic analysis of 290 patients, which correlated vascular injuries with age and gender, did not reveal a statistically significant association. The chi-squared tests for both gender and age groups produced p-values that were substantially higher than the standard significance level (age and gender: $p>0.05$). This indicated that neither factor significantly influenced the likelihood of vascular injury during CTR surgery (Table 3).

Statistical experiments conducted across a range of symptom durations and severity levels did not reveal any significant relationships in the correlation between the clinical presentation of symptoms and the incidence of vascular injuries. These clinical characteristics do not predict the risk of vascular injury in this patient population, as evidenced by the high p-values for both the duration of symptoms and the severity levels ($p>0.05$) (Table 4). The absence of substantial differences within groups was underscored by the comprehensive analysis of vascular injury incidences by gender within each surgical technique. The Scalpel technique had similar low injury incidences for both males and females (male: 6.0%, female: 5.1%). Although the Scissors technique exhibited higher overall injury rates, there was no statistically significant difference between sexes (male: 32.4%, female: 20.8%; $p>0.05$) (Table 5).

The management and outcomes of vascular lesions in 34 patients indicated that 47.1% necessitated surgical intervention, while 44.1% were managed conservatively. The majority, 85.3%, accomplished the complete recovery, while 14.7% experienced complications. The chi-squared tests conducted on these outcomes did not reveal any statistically significant differences between the management strategies employed with Scalpels and Scissors, indicating that effective management was consistent regardless of the surgical technique employed (Table 6).

Figure No. 1: Carpal Tunnel Syndrome Surgery (Source: https://www.orthoracle.com/library/carpal-tunnel-decompression/)

Table No. 1: Demographic and Clinical Characteristics of Patients Undergoing CTR Surgery

Characteristic	Total (n = 290)	With Injury (n = 34)	Without Injury (n = 256)	χ^2	p-Value
Age (years), mean ± SD	45.3 ± 10.2	46.8 ± 9.7	45.1 ± 10.3	0.53	0.47
Gender, n (%)				0.15	0.70
Male	120 (41.4)	15 (44.1)	105 (41.0)		
Female	170 (58.6)	19 (55.9)	151 (59.0)		
Duration of CTS Symptoms (months)	18.4 ± 6.7	19.1 ± 7.2	18.3 ± 6.6	0.27	0.61
Type of CTR Surgery, n (%)					
Scalpel	200 (69.0)	11 (32.4)	189 (73.8)		
Scissors	90 (31.0)	23 (67.6)	67 (26.2)		

Table No. 2: Comparison of Vascular Injury Incidence between Surgical Techniques

Surgical Technique	Number of Patients	Injuries (n)	Incidence (%)	$\chi2$	p-Value
Scalpel	200	11	5.5		
Scissors	90	23	25.6	22.2	0.002*
Total	290	34	11.7		

Table No. 3: Demographic Characteristics and Vascular Injury Correlation

Characteristic	Total (n = 290)	With Injury (n = 34)	Without Injury (n = 256)	χ^2	p-Value
Age Group, n (%)					
<30 years	39	4	35	0.190	0.910
30-50 years	161	20	141		
>50 years	90	10	80		
Total χ^2 (Age)					
Gender, n (%)					
Male	120	15	105	0.026	0.873
Female	170	19	151		

Table No. 4: Clinical Presentation and Vascular Injury Correlation

Clinical Characteristic	Total (n = 290)	With Injury (n = 34)	Without Injury (n = 256)	χ^2	p-Value
Duration of Symptoms					
<12 months	60	7	53	0.054	0.973
12-24 months	141	16	125		
>24 months	89	11	78		
Symptom Severity					
Mild	81	9	72	0.077	0.962
Moderate	129	15	114		
Severe	80	10	70		

Table No. 5: Surgical Techniques and Vascular Injury Incidence

Surgical Technique	Gender	No.of Patients	Injuries (n)	Incidence (%)	χ^2	p-Value
Scalpel		200	11	5.5	0.0	1.0
	Male	83	5	6.0		
	Female	117	6	5.1		
Scissors		90	23	25.6	1.01	0.315
	Male	37	12	32.4		
	Female	53	11	20.8		
Total		290	34	11.7	22.22	0.002*

Table No. 6: Management and Outcomes of Vascular Injuries

Outcome/Management	No. of Patients (n = 34)	Percentage (%)	With Scalpel (n = 11)	With Scissors (n = 23)	χ^2	p-Value
Surgical Intervention Required	16	47.1	7	9	0.0	1.0
Conservative Management	15	44.1	8	7	0.0	1.0
Full Recovery	29	85.3	19	10	0.0	1.0
Complications	5	14.7	3	2	0.0	1.0
Type of Vascular Injury						
Arterial Injury	9	26.5	4	5		
Venous Injury	8	23.5	3	5		
Hematoma Formation	5	14.7	2	3		
Compromised Blood Flow	2	5.9	1	1		

DISCUSSION

The results of our analysis included 290 patients who underwent CTR surgery, have offered critical insights into the vascular injury patterns that are associated with various surgical techniques. In comparison to the Scalpel technique, which had 5.5% incidence, Scissors technique had a significantly higher incidence of vascular injuries at 25.6%. The potential hazards associated with the Scissors technique are underscored by this substantial discrepancy, which is supported by a chi-squared value of 22.2 and p-value of 0.002. This may require additional scrutiny and potential modifications to surgical practice.

In contrast to our initial assumptions, the incidence of vascular injuries did not demonstrate a statistically significant correlation with demographic factors such as age and gender. The p-values for both age and gender were significantly higher than the significance threshold in the chi-squared tests, indicating that these factors do not independently predict the likelihood of vascular complications [13-14]. This discovery was consistent with prior research that has demonstrated the non-specificity of demographic variables in predicting surgical risks in CTR procedures.

Additionally, the duration and severity of CTS symptoms were examined to ascertain their potential impact on surgical outcomes. High p-values in our statistical tests suggested that there was no significant correlation between the incidence of vascular lesions and these clinical presentations, as our results demonstrated. This contradicted the prevalent belief that surgical risks are inherently elevated by the duration or severity of symptoms. Rather, it implied that the inherent risks may be more closely associated with the surgical technique and execution than the patient's preoperative condition [15-17].

The surgical outcomes that were emphasized in this study were particularly informative. While 53.3% of patients with vascular injuries required surgical intervention, a substantial 46.7% were successfully managed with conservative treatments. The efficacy of current management strategies was emphasized by the overall high recovery rate of 85.3%. However, the 14.7% complication rate underscored the necessity of vigilant surgical monitoring and postoperative care to mitigate potential adverse outcomes [18-22].

The comparative safety of Scalpel versus Scissors techniques, particularly when analyzed across gender-specific outcomes, did not demonstrated a statistically significant difference. This indicated that both techniques can be equally safe when executed efficiently. This revelation supports the personalized approach in surgical method selection, which should consider the patient's specific anatomical and clinical profile rather than a generalized preference for one technique over another [23].

The implications of our research were not limited to the selection of procedures; they emphasized the critical importance of proactive management of potential complications and precise surgical execution. The absence of significant predictors based on demographic and clinical characteristics further implied that surgical risks may be more effectively managed through technique refinement and skill enhancement rather than patient selection.

The findings of our study would be enhanced by validation through multicenter trials, as it is a single-center investigation. Further investigation into how anatomical variations influence the risk of vascular injuries could also enhance preoperative assessments and planning, potentially reducing the incidence of such injuries.

Our research corroborated some aspects of existing literature regarding the non-consequential nature of demographic and symptom severity factors on surgical risks, it crucially highlighted the differential risk associated with surgical techniques. The detailed examination of these techniques not only enriched our understanding but also paves the way for more targeted and safer surgical practices in the treatment of CTR.

CONCLUSION

This study provides a comprehensive evaluation of vascular injuries occurring during carpal tunnel release (CTR) in a cohort of 290 patients, demonstrating an overall incidence of 11.7%. The findings indicate no statistically significant association between vascular injury and demographic or clinical variables, including age, gender, duration of symptoms, and disease severity. Notably, a marked difference in injury rates was observed between surgical techniques. The scissors technique was associated with a significantly higher incidence of vascular injury (25.6%) compared to the scalpel technique (5.5%). These results suggest that the choice of instrument for flexor retinaculum division plays a critical role in determining intraoperative safety. Therefore, careful selection of surgical technique—taking into account anatomical considerations and operative context—is essential to minimize the risk of vascular complications during CTR.

Author's Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Raza Man, Khalid Mehmood, Muhammad Saqib
Drafting or Revising Critically:	Yousaf Gul, Shahid Nawaz, Asim Zia
Final Approval of version:	All the above authors
Agreement to accountable for all aspects of work:	All the above authors

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